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Comparison of Measures of Adiposity and Cardiovascular Disease Risk Factors Among African American Adults: The Jackson Heart Study

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Abstract

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Obesity, particularly central adiposity, is a well-established risk factor for cardiovascular disease (CVD). Waist circumference (WC) is measured in numerous epidemiologic studies as a relatively simple indicator of central adiposity. However, recently, investigators have considered a measure that takes height into consideration Waist-to-Height Ratio (WHtR) as a more sensitive predictor of CVD. A limited number of studies have examined the association between various measures of central adiposity and obesity with CVD, but there is a dearth of information on this topic focused specifically on African American adults. Given the high rates of cardiovascular disease and metabolic risk factors in this population, it is important to develop validated, easy-to-measure indicators of CVD risk for clinical use. Data from 4,758 African American adults participating in the baseline visit of the Jackson Heart Study with available risk factor data were examined, with three measures of body habitus [body mass index (BMI), WC and WHtR] and five CVD risk factors (HDL- and LDL-cholesterol, triglycerides, diabetes and hypertension), the latter also categorized into multiple (2+) risk factors present. C-statistics for WC, BMI, and WHtR were computed and compared for each model to assess their discriminant abilities. WHtR was a stronger correlate of HDL cholesterol, triglycerides, diabetes, hypertension and multiple risk factors compared to BMI, and was a stronger corrleate of HDL-cholesterol when compared to WC. These data indicate that, for African American adults, WHtR may be more appropriate measure to identify those at elevated risk for CVD.

Keywords

Obesity; Cardiovascular Disease; Waist Circumference; African Americans

Introduction

Obesity is a well-established risk factor for cardiovascular diseases (CVD) [1]. Evidence suggests that centrally located body fat may be a more important contributor to CVD risk than measures that do not take central adiposity, such as BMI, into consideration [2–3]. Waist circumference (WC) and its corollary, waist-to-hip ratio (WHR) are used in epidemiologic studies as relatively simple to measure indicators of central adiposity and been shown to be more reflective of overall adiposity relative to other measures [4]. However, recently, investigators have considered a measure that takes height into consideration (Waist-to-Height Ratio, WHtR) as a more sensitive predictor of CVD [5 – 12]. A 2008 report from the World Health Organization (WHO) provided a summary of research to date on WC and WHtR as indicators of chronic disease risk. This report indicated the need to consider age, sex and race/ethnic differences in measures of central adiposity [13].

Among those studies that have examined the predictability of measures of central adiposity on CVD risk, specifically WHtR, few have focused specifically on African American adults. The WHO report [12] did not have reference to this population. Given the high rates of CVD and metabolic risk factors for CVD in this population [1], it is important to develop validated, easy-to-measure indicators of CVD risk for clinical use. This analysis used data from a large epidemiologic study of CVD in African Americans to compare the predictive ability of three measures of adiposity, BMI, WC and WHtR for assessing CVD risk. We used baseline data and compared the associations of these composition measures to traditional CVD risk factors and composites of these indicators by each of these body habitus measures using logistic regression and c-statistics. We hypothesized that WHtR will be more strongly related to CVD risk factors among African Americans relative to the other body habitus measures.

Methods

Overview

The Jackson Heart Study (JHS) has been described in detail elsewhere [14 – 15]. Briefly, the JHS is the largest longitudinal epidemiologic study of CVD in African Americans. The JHS enrolled 5,306 participants aged 21–84 years at the time of the baseline assessment (2000–2004) from the Jackson, Mississippi metropolitan area (Hinds, Madison, and Rankin counties). Participants were recruited from four different sources: 1) previous participants in the Atherosclerosis Risk in Communities (ARIC) study (30% of JHS cohort); 2) family members of JHS participants (28%); 3) random selection from the three counties (17%); and 4) community volunteers (25%). The goal of the JHS was to examine factors that influence the development of CVD in African American men and women to learn how to prevent this group of diseases in this population. JHS participants provided information on demographic, socioeconomic, and lifestyle variables, as well as medication use. Certified technicians and nurses conducted clinic interviews. Two subsequent in-person follow up visits have been completed since baseline (2005–2008 and 2009–2013). Data for this analysis come from the baseline visit, with the analysis limited to the 4,758 participants with data for all the variables considered.

Dependent Variables

Blood samples were collected using standard procedures and analyzed at a central laboratory (University of Minnesota) [16]. Fasting glucose and lipids were measured on a Vitros 950 or 250, Ortho-Clinical Diagnostics analyzer (Raritan, NJ) in accordance with the College of American Pathologists Proficiency Testing Program (Carpenter). Type 2 diabetes status was defined according to the 2010 American Diabetes Association guidelines: 1) physician diagnosis, 2) use of diabetes medication, 3) fasting glucose ≥ 126 mg/dl, or 4) A1C ≥ 6.5% [17]. Blood pressure was measured using the Omron HEM907XL automated BP monitor. Two resting systolic and diastolic blood pressures were measured at 5-minute intervals and the average was used for the current analysis.

CVD risk factors were considered as continuous variables and were categorized along clinically relevant thresholds. Triglycerides were dichotomized into a low group consisting of < 150 mg/dL and a high group. LDL-cholesterol was dichotomized into a low group consisting of < 160 mg/dL and a high group. HDL-cholesterol was dichotomized using sex specific values with a low group consisting of males with HDL-cholesterol ≤ 35 mg/dL or females with an HDL ≤ 45 mg/dL and a high group. Diabetes was defined as current use of insulin or oral antidiabetic agent, fasting glucose ≥ 126 mg/dL, or HbA1C ≥ 6.5%. Hypertension was defined as having a systolic blood pressure of ≥ 140 mmHg or a diastolic blood pressure ≥ 90 or a self-reported prescription of blood pressure medications. CVD risk factors were defined as having low HDL, high LDL, high triglycerides, having diabetes, and having hypertension. These risk factors were summed into a risk count score. Risk count score was dichotomized into < 2 risk factors and greater.

Independent Variables

Weight was measured to the nearest 0.1 kilogram and height to the nearest centimeter. Body mass index (BMI) was calculated as weight divided by the square of the height. WC was measured to the nearest centimeter as the average of two readings at the umbilicus with the patient upright. WC was dichotomized based on the National Cholesterol Education Program Adult Treatment Panel III cutoff points as ≤102 cm or >102 cm for men, and ≤88 cm or >88 cm for women. BMI was categorized into Underweight, Normal, Overweight, and Obese categories corresponding to BMI levels of < 18.5, 18.5 – 25, 25 – <30, ≥30 kg/m^2. Underweight and normal weight were combined in the analyses since the number of underweight participants was relatively small. As has been used in other studies [6], waist-to-height ratio (WHtR) was calculated as waist / height and was dichotomized into ≤ 0.5 and greater.

Statistical Analysis

General linear models were used to examine the association between demographic and health characteristics and each of the three body habitus measures (Table 2). Logistic regression analyses were performed to examine the correlation of WC, BMI, and WHtR with known CVD risk factors, including low HDL, high LDL, high triglycerides, diabetes status, and hypertension status. For each CVD risk factor, three separate logistic regression models were fit using WC, BMI, or WHtR as a predictor while adjusting for age and gender. C-statistics for WC, BMI, and WHtR were computed and compared based on *U*-statistics theory for each risk factor to assess their discriminant abilities [18]. Similar analyses were conducted for the dichotomized risk score. All analyses were performed on SAS v9.4 (SAS Inc., Cary, NC).

Results

Table 1 displays demographic and health characteristics of the study population at the baseline visit stratified by gender. The mean age of the sample was approximately 55 years, with the majority being in the 45 – 64 year age range. Approximately 15 – 20% had high triglycerides and high LDL-cholesterol. More women had low HDL-cholesterol compared to men (27.0% vs. 17.5%). Diabetes was slightly more prevalent among women compared to men (19.4% vs. 17.0%), as well as hypertension (61.6% vs. 57.3%). Men and women had on average one risk factor, and about 36% of men and 41% of women had at least two risk factors present.

With regard to body habitus measures, the mean WC and mean BMI for men and women was 101.3 and 100.4 cm, and 29.9 and 32.8 kg/m^2, respectively. Women were far more likely than men to have a higher WC (75.1% vs. 40.4%). Similarly, far more women than men were classified as obese (59.9% vs. 40.5%). The mean WHtR was similar for men and women (0.6), but slightly more women than men had a WHtR above the recommended cutoff point level (86.8% vs. 81.4%).

Table 2 shows the distribution of the selected demographic characteristics according to the categories of BMI, WC and WHtR. The proportion of female participants increased from low- to high-risk categories. For BMI, the overweight group has the highest mean age, and for the WC and WHtR, participants in the highest-risk categories were older. In general, across the health characteristics, the high-risk body habitus categories corresponded with higher CVD risk, and the proportion of participants with 2+ CVD risk factors was highest in the highest-risk body habitus categories for all measures.

Table 3 shows age- and sex-adjusted c-statistic differences between WHtR and BMI values, and between WHtR and WC values, for each of the five CVD risk factors individually, and for the dichotomous compilation of risk factors (<2, ≥ 2). For the comparison between WHtR and BMI, the c-statistic value was significantly higher ($p < 0.0001$) between triglycerides, diabetes, hypertension, and having ≥2 risk factors. For the comparison between WHtR and WC, the WHtR c-statistic was similar between the two measures for most risk factors, and was significantly greater only for HDL-cholesterol.

Discussion

CVD is a major public health issue, and African Americans are disproportionately impacted by this condition [1]. Obesity is a well-recognized risk factor for CVD [1]. Thus, tools are needed to adequately identify African Americans at increased risk for CVD in the clinical setting. Traditionally, BMI has been used as a surrogate for more invasive measures of body composition and obesity status, but concerns have been raised that this measure does not accurately take into consideration central adiposity, which in and of itself is a risk factor for CVD, leading for a call to validate measures such as WC and WHtR to be used to assess CVD risk [13].

In this analysis, we examined the associations of three measures of body habitus, BMI, WC and WHtR with traditional CVD risk factors in a large, well-characterized sample of African American adults. We found that WHtR was more strongly related to CVD risk than BMI, was similar to WC in terms of most CVD risk factors, and was more strongly related to HDL-cholesterol compared to both BMI and WC. Our findings are similar to those of other studies on this topic [5 – 12]. In their systematic review, Browning and colleagues found that the majority of studies in their review favored WHtR and WC as stronger predictors of cardiometabolic risk compared to BMI, with c-statistic values of 0.704, 0.693 and 0.671, respectively. The studies in their analysis included populations of Caucasian, Asian and Central American descent, and affirmed the 0.5 cutoff for WHtR as the optimal level of assessing CVD and diabetes risk [19]. It is also worth noting that in their cross-sectional analyses examining associations between CVD risk factors and obesity indices, similar to our design, most of the studies in this systematic review adjusted for BMI in the WC and WHtR logistic models.

There is some evidence that the relationship between measures of adiposity and CVD risk differs between whites and African Americans. Katzmarzyk and colleagues [20] found that BMI, body adiposity index, WC, WHtR and waist-to-hip ratio were also significantly and positively associated with all-cause mortality in whites, but WC was the only indicator that significantly predicted mortality in African Americans. However, a recent study by Kazlauskaite and colleagues showed that WHtR is similarly effective as a CVD risk screening tool for midlife Hispanic, Chinese, Japanese, White and African American women [21].

This study has a number of strengths that should be acknowledged. First, we analyzed data from a large, population-based study of African American adults, a population at significant risk for CVD. Second, this is, to our knowledge, the largest study of the relationship of measures of body habitus and CVD risk among African American adults. Second, this study included well- validated measures of traditional CVD risk factors. Finally, our sample size allowed us to assess these relationships across various demographic characteristics, as well as aggregate CVD risk factors to determine the association of body habitus with "clusters" of risk factors.

Despite these strengths, there are several limitations to this analysis. First, we assessed the body habitus/CVD risk factor relationship using cross-sectional data, so we are unable to assign causality to these observed relationships. We also did not examine the relationship between these measures of body habitus and CVD events. This study only included African Americans, so we are not able to make comparisons within this study to other racial/ethnic groups. Finally, the JHS only included an assessment of central adiposity with a measure of central adiposity by measuring the circumference at the point of the umbilicus.

In summary, this study provides evidence that measures of central adiposity, particularly WHtR, may be more appropriate for assessing CVD risk in African American adults. Given the simple public health message that your waist should be no more than half your height [19, 22], WHtR potentially provides an easy-to-use screening tool for the assessment of CVD risk in a clinical setting. Further research is needed to assess the longitudinal risk associated with measures of central adiposity in this population.

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Table 1

Selected Demographic and Health Characteristics of Study Participants By Sex

	Male (N = 1716)		Female (N = 3042)	
Characteristic	**Mean (SD)**	**N (%)**	**Mean (SD)**	**N (%)**
Age (Mean, SD)	54.3 (13.0)		55.5 (12.8)	
Age Group (Years, %)				
<45		449 (26.2)		713 (23.4)
45 –< 65		884 (51.5)		1577 (51.8)
≥65		383 (22.3)		752 (24.7)
Triglycerides, mg/dL (Mean, SD)	108.2 (59.5)		98.4 (51.3)	
Triglycerides, mg/dL (%)				
Low		1396 (81.4)		2623 (86.2)
High		320 (18.6)		419 (13.8)
Total Cholesterol, mg/dL (Mean, SD)	196.1 (39.3)		200.5 (39.7)	
LDL-Cholesterol, mg/dL (Mean, SD)	128.4 (36.9)		125.6 (36.4)	
LDL-Cholesterol, mg/dL (%)				
Low		1407 (82.0)		2527 (83.1)
High		309 (18.0)		515 (16.9)
HDL-Cholesterol, mg/dL (Mean, SD)	46.1 (12.7)		55.2 (14.6)	
HDL-Cholesterol, mg/dL (%)				
High		1415 (82.5)		2222 (73.0)
Low		301 (17.5)		820 (27.0)
Diabetes (%)				
No		1424 (83.0)		2453 (80.6)
Yes		292 (17.0)		589 (19.4)
Hypertension, mmHg (%)				
No		733 (42.7)		1168 (38.4)
Yes		983 (57.3)		1874 (61.6)
Total Risk Factors (Mean, SD)	1.3 (1.0)		1.4 (1.1)	
Risk Factor Categories (%)				
0–1		1093 (63.7)		1804 (59.3)
≥2		623 (36.3)		1238 (40.7)
Waist Circumference, cm (Mean, SD)	101.1 (15.0)		100.2 (16.7)	
High Waist Circumference (%)				
Low		1023 (59.6)		758 (24.9)
High		693 (40.4)		2284 (75.1)
BMI, kg/m^2 (Mean, SD)	29.8 (6.1)		32.8 (7.6)	
BMI Categories				
Underweight		13 (0.8)		11 (0.4)
Normal		301 (17.5)		367 (12.1)
Overweight		706 (41.1)		843 (27.7)
Obese		696 (40.6)		1821 (59.9)

Characteristic	Male (N = 1716) Mean (SD)	Male (N = 1716) N (%)	Female (N = 3042) Mean (SD)	Female (N = 3042) N (%)
Waist-Height Ratio (Mean, SD)	0.6 (0.1)		0.6 (0.1)	
Waist-Height Ratio (%)				
≤0.5		319 (18.6)		402 (13.2)
>0.5		1397 (81.4)		2640 (86.8)

Table 2

Comparison of Demographic and Health Characteristics by Body Habitus Characteristics

Characteristic	Under-weight/Normal	Over-weight	Obese	WC Low	WC High	WHtR Low	WHtR High
Sex (%)							
Female	378	843	1821	758	2284	402	2640
	(54.6%) *	(54.4%) *	(72.3%) *	(42.6%) *	(76.7%) *	(55.8%) *	(65.4%) *
Male	314	706	696	1023	693	319	1397
	(45.4%) *	(45.6%) *	(27.7%) *	(57.4%) *	(23.3%) *	(44.2%) *	(34.6%) *
Age (Mean, SD)	55.1	56.3	54.3	53.6	55.9	50.9	55.8
	(14.7) *	(12.8) *	(12.3) *	(13.4) *	(12.5) *	(13.7) *	(12.6) *
Age Group (Years, %)							
<45	192	341	629	517	645	261	901
	(27.7%) *	(22.0%) *	(25.0%) *	(29.0%) *	(21.7%) *	(36.2%) *	(22.3%) *
45 – < 65	304	796	1361	885	1576	343	2118
	(43.9%) *	(51.4%) *	(54.1%) *	(49.7%) *	(52.9%) *	(47.6%) *	(52.5%) *
≥65	196	412	527	379	756	117	1018
	(28.3%) *	(26.6%) *	(20.9%) *	(21.3%) *	(25.4%) *	(16.2%) *	(25.2%) *
Triglycerides, mg/dL (Mean, SD)	83.9	99.8	108.2	90.2	109.0	76.4	106.5
	(47.9) *	(54.1) *	(55.5) *	(50.9) *	(55.6) *	(41.0) *	(55.5) *
Triglycerides, mg/dL (%)							
Low	633	1319	2067	1599	2420	683	3336
	(91.5%) *	(85.2%) *	(82.1%) *	(89.8%) *	(81.3%) *	(94.7%) *	(82.6%) *
High	59	230	450	182	557	38	701
	(8.5%) *	(14.9%) *	(17.9%) *	(10.2%) *	(18.7%) *	(5.3%) *	(17.4%) *
Total Cholesterol, mg/dL (Mean, SD)	196.4	200.3	198.8	197.0	200.1	194.7	199.7
	(41.9)	(39.9)	(38.8)	(40.4) *	(39.1) *	(39.7) *	(39.6) *
LDL-Cholesterol, mg/dL (Mean, SD)	121.4	128.3	127.0	125.5	127.3	121.3	127.6
	(37.7) *	(36.9) *	(36.0) *	(37.2)	(36.3)	(36.0) *	(36.6) *
LDL-Cholesterol, mg/dL (%)							
Low	587	1259	2088	1487	2447	618	3316

Characteristic	Under-weight/Normal	Over-weight	Obese	WC Low	WC High	WHtR Low	WHtR High
	(84.8%)	(81.3%)	(83.0%)	(83.5%)	(82.2%)	(85.7%) *	(82.1%) *
High	105	290	429	294	530	103	721
	(15.2%)	(18.7%)	(17.0%)	(16.5%)	(17.8%)	(14.3%) *	(17.9%) *
HDL-Cholesterol, mg/dL (Mean, SD)	58.2	52.0	50.2	53.4	51.0	58.1	50.8
	(17.4) *	(14.2) *	(13.5) *	(15.5) *	(14.0) *	(16.6) *	(14.0) *
HDL-Cholesterol, mg/dL (%)							
High	602	1254	1781	1528	2109	648	2989
	(87.0%) *	(81.0%) *	(70.8%) *	(85.8%) *	(70.8%) *	(89.9%) *	(74.0%) *
Low	90	295	736	253	868	73	1048
	(13.0%) *	(19.0%) *	(29.2%) *	(14.2%) *	(29.2%) *	(10.1%) *	(26.0%) *
Diabetes (%)							
No	655	1319	1903	1630	2247	697	3180
	(94.7%) *	(85.2%) *	(75.6%) *	(91.5%) *	(75.5%) *	(96.7%) *	(78.8%) *
Yes	37	230	614	151	730	24	857
	(5.3%) *	(14.8%) *	(24.4%) *	(8.5%) *	(24.5%) *	(3.3%) *	(21.2%) *
Hypertension, mmHg (%)							
No	371	668	862	916	985	431	1470
	(53.5%) *	(43.2%) *	(34.2%) *	(51.4%) *	(33.1%) *	(59.8%) *	(36.4%) *
Yes	321	881	1655	865	1992	290	2567
	(46.4%) *	(56.9%) *	(65.8%) *	(48.6%) *	(66.9%) *	(40.2%) *	(63.6%) *
Total Risk Factors (Mean, SD)	0.9	1.2	1.5	1.0	1.6	0.7	1.5
	(0.9) *	(1.0) *	(1.1) *	(0.9) *	(1.1) *	(0.8) *	(1.1) *
Risk Factor Categories (%)							
0–1	544	1006	1347	1346	1551	602	2295
	(78.6%) *	(64.9%) *	(53.5%) *	(75.6%) *	(52.1%) *	(83.5%) *	(56.8%) *
2+	148	543	1170	435	1426	119	1742
	(21.4%) *	(35.1%) *	(46.5%) *	(24.4%) *	(47.9%) *	(16.5%) *	(43.2%) *

* Comparisons are within each category of the body composition measure; $P < 0.05$

Table 3

Comparison of Demographic and Health Characteristics by Continuous Body Habitus Measures (Mean, Standard Deviation)

Characteristics	BMI	WC	WHtR
Sex			
Female	32.8 (7.6) *	100.2 9 (16.7)	0.61 (0.10) *
Male	29.8 (6.1)	101.1 (15.0)	0.57 (0.08)
Age Group (Years)			
<45	32.4 (8.4) *	98.7 (18.1) *	0.58 (0.11) *
45 – 64	31.9 (7.1) *	101.0 (15.7)	0.60 (0.10) *
≥65	30.6 (6.3)	101.3 (14.8)	0.61 (0.09)
Triglycerides			
Low	31.67 (7.4)	99.7 (16.4)	0.59 (0.10)
High	32.5 (6.1)	104.7 (13.7)	0.62 (0.08)
LDL-Cholesterol			
Low	31.8 (7.4)	100.4 (16.5)	0.60 (0.10)
High	31.5 (6.3)	100.9 (14.4)	0.60 (0.09)
HDL-Cholesterol			
High	31.1 (7.0) *	99.1 (15.9) *	0.59 (0.10) *
Low	33.8 (7.6)	105.0 (15.9)	0.63 (0.10)
Diabetes			
No	31.1 (7.1) *	98.5 (15.6) *	0.58 (0.09) *
Yes	34.6 (7.3)	109.2 (15.4)	0.65 (0.10)
Hypertension			
No	30.5 (7.0) *	96.3 (15.6) *	0.57 (0.09) *
Yes	32.6 (7.3)	103.3 (15.9)	0.61 (0.10)
Risk Factor Categories			
0 – 1	30.7 (7.1) *	97.2 (15.7) *	0.58 (0.09) *
2+	33.3 (7.2)	105.6 (15.5)	0.63 (0.10)

Bottom row for each characteristic was used as the reference group

* P<0.05

Table 4

Age & Gender -Adjusted C-Statistic Comparisons Between Body Habitus Measures and CVD Risk Factors

	c-statistic Difference between WHtR and BMI (P-Value)	**c-statistic Difference Between WHtR and WC (P-Value)**	**BMI c-statistic**	**WC c-statistic**	**WHTR c-statistic**
HDL-Cholesterol	−0.0129	0.0050	0.6224	0.6403	0.6354
	(p=0.0002)	(p=0.0095)			
LDL- Cholesterol	0.0007	−0.0005	0.5411	0.5399	0.5403
	(p=0.7952)	(p=0.5423)			
Triglycerides	−0.0199	−0.0005	0.5969	0.6163	0.6168
	(p<.0001)	(p=0.8161)			
Diabetes	−0.0204	0.0012	0.7216	0.7432	0.7420
	(p<.0001)	(p=0.5442)			
Hypertension	−0.0047	−0.0005	0.7555	0.7597	0.7602
	(p=0.0120)	(p=0.5890)			
Multiple Risk Factors	−0.0181	0.0007	0.6778	0.6966	0.6959
	(p<.0001)	(p=0.6456)			