

Association of two novel adiposity indicators with visceral fat area in type 2 diabetic patients

Novel adiposity indexes for type 2 diabetes

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Abstract

The present study evaluated the performance of 2 novel adiposity indicators, body shape index (ABSI), and body roundness index (BRI), to determine the accumulation of visceral fat in type 2 diabetic patients.

A cross-sectional study was performed on 233 type 2 diabetic patients from Qinhuangdao, China. Visceral fat area (VFA) was measured using bioelectrical impedance. Accumulation of visceral fat was defined as $VFA \geq 100 \text{ cm}^2$.

In diabetic males, the area under the curve (AUC) values were 0.904 for waist circumference (WC), 0.923 for BRI, and 0.788 for ABSI. In diabetic females, the AUC values were 0.894 for WC, 0.915 for BRI, and 0.668 for ABSI. The AUCs were similar between BRI and WC ($P > .05$). The AUC for ABSI was lower compared to WC and BRI ($P < .05$). The optimal cut-off for BRI was 4.25 for diabetic males (sensitivity=87.8% and specificity=81.1%) and 4.75 for diabetic females (sensitivity=80.8% and specificity=88.1%).

BRI was an effective indicator for determining the accumulation of visceral fat in type 2 diabetic patients, however, it was not better compared to WC.

Abbreviations: ABSI = a body shape index, AUC = area under the curve, BIA = bioelectrical impedance analysis, BMI = body mass index, BRI = body roundness index, CT = computed tomography, MRI = magnetic resonance imaging, ROC = receiver operating characteristic, T2DM = type 2 diabetes, VFA = visceral fat area, WC = waist circumference, WHtR = waist-to-height ratio.

Keywords: adiposity indicator, type 2 diabetes, visceral fat area

1. Introduction

Diabetes mellitus is a significant public health concern in China. Type 2 diabetes (T2DM) has been increasingly observed in China due to the higher prevalence of obesity.^[1] Obesity increases the risk of T2DM by exacerbating insulin resistance.^[2,3] In addition, T2DM patients who are obese have a higher risk of all-cause mortality, cardiac, and non-cardiac death.^[4] The distribution of adipose tissue in the body significantly affects the detrimental effects of obesity.^[5] Compared to general obesity, central obesity correlates more closely to morbidity and mortality of T2DM patients.^[6,7] Excess visceral adipose has been associated

with vascular endothelial function, atherosclerosis, and cardiovascular disease.^[8–10] In addition, obesity and T2DM have been associated with increased levels of oxidative stress and low-grade chronic inflammation.^[11,12] Furthermore, obesity and oxidative stress contribute to the development of several malignancies.^[13]

Magnetic resonance imaging (MRI) and computed tomography (CT) have been demonstrated to be able to accurately quantify visceral adipose tissue. Recently, bioelectrical impedance analysis (BIA) has been developed to evaluate the accumulation of intra-abdominal fat.^[14] However, these methods require specialized medical equipment and are expensive to operate, which increases the financial burden on patients.

Hence, simple anthropometric indicators for evaluating visceral fat area (VFA) are needed. Waist circumference (WC) is a useful surrogate marker that has been commonly used for measuring abdominal visceral fat.^[15] In recent years, 2 new adiposity indexes, a body shape index (ABSI),^[16] and body roundness index (BRI)^[17] were proposed. Studies have demonstrated that ABSI and BRI are useful indexes for determining VFA.^[17,18] To our knowledge, no studies have been performed to use these adiposity indexes for determining VFA in T2DM patients. The aim of our study was to evaluate the performance of these 2 novel adiposity indicators for determining the accumulation of visceral fat in T2DM patients.

2. Methods

2.1. Subjects

After obtaining informed consent from T2DM patients, we performed our cross-sectional study. All T2DM patients were above 18 years of age.^[19] Exclusion criteria were as follows:

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- 1) patients with type 1 diabetes,
- 2) patients with clinical evidence of other endocrinopathies,
- 3) female patients who were pregnant.

This study was approved by the ethics committee of the First Hospital of Qinhuangdao (No. 2015C061).

2.2. Clinical measurements

Anthropometric measurements, including height, weight, and WC were acquired. WC was accurately measured at the midpoint between the lowest rib and the top of the iliac crest. Body mass index (BMI) and waist-to-height ratio (WHtR) were then calculated. ABSI was calculated based on the following formula: $WC/(BMI^{2/3} \times height^{1/2})$.^[18] BRI was calculated using an automated calculator (<http://www.pbrc.edu/bodyroundness>).^[17]

2.3. Accumulation of visceral fat

In this study, VFA was determined using the InBody S10 (Biospace Co, Ltd, Seoul, Korea). The measurements were performed with study subjects in the sitting position. Measurements were obtained using the 4-electrode 8-point touch electrode method. The areas where the 8 electrodes were attached (one each on the thumb and middle fingers on both hands, and one each on both ankles) were cleaned with electrolyte tissue and then the holder electrode was connected. Accumulation of visceral fat was defined as $VFA \geq 100 \text{ cm}^2$.^[20]

2.4. Statistical analyses

All analyses were performed using the SPSS 11.5 statistical software (SPSS 11.5 for Windows; SPSS, Inc., Chicago, IL). Using receiver operating characteristic (ROC) analysis, ROC curves for each obese indicator were drawn to demonstrate how well they were able to separate patients into groups with or without

accumulation of visceral fat. Sensitivity and specificity were then calculated to determine the optimal cut-off values. The optimal cut-off points were determined when the sensitivity and specificity were at their maximum on the ROC curves. Area under the curve (AUC) comparisons were performed using MedCalc 11.4.2.0 software (Ostend, Belgium). $P < .05$ was considered statistically significant.

3. Results

A cross-sectional study was performed on 233 type 2 diabetic patients from Qinhuangdao, China, and included 139 males and 94 females, mean age of 52.4 ± 11.9 years, with a history of diabetes of 6.8 ± 6.2 years. Age and history of diabetes were similar between patients who had $VFA < 100 \text{ cm}^2$ and $VFA \geq 100 \text{ cm}^2$ ($P > .05$). BMI, WC, WHtR, BRI, and ABSI were significantly higher in patients with $VFA \geq 100 \text{ cm}^2$ compared to patients with $VFA < 100 \text{ cm}^2$ ($P < .05$) (Table 1). VFA was positively correlated with BMI, WC, WHtR, BRI, and ABSI ($P < .001$) (Table 2).

For both diabetic males and females, the AUCs were similar between BRI and WC ($P > .05$). The optimal cut-off point for BRI was 4.25 for diabetic males (sensitivity = 87.8% and specificity = 81.1%) and 4.75 for diabetic females (sensitivity = 80.8% and specificity = 88.1%) (Table 3). However, the AUC for ABSI was lower compared to AUCs for WC and BRI ($P < .05$). The optimal cut-off point for ABSI was 0.0795 for diabetic males (sensitivity = 85.7% and specificity = 66.7%) and 0.0833 for diabetic females (sensitivity = 59.6% and specificity = 73.8%) (Table 3).

4. Discussion

Visceral fat accumulation is frequently observed in T2DM patients. BRI appears to be a good index to determine visceral fat accumulation. In this study, it was observed that BRI and WC

Table 1
Basic characteristics of the study population.

Variables	All (n=233)		Males (n=139)		Females (n=94)	
	VFA < 100 cm ²	VFA ≥ 100 cm ²	VFA < 100 cm ²	VFA ≥ 100 cm ²	VFA < 100 cm ²	VFA ≥ 100 cm ²
Age (yr)	52.9 ± 10.9	51.7 ± 13.1	51.1 ± 11.4	46.8 ± 14.1	56.7 ± 8.8	56.3 ± 10.2
History of diabetes (yr)	6.7 ± 6.2	6.8 ± 6.2	6.5 ± 6.3	4.9 ± 5.0	7.2 ± 6.0	8.6 ± 6.7
BMI (kg/m ²)	24.9 ± 2.5	28.9 ± 3.2*	25.5 ± 2.4	29.4 ± 2.9*	23.5 ± 2.2	28.4 ± 3.4*
WC (cm)	87.3 ± 7.4	100.6 ± 8.7*	88.6 ± 7.1	102.4 ± 7.6*	84.5 ± 7.4	98.9 ± 9.4*
WHtR	0.51 ± 0.04	0.60 ± 0.05*	0.51 ± 0.03	0.59 ± 0.04*	0.52 ± 0.04	0.62 ± 0.05*
BRI	3.68 ± 0.79	5.61 ± 1.21*	3.59 ± 0.75	5.31 ± 0.96*	3.86 ± 0.85	5.90 ± 1.35*
ABSI	0.079 ± 0.005	0.083 ± 0.005*	0.077 ± 0.004	0.082 ± 0.004*	0.081 ± 0.004	0.084 ± 0.005*

ABSI = a body shape index, BMI = body mass index, BRI = body roundness index, VFA = visceral fat area, WC = waist circumference, WHtR = waist to height ratio.

* Compared to VFA < 100 cm², $P < .05$.

Table 2
Simple correlations between anthropometric indicators and VFA in type 2 diabetic patients.

Variables	All (n=233)		Males (n=139)		Females (n=94)	
	r	P	r	P	r	P
BMI	0.730	<.001	0.730	<.001	0.829	<.001
WC	0.787	<.001	0.838	<.001	0.805	<.001
WHtR	0.843	<.001	0.846	<.001	0.819	<.001
BRI	0.836	<.001	0.842	<.001	0.813	<.001
ABSI	0.439	<.001	0.477	<.001	0.285	<.001

ABSI = a body shape index, BMI = body mass index, BRI = body roundness index, VFA = visceral fat area, WC = waist circumference, WHtR = waist to height ratio.

Table 3

The cut-offs values, sensitivities, specificities, Youden's index, and area under curve of anthropometric indicators for determining visceral fat accumulation.

Variables	Cut-off	Sensitivity	Specificity	Youden's index	AUC (95%CI)	P	P*	P†
Males								
WC	94.5	87.8	75.6	0.634	0.904 (0.851–0.957)	<.001		
BRI	4.25	87.8	81.1	0.689	0.923 (0.873–0.973)	<.001	.612	
ABSI	0.0795	85.7	66.7	0.524	0.788 (0.710–0.865)	<.001	.016	.004
Females								
WC	89.5	90.4	73.8	0.642	0.894 (0.831–0.958)	<.001		
BRI	4.75	80.8	88.1	0.689	0.915 (0.859–0.970)	<.001	.621	
ABSI	0.0833	59.6	73.8	0.334	0.668 (0.558–0.779)	<.001	<.001	<.001

ABSI=a body shape index, AUC=area under curve, BRI=body roundness index, CI=confidence interval, WC=waist circumference.

* Compared with WC.

† Compared with BRI.

were similar in performance. However, the performance of ABSI was poor compared to both WC and BRI. In this study, we determined the optimal cut-off points for BRI and ABSI to measure visceral fat accumulation in T2DM patients.

BRI was proposed by Thomas et al in 2013.^[17] It is an index that is estimated based on height, weight, WC, and hip circumference (optional). A web-based calculator was used in this study to streamline BRI calculations. The calculator was based on a geometrical model to quantify individual body shapes in a height-independent manner relative to a healthy body. Yang et al found that BRI could predict the incidence of T2DM risk in elderly Chinese.^[21] In addition, BRI could determine the presence of insulin resistance in obese and overweight individuals and adults without diabetes.^[22,23] Our previous study found that BRI was an effective indicator for determining metabolic syndrome in T2DM patients.^[24] In this study, BRI is closely associated with VFA and the AUC exceeded 0.9. However, BRI was not better compared to WC.

ABSI is calculated using a more complicated formula based on height, BMI and WC.^[16] The accuracy of the adiposity indicators for assessing VFA was evaluated using AUCs. The AUCs for ABSI was about 0.7 and were statistically lower compared to WC and BRI. The performance of ABSI was determined to be not satisfactory in this study, which is consistent with the results of previous studies. Compared to WC and BRI, the power of ABSI was poor for determining insulin resistance, metabolic syndrome and T2DM.^[21,25,26]

There were some limitations to our study. First, although hip circumference is not a mandatory variable to determine BRI, a combination of hip circumference and WC enhances the performance of BRI.^[17] Unfortunately, data on hip circumferences were lacking in our clinical database. Second, our work was based on a small patient cohort derived from a single center. Our results should be validated using larger patient cohorts in a multi-center setting.

In summary, BRI was a better indicator compared to ABSI for determining visceral fat accumulation in T2DM patients, however, both were inferior compared to measuring WC.

Author contributions

Fuzai Yin conceptualized and designed the study.

Junru Liu analyzed the data and drafted the initial manuscript.

Dongmei Fan and Xing Wang revised it critically for important intellectual content.

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