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Original Article

Body adiposity index as a risk factor for the metabolic syndrome in postmenopausal Caucasian, African American, and Filipina women

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ABSTRACT

Aims: To investigate the utility of the body adiposity index (BAI) and its association with the metabolic syndrome (MetS) in older Caucasian ($n = 369$), African American ($n = 336$) and Filipina ($n = 275$) women.
Methods: Dual energy X-ray absorptiometry, anthropometric measures, plasma glucose and medical history were assessed in 1993–1999.
Results: Despite smaller body size, 32.7% of Filipina women had higher MetS compared to African American and Caucasian women based on the National Cholesterol Education Program (NCEP) (32.7% vs 19.6% and 13.3%, respectively) or the International Diabetes Federation (IDF) (42.6% vs 33.0% and 18.7%, respectively $ps < 0.05$). BAI had higher positive correlations with BMI, %body fat (%BF), and %truncal fat in Caucasian than African American and Filipina women. Adjusted for age, smoking, estrogen use, exercise, and alcohol intake, odds of the MetS (NCEP) were 2.08 (95%CI: 1.52–2.85) by BAI, 3.04 (95%CI: 2.11–4.38) by BMI, and 2.13 (95%CI: 1.52–3.00) by %BF for Caucasian women; 0.92 (95%CI: 0.69–1.23) by BAI, 1.44 (95%CI: 1.09–1.90) by BMI, and 1.12 (95%CI: 0.84–1.50) by %BF for African American women; and 1.14 (95%CI: 0.88–1.47) by BAI, 1.51 (95%CI: 1.15–1.97) by BMI, and 0.96 (95%CI: 0.74–1.25) by %BF for Filipinas.
Conclusion: BAI was better able to assess adiposity in postmenopausal Caucasian women compared to African American and Filipina women. This index can distinguish ethnic differences in MetS confirmed by %BF.

1. Introduction

Obesity or accumulated adiposity is an important etiological factor in the clustering of clinical conditions that comprise the metabolic syndrome (MetS) [1]. These conditions include central obesity, hypertension, hyperglycemia, and dyslipidemia [2,3]. Having the MetS in turn, predisposes individuals for more serious chronic clinical outcomes, such as cardiovascular disease (CVD), type 2 diabetes, and possibly some cancers [2,4].

Although, high precision imaging techniques, including computed tomography (CT) or dual-energy X-ray absorptiometry (DXA) imaging, are considered to be the gold standard for measuring fat distribution, their clinical value is often undermined by the cost and time burden associated with CT or DXA. Therefore, other markers including weight, waist circumference, skinfold patterns, BMI and waist–hip ratio are used as convenient and economical clinical proxies to evaluate adiposity [5,6]. While anthropometric thresholds provide a general assessment of risk, they may not provide a valid basis for comparisons between ethnic groups, and ethnic specific thresholds must be considered [7–9].

Previous reports have shown the importance of considering ethnic differences in fat distribution when assessing adiposity using BMI [10,11]. Persons from different ethnic groups with similar BMIs can be at dissimilar risks for poor health outcomes attributable to increased adiposity. For example, several studies suggest that despite similar BMI, Indians, Asians, and Filipina women living in the US have higher visceral adipose tissue compared to Caucasians. while African American women have less visceral adipose tissue despite significantly larger BMI [12,13]. Also, variations of body fat do not correlate with BMI variations in Mexican American, non-Hispanic White, and non-Hispanic Black adolescents [14].

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A recent analysis by Bergman and colleagues, reported that the body adiposity index (BAI) based on hip circumference and height, was highly correlated with DXA measures of body fat in relatively young African American and Mexican American men and women (average age 35 years) [15]. The applicability of this index has been studied in various populations such as middle-aged and elderly Caucasian adults, post-menopausal Caucasian women, multi-ethnic cohorts predominantly Caucasian or African American, and Chinese adults, however the conclusions drawn have been inconsistent [16–21]. However, there have been no studies comparing BAI and its association with the MetS in older women of Caucasian, African American, and Filipino ethnicities.

The purpose of this study is to examine the association of BAI with other adiposity markers in Caucasian, African American, and Filipina women aged 50–70 years and to investigate the utility of BAI as a risk factor for the MetS in community dwelling women of these ethnicities.

2. Methods

2.1. Study population

Caucasian women in this study were members of the Rancho Bernardo Cohort who were initially enrolled in a community-based longitudinal study between 1972 and 1974 [22]. In 1997–1999, all surviving members of the original cohort were invited to participate in a research clinic visit focused on diabetes and its risk factors; approximately 70% of the locally residing, non-institutionalized cohort attended this visit. African American and Filipina women were enrolled as ethnic comparison groups to the Rancho Bernardo Study, using the same research protocol. African American women were participants in the Health Assessment Study of African American Women, a longitudinal study, and had been recruited between 1993 and 1997 [23]. Filipina women were recruited between 1995 and 1999 for the longitudinal UCSD Filipino Women's Health Study [24]. All women were residents of San Diego, California. Efforts were made to recruit African American and Filipina women of a socio-economic status similar to the Caucasian women of the Rancho Bernardo Study.

Only women aged 50–70 years at the time of their visit ($n = 1043$) were considered for this analysis in order to obtain three ethnic cohorts of comparable age. After excluding those missing weight, height, hip, waist, and any DXA measures ($n = 64$), the final study sample consisted of 369 Caucasian, 336 African American, and 275 Filipina women. The University of California, San Diego Human Research Protection Program approved this study; all participants gave written informed consent prior to participation.

2.2. Clinical measures

Self-administered standardized questionnaires were used to assess demographic characteristics and lifestyle (physical activity, cigarette smoking, and alcohol use). Physical activity was assessed by asking participants if they engaged in exercise or labor for 30 min at least three times per week. Cigarette smoking history (current/past/never) and alcohol use (consumption of 3 or more drinks per week) were also assessed in each cohort. Previous physician diagnoses of diseases were obtained by a nurse during a structured interview. Use of prescription and over-the-counter medications during the prior month was validated by a nurse using containers and pills brought to the clinic for that purpose.

Height and weight were measured using a stadiometer and a balance beam scale respectively, and used to calculate body mass index (BMI; weight in kg divided by height in meters squared). Waist girth was measured at the minimum point between the last rib and the iliac crest with a tape measure. If the minimum waist circumference was at the iliac crest because of excessive central obesity, waist girth was measured at the umbilicus. Hip circumference was measured at the largest point of the greater trochanter area.

A nurse specially trained in the Hypertension Detection Follow-up Protocol (HDFP) measured blood pressure twice using a mercury sphygmanometer after the participant had been seated quietly for 5 min [25]. Blood was obtained via venipuncture after a requested minimum 8–12 h fast. A 75 g oral glucose tolerance test was administered and venous blood collected 2 h post challenge. Fasting and post-challenge plasma glucose were measured using a glucose oxidase assay. Total cholesterol and triglycerides were measured with a biochromatic analyzer (ABA-200, Abbott Laboratories, Irving, TX. High-density-lipoprotein (HDL) and low-density-lipoprotein (LDL) were obtained according to the standard blood/lipid panel in a clinical research laboratory.

Percent total body fat content, right and left leg percent fat, and truncal percent fat were measured using dual-energy X-ray absorptiometry (model QDR-2000 X-ray bone densitometer, Hologic Inc., Waltham, MA). Daily calibration was performed using a standard phantom provided by the manufacturer. Precision errors for the DXA measures used here were approximately 1.2% or less.

2.3. Statistical analysis

BAI was calculated using formula developed by Bergman et al. where $\text{BAI} = (\text{hip circumference}/\text{height}^{1.5}) - 18$ [15]. High blood pressure was defined as systolic blood pressure $\geq$130 mmHg, diastolic blood pressure $\geq$85 mmHg, or use of antihypertensive medication.

The MetS was defined using the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III) and International Diabetes Federation (IDF) definitions [3]. According to the NCEP-ATP III definition, participants were classified as having the MetS if they had any three of the following conditions: Waist circumference >88 cm, triglycerides $\geq$150 mg/dl, HDL cholesterol level <50 mg/dl, fasting plasma glucose $\geq$110 mg/dl, blood pressure >135/85 mmHg or physician diagnosed hypertension. Based on the IDF definition, participants were classified as having the MetS, if they had a waist circumference $\geq$80 cm and 2 of any of the following conditions: triglycerides $\geq$150 mg/dl, HDL cholesterol level <50 mg/dl, fasting plasma glucose $\geq$100 mg/dl, blood pressure >135/85 mmHg or physician diagnosed hypertension. Based on 1999 WHO criteria, Type 2 diabetes was defined as fasting plasma glucose $\geq$126 mg/dl or 2-h post challenge glucose level $\geq$200 mg or a verified history of physician diagnosed type-2 diabetes, or reported use of insulin or oral hypoglycemic medication in the past 2 weeks.

Age-adjusted means and multiple comparisons across ethnic groups using the Caucasian women as the reference group were computed using general linear models with Tukey's test for continuous variables, χ^2 tests were performed for categorical variables. Variables not normally distributed (total cholesterol, LDL, HDL, and triglycerides) were log-transformed for analysis. Pearson correlations were computed as well as Fisher's z transformation on these coefficients for comparisons across cohorts. Multivariable logistic regression models were used to assess the association between BAI, BMI, and %BF separately with the odds of having the MetS after adjusting for age, current cigarette smoking, current estrogen use, alcohol use, and physical activity. Amount of increase for each risk factor was standardized across cohorts by using a one standard deviation specific to each cohort as the measure of unit increase. All data analyses were performed using SAS version 9.2 (SAS Inc., Cary, NC); all tests were two-tailed with statistical significance defined as $p < 0.05$.