



Comparison of correlations of equation-derived body fat percentage and body mass index with carotid intima-media thickness

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Received: 6 September 2018 / Accepted: 6 November 2018 / Published online: 23 November 2018
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Keywords Body fat percentage · Body mass index · Preclinical cardiovascular disease · Carotid intima-media thickness · Obesity

Introduction

Obesity is a critical cardiovascular disease (CVD) contributing risk factor. A proper overweight and obesity screening may help clinicians to better characterize patients' CVD risk to counsel patients on health risks, lifestyle changes, treatment options, and decreasing the effect of the risk factor.

Body mass index (BMI) is an affordable anthropometric measure that can be used to define obesity in epidemiological research but may not represent a reliable indicator of body adiposity at an individual level.

Dual energy X-ray absorptiometry (DEXA) and air displacement plethysmography (ADP) are accepted methods to obtain accurate measures of body fat percentage (BF%), although these techniques are less available and more expensive than BMI, which may be an important limitation for screening purposes.

CUN-BAE (Clínica Universidad de Navarra-Body Adiposity Estimator) is an equation for estimating BF%

affordably that has shown better association with several cardiometabolic risk factors such as systolic blood pressure, insulin resistance, insulin sensitivity, triglycerides, total cholesterol or LDL cholesterol than BMI in Caucasian subjects [1]. However, whether this equation-derived BF% shows a better association with preclinical CVD than BMI remains to be proven.

Using carotid intima-media thickness (cIMT) as an objective surrogate marker of preclinical CVD, we hypothesized that BF% estimated by CUN-BAE would be associated with cIMT in both men and women, with a greater magnitude of association than BMI. Testing this hypothesis may contribute to clarifying the clinical usefulness of equation-derived BF% to improve overweight and obesity screening and characterization of patients' CVD risk.

Methods

This is a cross-sectional study that recruited patients that went to the General Health Check-up Unit at Clínica Universidad de Navarra (Pamplona, Spain; <http://www.cun.es>) for a routine medical examination after fasting 12 h, from May 1999 to January 2016.

Eligibility criteria included patients aged ≥ 18 years with a measure of cIMT, and BMI ≥ 18.5 and < 30 kg/m². Patients with a personal history of CVD were excluded.

Overweight was defined as a BMI of 25–29.9, and obesity was defined as a BMI of 30 or higher, for men and women, regardless of their age. BF% was estimated using the equation proposed by Gomez-Ambrosi et al. [2]. The protocol to measure cIMT has been described previously [3]. Subjects were examined by certified sonographers blinded to the aim of this study. Ten-year CVD risk was assessed using the

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CUORE Project risk score (http://www.cuore.iss.it/cuore_exe/cuore_exe.asp).

The study had enough statistical power to detect a correlation coefficient between BF% and cIMT of 0.2. Assuming 80% power, a significance level of 0.05, and dropout rate of 15%, the required sample size would be 228.

Clinical and demographic variables were expressed as mean and standard deviation (SD) if quantitative data, or percentages if qualitative data. Correlations of BMI and estimated BF% with cIMT were evaluated by the Pearson correlation coefficient and the slope regression parameter (beta). Differences between any two correlations were compared by Wolfe's test. All analyses were performed using Stata 14. A p value < 0.05 (two-sided) was considered statistically significant.

Results

A total of 1,006 patients met the inclusion criteria, of which 28 presented a personal history of CVD and were excluded. Thus, the final analyses included 987 patients (Table 1). Men represented 75.7% of the whole study sample. Male patients were aged between 25 and 80 years (mean age: 53.5 years; SD: 11) and had an average BMI of 26.7 kg/m² (SD: 2.1; 79.3% of men were overweight), an average BF% of 27.5 (SD: 3.2), and an average cIMT of 0.71 mm (SD: 0.17). The mean age of women was 55.2 years (SD: 11.6; range:

20–87). In women, average BMI was 24.5 (SD: 2.8; 46.3% of women were overweight), average BF% was 36.7 (SD: 4.5), and average cIMT was 0.65 mm (SD: 0.14).

Among men, BMI showed no correlation with cIMT [$r=0.0283$; $p=0.4400$; $\beta=0.002$, 95% confidence interval (95% CI) -0.004 , 0.008]. However, estimated BF% was significantly correlated with cIMT ($r=0.2313$; $p<0.001$; $\beta=0.013$, 95% CI 0.009 , 0.016) (Fig. 1a). These correlations differed significantly from each other (p value from Wolfe's test: <0.001) (Fig. 1b). BMI showed correlation with 10-year CVD risk measured with CUORE Project score ($r=0.1080$; $p=0.0031$; $\beta=0.524$, 95% CI 0.177 , 0.870). Estimated BF% was also significantly correlated with CUORE Project score in men ($r=0.3997$; $p<0.001$; $\beta=1.269$, 95% CI 1.059 , 1.479).

Focusing the analyses on women, BMI was significantly associated with cIMT ($r=0.2983$, $p<0.001$; $\beta=0.015$, 95% CI 0.009 , 0.022) (Fig. 1c). Similarly, estimated BF% was significantly correlated with cIMT in women ($r=0.4111$; $p<0.001$; $\beta=0.013$, 95% CI 0.009 , 0.017), although the magnitude of the association between BF% and cIMT was significantly greater than that between BMI and cIMT (p value from Wolfe's test: <0.001) (Fig. 1d). BMI was significantly associated with 10-year CVD risk score ($r=0.2827$, $p<0.001$; $\beta=0.472$, 95% CI 0.267 , 0.677), and estimated BF% was also significantly correlated with CVD risk score in women ($r=0.4607$; $p<0.001$; $\beta=0.478$, 95% CI 0.360 , 0.596).

Table 1 Characteristics of the study population ($n=987$)

	Men	Women
<i>N</i>	747	240
Age (years)	53.5 (11.0)	55.2 (11.6)
Family history of IC, <i>n</i> (%)	147 (19.7)	40 (16.7)
HDLc (mg/dL)	49 (12.4)	62.6 (15.1)
LDLc (mg/dL)	148.5 (36.2)	147.8 (43.3)
Triglycerides (mg/dL)	117.7 (71.4)	87.6 (48.2)
Systolic blood pressure (mmHg)	126.2 (19.3)	126.1 (22.2)
Diastolic blood pressure (mmHg)	80.6 (9.1)	78.2 (9.9)
Glucose (mg/dL)	101.0 (25.1)	94.3 (16.2)
Smokers, <i>n</i> (%)	209 (28.0)	51 (21.3)
10-year CVD risk (CUORE Project risk score), <i>n</i> (%)		
High-risk ($\geq 20\%$)	89 (11.9)	5 (2.1)
Intermediate-risk ($\geq 3\%$ and $< 20\%$)	424 (56.8)	80 (33.3)
Low-risk ($< 3\%$)	233 (31.2)	154 (64.2)
Missing	1 (0.1)	1 (0.4)

CVD cardiovascular disease, HDLc high-density lipoprotein cholesterol, LDLc low-density lipoprotein cholesterol, IC ischemic cardiomyopathy

Values are expressed as mean (standard deviation), unless otherwise stated

Discussion

In this study of non-obese adults without personal history of CVD, we observed a statistically significant correlation of equation-derived BF% with preclinical CVD measured by cIMT in both men and women. This correlation was relatively low in men and moderate in women. BMI did not correlate with cIMT in men but showed a low correlation in women. The equation-derived BF% correlated better than BMI with cIMT in both men and women.

Previous results have also showed stronger correlation of equation-derived BF% with cardiometabolic outcomes in comparison with BMI [1]. These results could be explained by the inability of BMI to distinguish between body fat and lean body mass [4]. If the accuracy of BMI to indicate actual adiposity is less than that of estimated BF%, it seems reasonable to expect that estimated BF% appears to be more clearly associated with CVD outcomes linked to adiposity excess than BMI.

We also appreciated higher magnitudes of correlation of both BMI and BF% with cIMT in women than those observed in men that may reflect sex differences in body

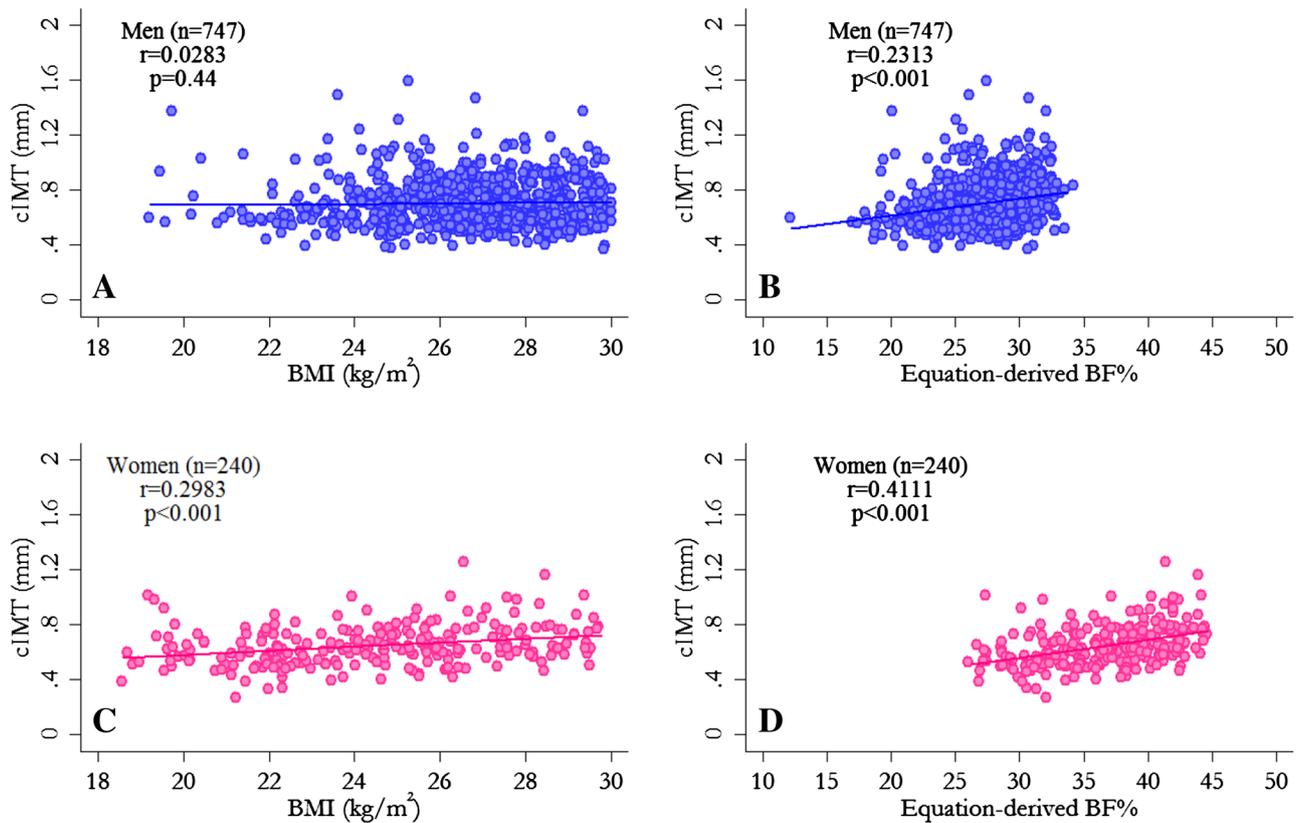


Fig. 1 Relationships of body mass index and equation-derived body fat percentage with carotid intima-media thickness in men and women. Solid lines: regression lines. *BF%* body fat percentage, *BMI* body mass index, *cIMT* carotid intima-media thickness

composition (men have more lean mass than women, and women have more body fat than men of the same BMI) [5].

In conclusion, this study shows that equation-derived BF% correlates better than BMI with preclinical CVD measured by cIMT in non-obese men and women with no history of CVD, suggesting that the role of BF% as an indicator of adiposity could be more useful than BMI at the individual level cardiovascular risk assessment of these patients.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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