Body Mass Index and Waist Circumference Predictors of Cardiovascular Risk in African Americans

Objective: The purpose of our study was to determine which measure of obesity is better at predicting cardiovascular risk in African Americans. We hypothesized that BMI alone would be significantly associated with cardiovascular reactivity. We also hypothesized that waist circumference alone would be significantly associated with cardiovascular reactivity. Lastly, we hypothesized that BMI and waist circumference together would be more associated with cardiovascular reactivity and account for more of the variance than the two measures alone.

Design: BMI and waist circumference were measured in 105 African American college students (21 men and 84 women) aged 18–27. In addition, heart rate, cardiac output, stroke volume, and systolic and diastolic blood pressure were measured as the participants viewed a racially noxious scene on videotape.

Results: BMI and waist circumference analyzed separately were significantly associated with stroke volume, cardiac output, and systolic blood pressure. These positive associations showed that heavier participants had higher systolic blood pressure and their hearts pumped out greater blood volume compared to their thinner counterparts. Body mass index also completely mediated the relationship between waist circumference and cardiovascular activity.

Conclusions: The findings may be attributed to the premise that the waist circumference standards are different for African Americans than for Whites. Future research should establish waist circumference thresholds that are better predictors of cardiovascular disease in African Americans. (*Ethn Dis.* 2012;22(2): 162–167)

Key Words: Body Mass Index, Waist Circumference, Cardiovascular Risk, Stroke Volume, Cardiac Output, Blood Pressure

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Introduction

Obesity is a well documented risk factor for cardiovascular disease, yet there is no consensus on the best method of assessment.[1] Body mass index (BMI), a measure of body fat based on height and weight, is the traditional method of measuring obesity and has been associated with the onset of cardiovascular disease. However, a major weakness of BMI is that it does not distinguish between muscle and fat which leads to misclassification of certain people.[2,3] Researchers[4–6] found that BMI is useful in predicting cardiovascular disease in individuals with a BMI ≥35, who have more fatty tissue and less muscle, and are more vulnerable to cardiovascular disease. For example Clark et al[6] examined the effects of body mass on cardiovascular reactivity to stress in African American college students. They found that obese men had increased reactivity to the racial stressor.

Another well documented method of assessing obesity is the measurement of abdominal fat. Waist circumference is considered a risk factor for cardiovascular disease because the abdomen tends to have more visceral fat than subcutaneous fat.[7] Visceral fat in the abdomen produces the hormone adiponectin which leads to a reduction in the body's response to insulin resulting in insulin resistance.[7] Brenner et al[8] investigated whether waist circumference or BMI is a better predictor of blood lipid concentrations. Waist circumference was significantly related to triglycerides, total cholesterol and high density lipoproteins after adjusting for BMI and covariates among men and women. After the authors adjusted for waist circumference and covariates, BMI was not significantly associated with the two serum lipid measures. In addition, waist circumference demonstrated better predictability of triglycerides, total cholesterol and high density lipoproteins among all sex and subgroups except among East Asian women. The authors concluded that waist circumference is a stronger predictor of cardiometabolic health when compared with BMI among young adults, especially among men.

Other researchers[9–12] have reported that BMI and waist circumference together, is the best predictor of the future onset of cardiovascular illnesses. For example, Sarno et al[9] studied the effects of BMI and waist circumference on the occurrence of arterial hypertension. The authors found that the combination of BMI and waist circumference increased the prevalence for arterial hypertension. Likewise, Janssen et al[10] investigated the ability of BMI and waist circumference to predict abdominal fat in a sample of healthy White men and women. The investigators found that BMI and waist circumference combined accounted for additional visceral abdominal fat and is a better predictor of metabolic risk than BMI or waist circumference alone.

While the debate over the best measure of obesity continues, few studies have examined the efficacy of BMI and waist circumference to predict cardiovascular illness in African Americans. To this end, the purpose of our study was to determine which measure of obesity would be associated with heart rate, stroke volume, cardiac output and systolic and diastolic blood pressure hyperactivity in African Americans. The following hypotheses were proposed: 1) BMI alone would be significantly associated with cardiovas-

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cular reactivity; 2) waist circumference alone would be significantly associated with cardiovascular reactivity; and 3) BMI and waist circumference together would be more associated with cardiovascular reactivity and account for more of the variance than the two measures alone.

METHOD

Study Sample

One hundred and five African American college students (21 males, 84 females), aged 18–27 years, participated in this study. All participants were screened for cardiovascular disorders and prescription medications that could interfere with the functioning of the cardiovascular system. Students aged <18 years and those who had cardiovascular disorders were not included in the study. The participants were citizens of the United States and were recruited from a university in the Southeast. All participants volunteered to be in the study and were treated in accordance to the American Psychological Association ethical guidelines. The University's Institutional Review Board approved the study protocol.

Materials and Procedure

Since racism and racial injustice has been proven to be a source of stress for African Americans,[13] a racially noxious scene on a digital video disc (DVD) was used to induce stress. The scene showed the horrific conditions endured by enslaved Africans as they were being transported to America for slavery.

Cardiovascular Activity

A Cardiovascular Profiling System by Hypertension Diagnostic, Inc. was used to noninvasively obtain body mass index, heart rate, stroke volume (volume of blood pumped by the heart with each beat), cardiac output (volume of blood pumped by the heart each minute) and blood pressure. A blood pressure cuff was placed on the left upper arm and an arterial pulsewave sensor was placed on the right wrist overlying the radial artery.

Body Mass Index

Body mass index was measured by using self-reported body weight and height. Body mass index was classified into three categories based on the guidelines of the Department of Health and Human Services.[14] The categories are: normal weight (BMI of 18.5–24.9 kg/m^2); overweight (BMI of 25–29.9 kg/m^2); and obese (BMI of ≥30 kg/m^2).

Waist Circumference

Waist circumference was measured at the level of the umbilicus with a standard tape measure. For men, a waist circumference <94 cm was classified as normal risk of cardiovascular disease, a waist circumference of 94 cm–101cm was classified as an increased risk of cardiovascular disease and a waist circumference of ≥102 cm was classified as a substantial risk for cardiovascular disease. For women, a waist circumference <80 cm was classified as normal risk of cardiovascular disease, a waist circumference of 80 cm–87 cm was classified as an increased risk of cardiovascular disease and a waist circumference of ≥88 cm was classified as a substantial risk for cardiovascular disease.

Procedure

Cardiovascular reactivity was measured as the participants viewed the scene on the DVD. Samples were taken prior to each scene (pre-stressor period), during the scene (stressor period), and while the participant recovered from the scene (recovery period). Each period lasted three minutes and measurements were taken 20 seconds into the period. The measurement of waist circumference was counterbalanced so that it was taken prior to viewing the scene and after viewing the scene an equal number of times.

RESULTS

Multiple regression analyses were used to determine the association of BMI and waist circumference with each cardiovascular measure. Multiple regression analyses were also used to examine the association of BMI and waist circumference with the cardiovascular measures collapsed across periods. In addition, a correlation analysis was used to examine the relationship among BMI, waist circumference and cardiovascular reactivity to the emotional arousing stimulus. Means and standard deviations for all study variables are in Table 1. The SPSS statistical package (version 17) was used for the statistical analysis.

BMI and Cardiovascular Reactivity

Our first hypothesis suggested that BMI alone would be significantly associated with cardiovascular reactivity. This hypothesis was supported by the data. Body mass index was significantly associated with systolic blood pressure, during the pre-stressor, R^2=.121, F (1, 101)=13.9, P<.001; stressor, R^2=.215, F (1, 99)=19.09, P<.001; and recovery periods, R^2=.111, F (1, 98)=12.18, P<.05. Body mass index also was significantly associated with stroke volume during the pre-stressor,

Table 1. Means and standard deviations for all study variables[a]

	Means	Standard Deviations
BMI (kg/m^2)	26.56	6.64
Waist Circumference (cm)	86.50	16.46
Heart rate (bpm)	72.50	10.34
Stroke volume (mL)	78.34	15.08
Cardiac output (L/mm)	5.68	.83
Systolic blood pressure (mm Hg)	115.87	10.60
Diastolic blood pressure (mm Hg)	63.42	7.62

[a]Collapsed across periods.
N = 105.

R^2=.234, *F* (1, 102)=31.09, *P*<.001; stressor, R^2=.215, *F* (1, 99)=27.18, *P*<.001; and the recovery periods, R^2=.216, *F* (1, 98)=27.07, *P*<.001. Lastly, BMI was significantly associated with cardiac output during the pre-stressor, R^2=.562, *F* (1, 102)=131.03 *P*<.001; stressor, R^2=.569, *F* (1, 99)=130.65, *P*<.001; and recovery periods, R^2=.580, *F* (1, 98)=135.37, *P*< .001 as well as diastolic blood pressure during the pre-stressor period, R^2=.045, *F* (1, 102)=4.81, *P*<.05, and the stressor period, R^2=.043, *F*(1, 99)=4.40, *P*<.05.

In addition, the multiple regression analysis revealed BMI was significantly associated with cardiovascular reactivity collapsed across groups. BMI was significantly associated with systolic blood pressure, R^2=.129, *F* (1,102),=15.17, *P*<.001, stroke volume, R^2=.24, *F*(1,102)=32.42, *P*<.001, and cardiac output, R^2=.58, *F*(1,102)=140.01, *P*<.001. These findings indicate that participants with higher BMIs also had higher levels of systolic and diastolic blood pressure, and greater stroke volume and cardiac output. See Table 2 for BMI regression values.

The product-moment correlations revealed that similar to the regressions, BMI was significantly correlated with systolic blood pressure during the pre-stressor period, *r* =.348, *P*<.001; stressor period, *r*=.402, *P*<.001; and the recovery period, *r*=.332, *P*<.05; and diastolic blood pressure during the pre-stressor, *r*=.212, *P*< .05; and stressor periods, *r*=.206, *P*<.05; (see Table 4 for all significant correlations). Body mass index was also significantly correlated with stroke volume during the pre-stressor, *r*=.483, *P*<.05; stressor period, *r*=.464, *P*<.05; and the recovery period, *r*=.465, *P*<.05. Lastly, BMI was significantly correlated with cardiac output during the pre-stressor period, *r*=.750, *P*<.001; stressor period, *r*=.754, *P*<.001; and the recovery period, *r* =.762, *P*<.001.

Table 2. The association of BMI and cardiovascular reactivity[a]

	Beta	SE	*t*
Systolic blood pressure pre-stressor	.348	.160	3.73
Systolic blood pressure stressor	.402	.156	4.37
Systolic blood pressure recovery	.332	.154	3.49
Stroke volume pre-stressor	.483	.210	5.58
Stroke volume stressor	.464	.202	5.21
Stroke volume recovery	.465	.205	5.20
Cardiac output pre-stressor	.750	.008	11.45
Cardiac output stressor	.754	.008	11.43
Cardiac output recovery	.762	.008	11.64
Diastolic blood pressure pre-stressor	.212	.123	2.19
Diastolic blood pressure stressor	.206	.118	2.09
Systolic blood pressure[b]	.360	.148	3.90
Stroke volume[b]	.491	.196	5.69
Cardiac output[b]	.761	.008	11.83

[a]These results were obtained when BMI was entered into the regression equation alone.
[b]Collapsed across periods.
All associations were significant at the *P*≤.05 level

Waist Circumference and Cardiovascular Reactivity

Our second hypothesis stated that waist circumference alone would be significantly associated with cardiovascular reactivity. In support of the hypothesis, a separate regression analysis revealed that when waist circumference was entered into the regression equation alone, it was significantly associated with systolic blood pressure during the pre-stressor, R^2=.085, *F* (1, 100)= 9.33, *P*<.05; stressor, R^2=.367, *F* (1, 98)=15.23, *P*<.001; and recovery periods, R^2=.059, *F* (1, 97)=6.12, *P*<.05. Waist circumference also was significantly associated with stroke volume during the pre-stressor, R^2=.383, *F* (1, 101)=17.3, *P*<.001; stressor, R^2=.126, *F* (1, 98)=14.16, *P*<.001; and the recovery periods, R^2=.136, *F* (1, 97)=15.33, *P*<.001. Lastly, waist circumference was significantly associated with cardiac output during the pre-stressor, R^2=.437, *F* (1, 101)=78.4, *P*<.001; stressor, R^2=.386, *F* (1, 98)=61.7, *P*<.001; and recovery periods, R^2=.382, *F* (1, 97)=59.8, *P*<.001. In addition, the multiple regression analysis revealed that waist circumference was significantly associated with cardiovascular reactivity collapsed across groups. It was significantly associated with systolic blood pressure, R^2=.09, *F*(1,101),=9.99, *P*<.05, stroke volume, R^2=.15, *F*(1,101)= 17.84, *P*<.001, and cardiac output, R^2=.406, *F*(1,101)=69.12, *P*<.001. See Table 3 for waist circumference regression values. Similar to BMI, these findings indicate that participants with higher levels of waist circumference also

Table 3. The association of waist circumference and cardiovascular reactivity[a]

	Beta	SE	*t*
Systolic blood pressure pre-stressor	.379	.275	2.34
Systolic blood pressure stressor	.340	.268	2.15
Systolic blood pressure recovery	.413	.262	2.55
Stroke volume pre-stressor	.498	.366	3.29
Stroke volume stressor	.502	.349	3.24
Stroke volume recovery	.464	.349	3.03
Cardiac output pre-stressor	.633	.015	5.61
Cardiac output stressor	.742	.014	6.50
Cardiac output recovery	.761	.014	6.85
Systolic blood pressure[b]	.381	.255	2.38
Stroke volume[b]	.508	.341	3.37
Cardiac output[b]	.725	.014	6.51

[a]The results were included when BMI was entered into the equation with waist circumference.
[b]Collapsed across periods.
All associations were significant at the $P \leq .05$ level.

had higher levels of systolic blood pressure, and greater blood output.

The product-moment correlation analysis revealed that waist circumference was significantly correlated with systolic blood pressure during the pre-stressor period, $r = .292$, $P < .05$; stressor period, $r = .367$, $P < .001$; and recovery period, $r = .244$, $P < .05$; and stroke volume during the pre-stressor, $r = .383$, $P < .001$; stressor period, $r = .355$, $P < .001$; and the recovery period, $r = .369$, $P < .001$. In addition, waist circumference was significantly correlated with cardiac output during the pre-stressor period, $r = .661$, $P < .001$; stressor period, $r = .622$, $P < .001$; and the recovery period, $r = .618$, $P < .001$. Lastly, product-moment correlations analysis revealed that BMI was significantly correlated with waist circumference, $r = .926$, $P < .001$. See Table 4 for correlation values.

The Association of BMI and Waist Circumference Combined with Cardiovascular Activity

Our third hypothesis stated that BMI and waist circumference together would be more associated with cardiovascular reactivity and account for more of the variance than the two measures alone. The hypothesis was not supported by the data. Body mass index was significantly associated with systolic blood pressure, during the pre-stressor, $R^2 = .13$, $F(2, 99) = 7.6$, $P < .05$; stressor, $R^2 = .174$, $F(2, 97) = 10.2$, $P < .001$; and recovery periods, $R^2 = .120$, $F(2, 97) = 10.2$, $P < .001$. Body mass index also was significantly associated with stroke volume during the pre-stressor, $R^2 = .23$, $F(2, 100) = 14.9$, $P < .001$; stressor, $R^2 = .21$, $F(2, 97) = 13.03$, $P < .001$; and the recovery periods, $R^2 = .212$, $F(2, 96) = 12.9$, $P < .001$. Lastly, BMI was significantly associated with cardiac output during the pre-stressor, $R^2 = .57$, $F(2, 100) = 66.8$, $P < .05$; stressor, $R^2 = .57$, $F(2, 97) = 64.9$, $P < .001$; and recovery periods, $R^2 = .59$, $F(2, 96) = 67.5$, $P < .001$. These findings show that BMI was positively associated with systolic blood pressure, stroke volume and cardiac output. In addition, the multiple regression analysis revealed BMI was significantly associated with cardiovascular reactivity collapsed across groups. Body mass index was significantly associated with systolic blood pressure, $R^2 = .14$, $F(2,100), = 8.06$, $P < .05$, stroke volume, $R^2 = .24$, $F(2,100) = 15.53$, $P < .001$, and cardiac output, $R^2 = .58$, $F(2,100) = 69.86$, $P < .001$. Unexpectedly, waist circumference did not significantly associate with any of the cardiovascular indices when both BMI and waist circumference were entered into the regression equation. In addition, the association of BMI decreased slightly when waist circumference was entered into the regression equation.

After adjustment for sex, BMI was significantly associated with systolic blood pressure during the pre-stressor ($R^2 = .32$), stressor ($R^2 = .28$), and recovery periods ($R^2 = .18$); stroke volume during the pre-stressor ($R^2 = .39$), stressor ($R^2 = .33$), and recovery periods ($R^2 = .38$); and cardiac output during the pre-stressor ($R^2 = .61$), stressor ($R^2 = .61$), and recovery periods ($R^2 = .63$). Although the adjustment augmented the relationship between BMI and cardiovascular reactivity to stress, it did not influence the relationship between waist circumference and cardiovascular activity. See Table 5 for sex associations with cardiovascular activity.

Table 4. Correlations among BMI, waist circumference and cardiovascular activity[a]

	Waist Circumference	BMI
Systolic blood pressure pre-stressor	.292	.348
Systolic blood pressure stressor	.367	.402
Systolic blood pressure recovery	.244	.332
Diastolic blood pressure pre-stressor	-	.212
Diastolic blood pressure stressor	-	.206
Diastolic blood pressure recovery	-	-
Stroke volume pre-stressor	.383	.483
Stroke volume stressor	.355	.464
Stroke volume recovery	.369	.465
Cardiac output pre-stressor	.661	.750
Cardiac output stressor	.622	.754
Cardiac output recovery	.618	.762
BMI	.926	-

[a]All correlations are significant at the $P \leq .05$ level.

Table 5. The association of sex and cardiovascular reactivity

	Beta	SE	*t*
Systolic blood pressure pre-stressor	−.401	2.45	4.73
Systolic blood pressure stressor	−.287	2.52	3.26
Systolic blood pressure recovery	−.211	2.52	2.24
Stroke volume pre-stressor	−.399	3.17	5.03
Stroke volume stressor	−.330	3.21	3.89
Stroke volume recovery	−.398	3.09	4.86
Cardiac output pre-stressor	−.169	.137	2.67
Cardiac output stressor	−.161	.136	2.50
Cardiac output recovery	−.190	.136	3.00

All associations were significant at the $P \leq .05$ level.

DISCUSSION

The first major finding revealed that when BMI was entered into the regression equation alone, it was significantly associated with systolic blood pressure, stroke volume and cardiac output prior to, during and after the stressor. Body mass index also was significantly associated with diastolic blood pressure during the pre-stressor and stressor periods. In addition, BMI correlated with systolic and diastolic blood pressures as well as stroke volume and cardiac output. These positive associations showed that heavier participants had higher systolic blood pressure and their hearts pumped out greater blood volume compared to their thinner counterparts. These results are similar to Javed et al[15] who found that BMI significantly predicted hypertension in African American elderly women, which indicated that as BMI increased, the risk for hypertension increased.

An unexpected finding revealed that waist circumference was significantly associated with cardiovascular reactivity when analyzed alone; however, this relationship was no longer significant after BMI was entered into the equation.

The second major finding showed that when entered into the regression equation alone, waist circumference was significantly associated with systolic blood pressure, stroke volume and cardiac output. The positive associations of BMI and waist circumference with cardiovascular activity may be attributed to the need of the heart to circulate a greater volume of blood to reach a greater mass of cells with oxygenation and nutrients.[16]

An unexpected finding revealed that waist circumference was significantly associated with cardiovascular reactivity when it was entered into the regression equation alone; however, this relationship was no longer significant after BMI was entered into the equation. This finding indicated that BMI completely mediated the relationship between waist circumference and cardiovascular reactivity. The mediation was enhanced after the adjustment for sex. Similar to the present study, Waldstein et al[17] found that high density cholesterol, dietary practices and fasting insulin levels attenuated the relationship between waist circumference and systolic and diastolic blood pressure in African Americans. The mediation of waist circumference and cardiovascular reactivity may be attributed to the premise that African Americans have less abdominal adipose tissue than Whites with the same waist circumference.[18–21] To this end, waist circumference thresholds standardized on Whites may not be an accurate predictor of cardiovascular disease in African Americans. These inaccurate thresholds may contribute to the relationship between waist circumference and cardiovascular reactivity being susceptible to mediation by other factors.

A major limitation of the study was that insulin resistance and cholesterol levels were not accessed and thus were excluded as mediating variables. Examining insulin resistance and cholesterol levels may help to elucidate the relationship between obesity and cardiovascular disease.

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AUTHOR CONTRIBUTIONS

Design and concept of study: Clark
Acquisition of data: Clark
Data analysis and interpretation: Clark, Greenberg, Harris, Carson
Manuscript draft: Clark, Greenberg, Harris, Carson
Statistical expertise: Clark, Greenberg
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