Fasting Serum Glucose and Cholesterol as Predictors of Cardiovascular Reactivity to Acute Stress in a Sample of African American College Students

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Objective: African Americans are at a greater risk of cardiovascular hyperactivity to stress than Caucasians; however the risk factors for this activity are not clearly delineated for African Americans. The purpose of this study was to determine the ability of fasting serum cholesterol concentration and fasting serum glucose (FSG) to predict cardiovascular reactivity to stress in African Americans.

Design, Setting, Participants: Serum cholesterol concentration and FSG levels were measured in 48 (40 women, 8 men) African American college students aged 18–30 years. Heart rate, cardiac output, stroke volume, mean arterial pressure and systolic and diastolic blood pressure were measured as the participants viewed a racially noxious scene on a digital video disc. Measurements were taken prior to the scene (pre stressor period), during the scene (stressor period), and while the participant recovered from the scene (recovery period).

Results: A multiple regression analysis revealed that total serum cholesterol and LDL significantly predicted diastolic blood pressure during the pre-stressor period. FSG significantly predicted mean arterial pressure during the recovery period, and predicted stroke volume during the pre-stressor period, stressor period, and the recovery period.

Conclusions: FSG was a better predictor of cardiovascular reactivity to stress than serum cholesterol concentration, predicting mean arterial pressure and stroke volume. This finding may be due to the association of glucose with diabetes, which is more prevalent in African Americans. (*Ethn Dis.* 2015;25[2]:175–179)

Key Words: Serum Cholesterol Concentration, Fasting Serum Glucose (FSG), Cardiovascular Reactivity to Stress

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Introduction

Abnormal serum cholesterol and serum glucose levels are known risk factors of cardiovascular hyperactivity to stress in Caucasians; however, the association of these variables with cardiovascular hyperactivity to stress is not as clear for African Americans. While African Americans die of heart disease at higher rates compared with Caucasians, they have been found to have lower triglyceride levels[1] and higher high density lipoproteins[2,3] than Caucasians. Dagogo-Jack et al[1] conducted a longitudinal study examining factors associated with the etiology of pre-diabetes in a biracial sample of African American and White participants. They found that African Americans had lower triglyceride levels, lower fasting glucose levels and higher hemoglobin A1c levels than Whites. Messiah, Arheart, Lopez-Mitnik, Lipshultz, and Miller[4] studied 3,864 Hispanics, non-Hispanic Blacks and non-Hispanic White youths, and found that the Black participants were less likely to have abnormal high-density lipoprotein (HDL) cholesterol and the White participants were more likely to have increased triglycerides.

Understanding the mechanisms underlying the relationship of abnormal serum cholesterol and serum glucose may help to elucidate the role of these factors in cardiovascular hyperactivity to stress in African Americans. For example, Clark, Moore, and Adams[5] found that stress may mediate the relationship between cholesterol concentrations and cardiovascular activity. They examined cholesterol concentrations and cardiovascular reactivity to stress in African American college students and found that low-density lipoprotein (LDL) and HDL were significantly negatively associated with stroke volume and significantly positively associated with diastolic and systolic blood pressure responses to a racial stressor. They concluded that the stress response is a good indicator of cardiovascular and metabolic functioning. Similar results were found by Jakulj et al[6] who examined the effects of a high-fat meal and psychological stressors (mental arithmetic task, a public speaking task, arm ischemia, and a cold pressor task) on cardiovascular activity. They found that high-fat meals and stress had a significant effect on total peripheral resistance. They concluded that improper diet and cardiovascular responses to stress may damage the arteries and lead to cardiovascular disease.

The ability of cholesterol concentration, serum glucose and waist circumference to predict aortic pulse-wave velocity progression, a measure of arterial stiffness, was examined in a sample of African American and Caucasian women.[7] The investigators found that, although systolic blood pressure and waist circumference were the strongest predictors of pulse-wave velocity, diastolic blood pressure, low density lipoproteins, and glucose levels were positively associated with aortic pulse-wave velocity progression in the African American participants.

In a sample of African Americans and Hispanics, Lin et al[8] reported that participants with large waist circumferences, high blood pressures and increased levels of triglycerides had high levels of fasting glucose. Topè and Rogers[9] examined metabolic factors in

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a sample of predominantly African American college students and found that BMI mediated the metabolic risk factors of cardiovascular disease. Specifically, obese participants had higher blood pressures, lower levels of HDL, and higher fasting glucose levels than their lighter weight counterparts. While cholesterol concentration and serum glucose have been found to be associated with cardiovascular activity, understanding the mechanisms underlying this relationship is imperative. According to Shishehbor, Hoogwerf and Lauer,[10] abnormal heart rate recovery to an exercise test was associated with triglyceride-to-HDL cholesterol ratio indicating that this type of autonomic activity is a risk factor of cardiovascular disease. Since cardiovascular hyperactivity is a precursor of cardiovascular disease, the purpose of our study was to determine the ability of serum cholesterol concentration and fasting serum glucose (FSG) to predict cardiovascular reactivity to stress in African Americans. The following hypotheses were proposed. First, serum cholesterol concentration would be a significant predictor of cardiovascular reactivity. Specifically, there would be a positive association of total cholesterol, LDL triglycerides and cardiovascular activity and a negative association of HDL and cardiovascular activity. Second, we hypothesized that FSG would be a better predictor of cardiovascular activity than serum cholesterol. Specifically FSG would be positively associated with cardiovascular activity. Third, serum cholesterol concentration and FSG together would be the best predictor of cardiovascular reactivity and account for more of the variance than the measures alone.

METHOD

Study Sample

Forty eight (40 women, 8 men) non-diabetic African American college students aged 18–30 years (average of 21.7 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 under the age of 18, had cardiovascular disorders or were taking prescribed medications were not allowed to participate in the study. Thirty-eight percent (18) of the participants were of normal weight, 33% (16) were overweight and 29% (14) were obese. In addition, 81% (39) of the participants reported that they do not smoke cigarettes and 19% (9) reported that they do smoke cigarettes. The participants were citizens of the United States and were recruited from classes in the psychology department. All participants were treated in accordance to the American Psychological Association ethical guidelines. The University Institutional Review Board approved the study protocol.

Materials and Apparatus

A Hypertension Diagnostic Pulsewave CR 2000 cardiovascular profiling instrument,[11,12] a well-established method of assessing cardiovascular activity, was used to measure heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, stroke volume, and cardiac output. The oscillometric method was used to determine the measures of blood pressure. In addition, cardiac ejection time measured from blood pressure waveforms were used to obtain measures of heart rate, stroke volume and cardiac output.

Psychological Stressor

Cardiovascular measures were taken as the participants viewed a racially noxious scene on DVD. The scene depicted the horrendous conditions that Africans experienced as they were transported to America for slavery. Prior to viewing the scene, the participants were told that they would view a scene but were not given any details on it. The scene has been used to elicit emotional arousal in previous studies.[12,13]

Body Mass Index

Body mass index was measured by using body weight and height measured on a Seca Column scale. Based on the guidelines of the Department of Health and Human Services, body mass index was classified into three categories: normal weight (BMI of 18.5–24.9 kg/m^2); overweight (BMI of 25–29.9 kg/m^2); and obese ($\geq$BMI of 30 kg/m^2).

Metabolic Risk Factors

A blood sample was taken from each participant after 12 hours of fasting. The blood was drawn from a nurse practitioner in the University's Student Health Center. Lab Corp assayed the blood for serum cholesterol and FSG.

Baseline Serum Cholesterol

The fasting blood sample was enzymatically assayed for total serum cholesterol, low-density lipoproteins, high-density lipoproteins and triglycerides. Participants with total serum cholesterol levels of $\geq$200 mg/dL, low-density lipoprotein levels $\geq$130 mg/dL, high-density lipoprotein levels of $\leq$40 mg/dL and/or triglyceride levels of $\geq$150 mg/dL were considered to be at risk for cardiovascular disease.

Baseline FSG

A fasting serum glucose level between 100–125 mg/dL indicated that the individual was pre-diabetic. A fasting glucose level at ≥126 mg/dL indicated that the person was diabetic.[14]

Procedure

After the informed consent form was read and signed, cardiovascular reactivity was non-invasively measured as the participants viewed the videotaped scene. Cardiovascular measures were taken prior to the 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 80 seconds into the period. At the University Student Health Center, blood samples were taken within one week of viewing the scene. The sample was taken prior to the implementation of the stressor for half of the participants and after the stressor for the other half of participants.

A multiple regression analysis was conducted to examine the ability of total cholesterol, triglycerides, high density lipoprotein, low density lipoprotein and FSG to predict cardiovascular reactivity to the stressor. A multiple regression analysis was also used to examine the ability of serum cholesterol and FSG to predict cardiovascular reactivity collapsed across periods. The Statistical Package for the Social Sciences computer program was used to conduct all data analyses. A 95% confidence interval level was used to determine significance of each statistical analysis. Means for all study variables are in Table 1.

Table 1. Means and standard deviations for all study variables, *N*=48

	Mean	Std. Deviation
Systolic blood pressure, mm Hg[a]	116.03	11.52
Diastolic blood pressure, mm Hg[a]	64.08	7.63
Mean arterial pressure, mm Hg[a]	84.02	23.54
Cardiac output, L/mm[a]	5.64	7.63
Stroke volume, mL[a]	79.66	15.67
FSG, mg/dL	89.85	37.40
Total serum cholesterol, mg/dL	165.06	31.55
Triglyceride, mg/dL	59.31	22.07
LDL, mg/dL	93.15	25.70
HDL, mg/dL	60.23	16.43

[a] Data collapsed across periods.

RESULTS

Serum Cholesterol Concentration and Cardiovascular Reactivity to Stress

It was hypothesized that serum cholesterol concentration would significantly predict cardiovascular reactivity to the stressor. This hypothesis was partially supported by the data. The analysis revealed that total serum cholesterol independently predicted diastolic blood pressure during the pre-stressor period (see Table 2 for significant serum cholesterol beta values, data for non-significant variables are not shown). This finding indicates that participants with high total cholesterol levels also had high diastolic blood pressures as they anticipated the stressor. HDL also significantly predicted diastolic blood pressure during the pre-stressor period. In addition, LDL significantly predicted diastolic blood pressure during the pre-stressor period. The negative association between LDL and diastolic blood pressure indicates that high levels of LDL were associated with low blood pressures during the pre-stressor period. The negative association between HDL and diastolic blood pressure indicates that, as expected, low levels of this cholesterol index were associated with high blood pressures during the pre-stressor period. For the variables that were significant in the linear regression, a hierarchal multiple regression analysis controlled for BMI to determine its impact on the regression model. BMI was controlled because of its known association with metabolic factors. The regression analysis revealed that BMI did not significantly affect the ability of serum cholesterol to predict diastolic blood pressure during the pre-stressor period.

FSG and Cardiovascular Reactivity to Stress

It was hypothesized that FSG would be a better predictor of cardiovascular reactivity to the stressor than serum cholesterol concentration. The hypothesis was supported by the data in that FSG predicted more cardiovascular indices than any of the serum cholesterol concentrations (See Table 3 for significant FSG beta values, data for non-significant variables are not shown). While the regression model did not significantly predict any of the cardiovascular indices, FSG independently predicted mean arterial pressure during the recovery period. This finding indicates that the participants with high FSG levels recovered from the stressor quicker than their counterparts. FSG also significantly predicted stroke volume during the pre-stressor, stressor,

Table 2. Cholesterol predictors of diastolic blood pressure during the pre-stressor period

	Beta	SE	t	*P*
Total cholesterol, mg/dL	20.06	2.03	2.08	.044
Triglyceride, mg/dL	−2.66	.42	1.98	.055
LDL, mg/dL	−16.63	2.05	2.09	.043
HDL, mg/dL	−10.38	2.05	2.12	.040

Table 3. Fasting serum glucose predictors of cardiovascular activity

	Beta	SE	T	*P*
Mean arterial pressure				
Recovery	−.32	.03	2.12	.041
Stroke volume				
Pre-stressor	−.34	.07	2.07	.046
Stressor	−.33	.06	2.04	.049
Recovery period	−.34	.07	2.03	.050

and the recovery periods. Lastly, FSG significantly predicted stroke volume collapsed across periods. The negative association between FSG and stroke volume indicates that the hearts of participants with high glucose levels pumped less blood in response to the stressor signifying they were more aroused by the stressor than participants with low FSG levels. A hierarchal multiple regression was also used to determine the impact of BMI on the regression model. Once BMI was entered into the equation, the regression model significantly predicted stroke volume during the pre-stressor, stressor period, and recovery periods. The hierarchal regression also revealed that BMI confounded the relationship between FSG and stroke volume. BMI, which significantly predicted stroke volume during all three periods (see Table 4 for the results of the hierarchal regression predicting stroke volume), suppressed the ability of FSG to significantly predict this cardiovascular index across the three periods.

Table 4. Hierarchal multiple regression analysis predicting stroke volume

	R^2	ΔR^2	F	Beta	SE	t	*P*
Pre-stressor period							
Step 1	.316	.316	16.6				.000
BMI				.562	.27	4.08	.000
Step 2	.398	.082	4.2				
BMI				.549	.25	4.46	.001
FSG				−.258	.06	4.46	.001
Triglycerides				.048	.14	.319	.752
LDL				−.094	.12	.626	.536
HDL				.062	.15	.428	.671
Stressor period							
Step 1	.416	.416	27.1				.000
BMI				.645	.23	5.20	.000
Step2	.487	.071	6.45				
BMI				−.640	.21	5.86	.000
FSG				−.228	.05	1.78	.083
Triglycerides				.001	.12	.011	.992
LDL				−.124	.09	.924	.362
HDL				−.003	.13	.021	.983
Recovery period							
Step1	.351	.351	19.5				.000
BMI				.593	.25	4.2	.000
Step 2	.413	.062	4.51				
BMI				.560	.27	3.87	.001
FSG				−.246	.06	1.74	.091
Triglycerides				.004	.13	.024	.981
LDL				−.039	.11	.263	.794
HDL				.008	.15	.053	.958

The third hypothesis, which stated that serum cholesterol concentration and FSG together would be the best predictor of cardiovascular reactivity and account for more of the variance than the two measures alone, was not supported by the data. The cholesterol-glucose regression model did not significantly predict any of the cardiovascular indices.

DISCUSSION

The first major findings revealed that, as expected, total serum cholesterol was positively associated with diastolic blood pressure and HDL was negatively associated with diastolic blood pressure. These findings indicate that consistent with the literature, these measures of cholesterol are risk factors for cardiovascular activity in African Americans. The association of total serum cholesterol and HDL with diastolic blood pressure may be due to cholesterol blockage in the blood stream. When increased amounts of cholesterol and other lipids are found within the bloodstream, the flow of blood becomes obstructed. The obstruction interferes

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with the force at which the blood flows through the arteries and leads to increased blood pressure.[5,15]

An unexpected finding revealed that LDL was negatively correlated with diastolic blood pressure reactivity to the stressor indicating that the participants with high levels of LDL responded effectively to the stressor compared to their counterparts. This finding is inconsistent with the literature and may be due to the association of LDL with other cardiovascular risk factors such as obesity. Clark and Hill[11] found that obese participants had greater stroke volume and cardiac output to a racial stressor than did participants of normal weight indicating that they were less emotionally aroused by the stressor than were participants of normal weight. They concluded that this finding may have been due to the desensitization of the obese participants to all forms of discrimination. The association of LDL to body weight may have accounted for the decreased blood pressures in the high LDL group. Future research should examine the role of LDL in predicting cardiovascular disease in this group.

The second major finding revealed that while FSG was a better predictor of cardiovascular activity than serum cholesterol concentration, BMI confounded the relationship between FSG and stroke volume. BMI suppressed the ability of FSG to significantly predict stroke volume. This suppression may be due to the relationship between BMI and FSG. Increases in body fat lead to insulin resistance which prevents the insulin from removing glucose from the bloodstream resulting in increased glucose levels.[17]

CONCLUSION

The results from our study showed that while FSG predicted more cardiovascular indices than serum cholesterol, BMI confounded the relationship between FSG and cardiovascular activity in African Americans. Future studies examining the relationship between FSG and cardiovascular activity in African Americans should investigate the ability of BMI to mediate that relationship.

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AUTHOR CONTRIBUTIONS

Design and concept of study: Clark, Perkins
Acquisition of data: Clark
Data analysis and interpretation: Clark, Carson, Boyd, Jefferson
Manuscript draft: Clark, Perkins, Carson, Boyd, Jefferson
Statistical expertise: Clark
Acquisition of funding: Boyd
Administrative: Clark, Perkins, Carson, Boyd, Jefferson
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