Race/ethnic comparisons of waist-to-height ratio for cardiometabolic screening: The study of women's health across the nation

Rasa Kazlauskaite[1,2], Elizabeth F. Avery-Mamer[1], Hong Li[1], Chandra P. Chataut[2,3], Imke Janssen[1], Lynda H. Powell[1], and Howard M. Kravitz[1,4]

[1]Department of Preventive Medicine, Rush University Medical Center, Chicago, IL

[2]Department of Medicine, Rush University Medical Center, Chicago, IL

[3]Department of Medicine, John H. Stroger Hospital of Cook County, Chicago, IL

[4]Department of Psychiatry, Rush University Medical Center, Chicago, IL

Abstract

Objective—To compare the performance of waist-to-height ratio as a screening tool for cardiometabolic conditions – hypertension, prediabetes/diabetes, dyslipidemia, and subclinical inflammation – in 5 race/ethnic groups of mid-life women.

Methods—Waist-to-height ratio and 4 cardiometabolic conditions were assessed in 3033 premenopausal midlife women (249 Hispanic, 226 Chinese, 262 Japanese, 1435 European-American, and 861 African American). The areas under the receiver operating characteristic curve (AUROC) were compared across the five race/ethnic groups using waist-to-height ratio to determine the likelihood of the four cardiometabolic conditions.

Results—The performance of waist-to-height ratio to detect one or more cardiometabolic conditions was comparable among all race/ethnic groups (AUROC > 0.60, $p = 0.252$), and was good/fair (AUROC > 0.60) when hypertension, prediabetes/diabetes, dyslipidemia, or subclinical inflammation were analyzed separately. The performance of waist-to-height ratio of 0.50 was skewed towards higher specificity among groups with low prevalence of cardiometabolic conditions and lower median waist-to-height ratio, and towards higher sensitivity among groups with high prevalence of cardiometabolic conditions and higher median waist-to-height ratio.

Conclusions—Waist-to-height ratio can be used for community-based screening of mid-life women who may need secondary prevention for cardiometabolic conditions. A simple public health message: "Keep your waist to less than half of your height" applies to midlife women.

Keywords

waist circumference; metabolic syndrome; anthropometry; minority groups; middle-aged

1 INTRODUCTION

Indices of abdominal obesity, especially waist-to-height ratio (WHtR), appear to be superior to body mass index (BMI) to screen individuals for cardiometabolic conditions (hypertension, dyslipidemia, prediabetes/diabetes, and subclinical inflammation), cardiovascular disease, and years of life lost (Ashwell, Gunn, & Gibson, 2012; Ashwell, Mayhew, Richardson, & Rickayzen, 2014; Kodama et al., 2012). Moreover, WHtR has been advocated as a practical screening tool for cardiometabolic complications irrespective of age and sex (Ashwell et al., 2014). A universal boundary value aiming at WHtR < 0.5 has been proposed to simplify public health messages for prevention of obesity-related morbidity (Browning, Hsieh, & Ashwell, 2010).

Although the studies supporting WHtR use have included ethnically diverse populations globally, most data are available from cohorts of Asian-Pacific, African, and European descent (Evans et al., 2011). More research is needed to explore the associations of WHtR with the range of cardiometabolic conditions in American women of diverse race/ethnic backgrounds (Harris, Stevens, Thomas, Schreiner, & Folsom, 2000; Kotchen et al., 2008).

Our objective was to compare the WHtR as a screening tool for hypertension, dyslipidemia, prediabetes/diabetes, subclinical inflammation among Hispanic, Chinese, Japanese, European-American, and African American mid-life women. Our secondary objective was to explore the performance of a screening-relevant WHtR > 0.5 boundary value to screen for cardiometabolic outcomes across these 5 race/ethnic groups.

2 METHODS

Participants were enrolled in Study of Woman's Health Across the Nation (SWAN), a longitudinal, multiethnic/racial, seven-site cohort study of the health determinants across the menopausal transition. SWAN's recruitment methods, eligibility criteria, and design have been published (Matthews et al., 2005; Sowers et al., 2000). Briefly, women were 42–52 years old, non-pregnant, not-lactating; reported a menstrual period and no use of hormone therapy during the 3 months preceding enrollment, and self-identified as one of the five race/ethnic groups: African American (from Boston, Chicago, Pittsburgh, and the Detroit area), Chinese (from Oakland, CA), Hispanic (from Newark, NJ), Japanese (from Los Angeles, CA), and European-American (all sites). Each site recruited community-based cohorts of European-American women and women from one pre-specified minority group. This report includes study baseline data (1996–1997) from 3033 participants (92%) with a complete set of variables to define WHtR and cardiometabolic conditions (hypertension, dyslipidemia, prediabetes/diabetes, and subclinical inflammation).

A standardized SWAN protocol was used to measure anthropometric indicators (waist circumference and height), medication use, diabetes history, and cardiometabolic risk

indicators (blood pressure, fasting serum glucose and lipids), as previously described (Matthews et al., 2005; Sowers et al., 2000). Specifically, waist circumference was measured to the nearest 0.1 cm with a measuring tape placed horizontally around the narrowest part of the torso over undergarments or light clothing at the end of a normal exhalation. WHtR was calculated as waist circumference (cm)/height(cm). Three blood pressure measurements were taken with the participant seated after a minimum of 5 min of rest, and the last 2 values were averaged. The technicians were certified for their performance and compliance with the standard SWAN protocol before collecting physical measures. The venous blood samples collected after an 8-hour fast were used for analysis of fasting glucose, triglycerides, high-density lipoprotein cholesterol (HDL), and high-sensitivity C-reactive protein (hsCRP). If the participant admitted eating within 8 hours of blood collection, the non-fasting state was indicated (<5% of samples across all race/ethnic groups). Medical history and prescription medication use was assessed using standard SWAN questionnaires.

Using the data collected in the SWAN study at baseline, **high cardiometabolic risk** was defined as having at least one of the FOUR cardiometabolic conditions:

1. ***Prediabetes/diabetes***, defined as a fasting blood glucose 5.56 mmol/L (or non-fasting of 7.78 mmol/L), self-reported diagnosis of diabetes, or use of glucose-lowering medications (American Diabetes Association, 2015).

2. ***Hypertension***, defined as a blood pressure 140/90 mm Hg, or use of prescription antihypertensive medications (Go et al., 2014).

3. ***Dyslipidemia***, defined as fasting triglyceride level 1.70 mmol/L (or non-fasting 2.26 mmol/L), HDL-cholesterol < 1.29 mmol/L, or use of prescription lipid-lowering medications (Stone et al., 2014).

4. ***Subclinical inflammation***, defined as high-sensitivity C-reactive protein (hsCRP) level 2 mg/L (Blaha et al., 2011).

Three methods were used to compare the performance of the WHtR as a screening marker for cardiometabolic conditions among race/ethnic groups. First, the Area Under the Receiver Operating Characteristic Curves (AUROC) was calculated with WHtR as a classification variable and each of the cardiometabolic conditions as a reference variable. AUROCs for each race/ethnicity were compared using the method of DeLong (DeLong, DeLong, & Clarke-Pearson, 1988). The discriminative performance was considered good if AUROC was >0.70, fair if AUROC was 0.60–0.70, and poor if AUROC was <0.60 (Xia, Wilson, & Wishart, 2013). Second, we calculated the optimal WHtR boundary values for each cardiometabolic condition in each race/ethnic group using the maximum of the Youden index (*J*) based on the observed data (Bantis, Nakas, & Reiser, 2014). Third, the summary ROC curve were derived using the STATA ***midas*** module (Dwamena, Sylvester, & Calrlos, 2010) for WHtR = 0.50 in each condition and within each race/ethnic group. All analyses were performed using STATA®, version 14.1 (StataCorp, College Station, TX).

3 RESULTS

By design, almost half of the cohort was non-Hispanic European-American, a quarter was African American, whereas Hispanic, Chinese, and Japanese women represented 8.2, 7.5, and 8.6%, respectively (Supporting Information Table S1). Age at baseline was 45.9±2.7 years, similar across race/ethnic groups. Of note, African American and European-American women were >6 cm taller on average than Hispanic, Chinese, and Japanese women. More than 57% of African American and Hispanic women had WHtR >0.5, compared to less than one fifth of Chinese and Japanese women (Figure 1). The prevalence of high cardiometabolic risk (1 cardiometabolic condition) ranged 50–85% across race/ethnicities, with lowest prevalence in Chinese and Japanese women (Supporting Information Table S2).

The association of WHtR with cardiometabolic conditions was good/fair in all 5 race/ethnic groups (Table 1). Although the discriminative performance was significantly different among race/ethnic groups in models for individual cardiometabolic conditions (except for hypertension model), the performance of WHtR was similar in high cardiometabolic risk (1 condition) models. This suggests a good/fair performance of WHtR as a screening marker for cardiometabolic health in women of all 5 races/ethnicities.

The determination of optimal WHtR boundary value using the maximum of the Youden index (J) suggests heterogeneity across race/ethnic groups (Figure 1). The heterogeneity of the optimal WHtR boundary values to predict each cardiometabolic condition was lower within the race/ethnicity, perhaps due to overlap of cardiometabolic conditions within the groups.

The previously proposed "WHtR global boundary value of 0.50" (Browning, Hsieh, & Ashwell, 2010) was tested across the 4 individual cardiometabolic conditions in 5 race/ethnic groups (condition × group data points $n = 20$) by constructing a summary ROC curve (Figure 2). Significant heterogeneity (χ^2 likelihood ratio test $Q = 582.7$, dF = 2.0, $p < 0.001$) was observed among the 20 data points (Dwamena et al., 2010). The performance of WHtR global boundary value of 0.50 was skewed towards higher specificity in Chinese and Japanese women (with lower prevalence of cardiometabolic conditions and lower median WHtR); skewed towards higher sensitivity in African American and Hispanic women (with high prevalence of cardiometabolic conditions and high median WHtR); and clustered around the summary operating point (with sensitivity of 0.75, 95% CI 0.69–0.79, and specificity of 0.59, 95% CI 0.49–0.68) in European–American women. The performance characteristics of WHtR were similar within each racial/ethnic group, perhaps due to overlap of cardiometabolic conditions. Yet, the analysis indicates residual variability in adiposity thresholds among race/ethnic groups, possibly related to the spectrum of WHtR distribution (Figure 1) and prevalence of cardiometabolic conditions (Supporting Information Table S2), both higher in African American and Hispanic women and lower in Chinese and Japanese women.

4 DISCUSSION

This is the first study directly comparing the performance of WHtR as a screening marker for cardiometabolic conditions among mid-life women from 5 race/ethnic backgrounds residing in the United States. The overall discriminative performance of WHtR was good to fair across all five race/ethnic groups to screen for hypertension, dyslipidemia, pre-diabetes/ diabetes, or subclinical inflammation. In general, our study supports the previously advocated public health message "Keep your waist less than half of your height" for adiposity-related primary prevention of non-communicable diseases (Ashwell et al., 2012; Ware et al., 2014). However, the "global WHtR boundary value of 0.50" (Browning et al., 2010) has higher specificity in Chinese and Japanese women, and higher sensitivity in African American and Hispanic women. It is worth noting that our primary objective is to evaluate the WHtR as a screening test in the community-based settings to identify whether one may need further diagnostic testing for cardiometabolic conditions in a health care setting. WHtR does not replace the standard testing to diagnose individual cardiometabolic conditions. Abdominal obesity (with high WHtR) is one of the several related conditions contributing to cardiometabolic risk, and the other conditions (such as hypertension, dyslipidemia, prediabetes, and subclinical inflammation) require more specific diagnostic testing.

Adjustment for height intends to normalize WHtR for body build, related to race/ethnicity (Katzmarzyk et al., 2011). However, residual race/ethnic variation in WHtR boundary values persists after adjustment for height, and correlates with race/ethnicity-specific prevalence of cardiometabolic outcomes (Supporting Information Table S2) and the spectrum of WHtR (Figure 1), suggesting the influence of adipose tissue distribution, plasticity, expandability or other biological processes in the common pathogenesis of cardiometabolic conditions (Wells, 2012).

The principal strength of our study is the large and diverse sample of mid-life women which allows a 5-race/ethnic comparison of WHtR in screening for 4 common cardiometabolic conditions. For the purpose of race/ethnic comparisons in our analyses, the age homogeneity in our cohort offered an advantage, as cardiometabolic conditions are also related to aging.

The principal limitation of our study was the inability to assess the longitudinal relationship of WHtR with incident mortality and cardiovascular outcomes in this racially/ethnically diverse cohort. However, hypertension, dyslipidemia, prediabetes/diabetes, and subclinical inflammation are known to predict global cardiovascular risk regardless of race/ethnicity. The narrow age range and only women participants limit the generalizability of our findings to the other age groups and to men.

Midlife is a vulnerable period in women's life for progression of abdominal adiposity and related cardiometabolic conditions. A simple public health message: "Keep your waist to less than half of your height" applies to midlife women.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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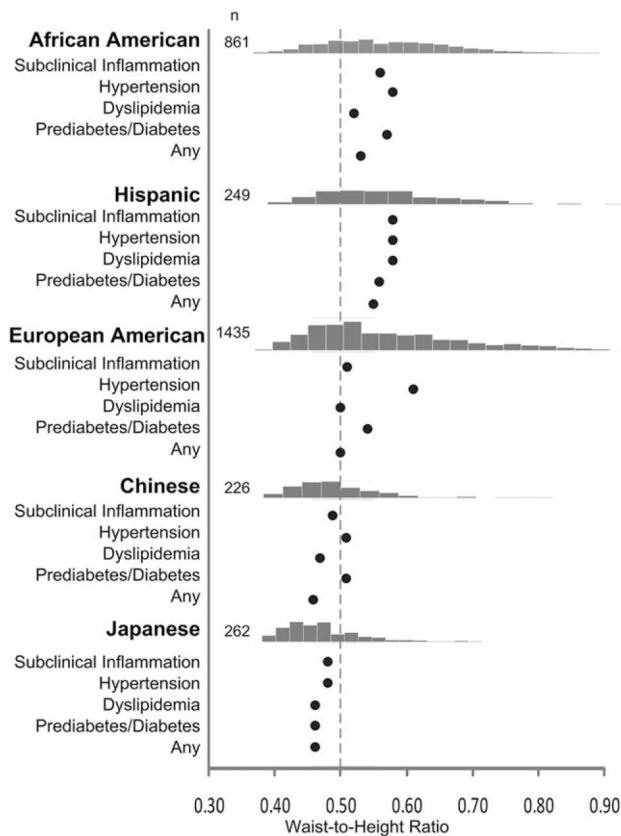
FIGURE 1.

The estimated boundary values (the maximum of Youden index) for waist-to-height ratio in each race/ethnic group to screen for subclinical inflammation, hypertension, dyslipidemia, prediabetes/diabetes, or any (1) of these cardiometabolic outcomes. The bar graphs present the frequencies of waist-to-height ratios in each race/ethnic group. The dashed line denotes the waist-to-height ratio boundary value of 0.50. Subclinical inflammation was defined as high-sensitivity C-reactive protein 2 mg/L (Blaha et al., 2011). Hypertension was defined as blood pressure 140/90 mm Hg, or use of prescription antihypertensive medications (Go et al., 2014). Dyslipidemia was defined as fasting triglyceride level 1.70 mmol/L (or non-fasting 2.26 mmol/L – less than 5% of samples were non-fasting), or HDL-cholesterol <1.29 mmol/L or use of any prescription lipid-lowering medications (Stone et al., 2014). Prediabetes/diabetes was defined as fasting blood glucose 5.56 mmol/L (or non-fasting 7.78 mmol/L), self-reported diagnosis of diabetes, or use of glucose-lowering medications (American Diabetes Association, 2015)
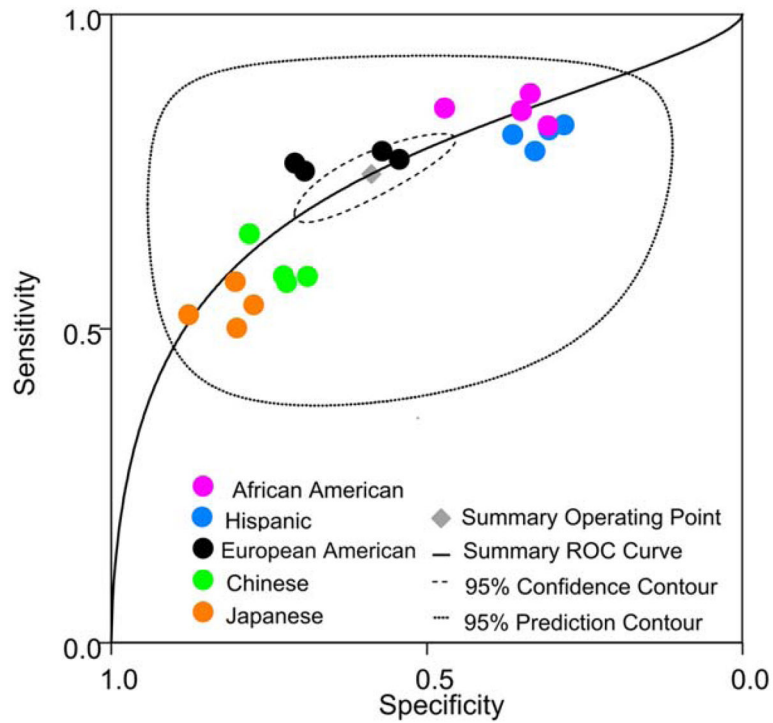
FIGURE 2.

The summary ROC curve for discriminative performance of WHtR boundary value of >0.50 (Browning et al., 2010) to screen for patients with high risk of cardiometabolic conditions. Each marker represents one of the 4 cardiometabolic outcomes: subclinical inflammation, hypertension, dyslipidemia, prediabetes/diabetes, whereas the marker colors indicate race/ethnic groups

TABLE 1

The discriminative performance of weight-to-height ratio to screen for cardiometabolic conditions

Cardiometabolic conditions	Area under the receiver operating characteristic curve (95% confidence interval)					
	African American	Hispanic	European American	Chinese	Japanese	p-value[e]
Subclinical inflammation[a]	0.78 (0.75–0.82)	0.68 (0.62–0.75)	0.80 (0.78–0.82)	0.74 (0.66–0.82)	0.78 (0.69–0.86)	0.020
Hypertension[b]	0.63 (0.59–0.67)	0.67 (0.58–0.77)	0.71 (0.67–0.75)	0.70 (0.58–0.82)	0.68 (0.57–0.80)	0.123
Dyslipidemia[c]	0.65 (0.61–0.68)	0.64 (0.57–0.71)	0.77 (0.75–0.80)	0.78 (0.72–0.84)	0.80 (0.75–0.87)	<0.001
Prediabetes/diabetes[d]	0.69 (0.65–0.72)	0.65 (0.58–0.73)	0.75 (0.71–0.78)	0.70 (0.62–0.79)	0.76 (0.69–0.83)	0.036
Overall high risk (≥1 condition)	0.80 (0.76–0.83)	0.73 (0.66–0.81)	0.81 (0.79–0.83)	0.68 (0.61–0.76)	0.73 (0.66–0.80)	0.252

[a] Subclinical inflammation was defined as high-sensitivity C-Reactive protein ≥2 mg/L (Blaha et al., 2011).

[b] Hypertension was defined as blood pressure ≥140/90 mm Hg, or use of prescription antihypertensive medications (Go et al., 2014).

[c] Dyslipidemia was defined as fasting triglyceride level ≥1.70 mmol/L (or non-fasting ≥2.26 mmol/L – less than 5% of samples were non-fasting), or HDL-cholesterol <1.29 mmol/L or use of any prescription lipid-lowering medications (Stone et al., 2014).

[d] Prediabetes/diabetes (abnormal glucose metabolism) was defined as fasting blood glucose ≥5.56 mmol/L (or non-fasting ≥7.78 mmol/L – less than 5% of samples were non-fasting), self-reported diagnosis of diabetes, or use of glucose-lowering medications (American Diabetes Association, 2015).

[e] Testing for an overall difference across ethnic groups (DeLong et al., 1988).