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Obesity and Risk of NAFLD: A Comparison of Bioelectrical Impedance Analysis and Conventional Derived Anthropometric Measures

Maya Balakrishnan[1], **Hashem B. El-Serag**[1,2], **Theresa Nguyen, MD**[1], **Jonathan Hilal**[1], **Fasiha Kanwal**[1,2], and **Aaron P. Thrift**[1,3]

[1]Section of Gastroenterology and Hepatology, Department of Medicine, Baylor College of Medicine, Houston, TX, USA

[2]Department of Medicine, Houston VA HSR&D Center for Innovations in Quality, Effectiveness and Safety, Michael E. DeBakey Veterans Affairs Medical Center, Houston, TX, USA

[3]Dan L Duncan Comprehensive Cancer Center, Baylor College of Medicine, Houston, TX, USA

Introduction

Increased body fat, particularly abdominal visceral fat, is central in the pathogenesis of non-alcoholic fatty liver disease (NAFLD) (1, 2). Identifying a clinically feasible fat assessment method is thus important. Body mass index (BMI) and waist circumference (WC) convey insufficient information on body composition, fat distribution, and visceral fat (3, 4). BMI's limitations are most evident in cases of "lean" but "metabolically unhealthy" individuals who despite a normal BMI have increased central adiposity and predisposition to cardiometabolic complications including NAFLD (5). While computerized tomography (CT), magnetic resonance imaging (MRI), and DEXA are precise fat assessment methods, they are impractical for routine use.

Bioelectrical impedance analysis (BIA) is a simple non-invasive assessment tool for body composition. BIA-estimated abdominal fat was found to have greater discriminatory ability than WC for identifying NAFLD in the only previous study to specifically address the issue (6). However it remains unclear whether BIA-estimated abdominal fat is truly superior to conventional measures for prediction of NAFLD risk as this previous study did not assess the association independent of BMI.

Correspondence to: Maya Balakrishnan, Section of Gastroenterology and Hepatology, Baylor College of Medicine, One Baylor Plaza, Houston, TX 77030; maya.balakrishnan@bcm.edu.

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Therefore, we sought to determine whether BIA-derived total body and trunk fat measures are more strongly associated with NAFLD risk than BMI and WC.

Methods

This study was nested within the Houston Barrett's Esophagus study, conducted in Michael E DeBakey Veterans Affairs Medical Center and previously described in detail (7). We included adults who had undergone BIA as part of the study, had abdominal imaging (CT, MRI, or ultrasound) within 6 months of enrollment, and no reported viral hepatitis or excessive alcohol use (>7 and >14 beverages/week respectively in women and men). NAFLD was determined based on imaging detected hepatic steatosis.

Total body fat mass (TBF), total body fat percentage (BF%), trunk fat mass (TFM), and BMI were estimated using the InBody 520 Direct Segmental 8-point Multifrequency BIA device (Biospace, Los Angeles, CA) which has 98% correlation with DEXA and 99% reproducibility (8). WC was obtained at the level of the umbilicus.

We compared BIA and conventional fat measures between the included 48 cases with NAFLD and 75 controls without NAFLD using logistic regression models adjusted for age, sex and race/ethnicity. We additionally adjusted the models including BIA measures by BMI and WC.

Results

Age, sex and race/ethnicity distributions were not different between cases and controls. We observed moderate to strong correlations between all body fat measures (among non-NAFLD controls: r=0.39–0.96).

We first examined associations of each measure – BMI, WC, TBF, BF%, and TFM – with NAFLD risk while adjusting for demographic characteristics (Table 1, OR^1). BMI, WC, TBF, and TFM were each statistically significantly associated with the NAFLD risk while BF% was not. With each 5kg increase in TBF and TFM there was a statistically significant increased risk of NAFLD (OR=1.27, 95% CI 1.04–1.54; and 1.45, 95% CI 1.05–2.01, respectively). Likewise, with each 5cm increase of WC there was a statistically significant increase in NAFLD risk (OR=1.34, 95% CI 1.11–1.62).

When we further adjusted for WC (Table 1, OR^2), the respective associations of BMI and TBF with NAFLD were attenuated and no longer statistically significant. Conversely, WC and TFM each remained significantly associated with increased NAFLD risk when adjusted for BF%. Finally, when WC and TFM were included in the same model, WC but not TFM was associated with NAFLD risk. None of the interactions were significant (p<0.05).

Discussion

Two BIA-measures (TBF and TFM) and both conventional measures (BMI and WC) were associated with increased NAFLD risk. However, only abdominal fat measures – WC and TFM – were associated with NAFLD risk independent of total body fat percentage. This suggests that both can be clinically useful tools for NAFLD risk assessment. WC had an effect size larger than and independent of TFM. This suggests that BIA determined TFM may not provide additional value over WC for NAFLD prediction.

This was the first study to ask whether BIA fat measures are better than conventional ones for estimation of NAFLD risk. However, the strong correlation between the various measures may have prevented teasing out the independent effect of each for NAFLD risk. Use of heterogeneous imaging modalities with varying sensitivities for hepatic steatosis may have led to misclassification bias. Also, the small sample size limited determining whether TFM modifies the effect of WC or BMI for NAFLD risk.

In summary, both TFM and WC predict increased NAFLD risk. However, WC was the strongest independent predictor of NAFLD risk. Further work should evaluate whether newer BIA technologies that have the ability to estimate visceral fat have a role for predicting NAFLD risk.

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Table 1

Associations between anthropometric measurements and risk of NAFLD (n=123)

	NAFLD + (n=48)	NAFLD − (n=75)	OR[1] (95% CI)	OR[2] (95% CI)
	n (%)	n (%)		
BMI (kg/m^2)				
<25	6 (12.5)	17 (22.7)	Referent	Referent
25–29.9	11 (22.9)	33 (44.0)	0.92 (0.27–3.12)	0.44 (0.10–1.97)
≥30	31 (64.6)	25 (33.3)	3.65 (1.12–11.9)	1.67 (0.29–9.48)
P-trend			0.004	0.13
BIA-Total body fat mass (kg)				
Tertile 1	6 (12.5)	25 (33.3)	Referent	Referent
Tertile 2	19 (39.6)	26 (34.7)	3.33 (1.10–10.1)	1.84 (0.53–6.41)
Tertile 3	23 (47.9)	24 (32.0)	4.09 (1.33–12.6)	2.02 (0.46–8.83)
P-trend			0.03	0.44
BIA-Total body fat percentage (%)				
Tertile 1	14 (29.2)	25 (33.3)	Referent	Referent
Tertile 2	18 (37.5)	27 (36.0)	1.19 (0.47–3.02)	0.73 (0.26–2.05)
Tertile 3	16 (33.3)	23 (30.7)	1.71 (0.57–5.19)	0.84 (0.22–3.26)
P-trend			0.34	0.79
Waist circumference (cm)				
Tertile 1	4 (8.3)	25 (33.3)	Referent	Referent
Tertile 2	20 (41.7)	26 (34.7)	6.22 (1.54–25.2)	6.75 (1.61–28.3)
Tertile 3	24 (50.0)	24 (32.0)	7.52 (1.75–32.3)	8.48 (1.68–42.8)
P-trend			0.01	0.02
BIA-Trunk fat mass (kg)				
Tertile 1	6 (12.5)	25 (33.3)	Referent	Referent
Tertile 2	19 (39.6)	26 (34.7)	2.98 (0.98–9.03)	4.03 (1.15–14.1)
Tertile 3	23 (47.9)	24 (32.0)	3.48 (1.13–10.8)	5.83 (1.16–29.2)
P-trend			0.05	0.06

[1] Model adjusted for age, sex and race/ethnicity.

[2] Models for BMI, total body fat weight and total body fat percentage adjusted for age, sex, race and waist circumference, and model for waist circumference and trunk body fat adjusted for age, sex, race and total body fat percentage.