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ORIGINAL RESEARCH

Goal-Striving Stress and Incident Cardiovascular Disease in Blacks: The Jackson Heart Study

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BACKGROUND: Goal-striving stress (GSS), the stress from striving for goals, is associated with poor health. Less is known about its association with cardiovascular disease (CVD).

METHODS AND RESULTS: We used data from the JHS (Jackson Heart Study), a study of CVD among blacks (21–95 years old) from 2000 to 2015. Participants free of CVD at baseline (2000–2004) were included in this analysis (n=4648). GSS was examined in categories (low, moderate, high) and in SD units. Incident CVD was defined as fatal or nonfatal stroke, coronary heart disease (CHD), and/or heart failure. We used Cox proportional hazards regression to estimate hazard ratios (HRs) and 95% confidence intervals (CIs) of incident CVD by levels of GSS, adjusting for demographics, socioeconomic status, health behaviors, risk factors, and perceived stress. The distribution of GSS categories was as follows: 40.77% low, 33.97% moderate, and 25.26% high. Over an average of 12 years, there were 140 incident stroke events, 164 CHD events, and 194 heart failure events. After full adjustment, high (versus low) GSS was associated with a lower risk of stroke (HR, 0.38; 95% CI, 0.17–0.83) and a higher risk of CHD (HR, 1.91; 95% CI, 1.10–3.33) among women. A 1-standard deviation unit increase in GSS was associated with a 31% increased risk of CHD (HR, 1.31; 95% CI, 1.10–1.56) among women.

CONCLUSIONS: Higher GSS may be a risk factor for developing CHD among women; however, it appears to be protective of stroke among women. These analyses should be replicated in other samples of black individuals.

Key Words: blacks ■ cardiovascular disease ■ diabetes mellitus ■ goal-striving stress ■ hypertension ■ JHS (Jackson Heart Study) ■ obesity

Cardiovascular disease (CVD) is the leading cause of death and contributes to >109 billion dollars in medical care costs each year.[1,2] CVD death rates are higher for blacks than any other racial and ethnic group.[3] Despite advances in prevention and treatment, patients with CVD are also likely to have recurrent cardiac events even with risk management and interventions.[4] Given the clinical and public health significance of CVD, there is considerable interest in identifying psychosocial factors that are associated with CVD to identify targets to reduce mortality and improve quality of life.

Research has found associations between psychosocial stressors, such as neighborhood disadvantage,[5] and financial stress[6] and increased risk of CVD. Psychosocial stressors can induce cardiovascular dysfunction via increases in blood pressure, which subsequently contributes to endothelial damage and inflammation.[7] Major CVD risk factors, such as hypertension and diabetes mellitus, could also influence CVD risk among those who are exposed to elevated psychosocial stress.[8] Stress also influences CVD onset through maladaptive coping behaviors, such as smoking, high alcohol consumption, and poor diet.[9] Blacks

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CLINICAL PERSPECTIVE

What Is New?

- Among blacks from the JHS (Jackson Heart Study), high goal-striving stress was associated with a lower risk of stroke but a higher risk of coronary heart disease among women.

What Are the Clinical Implications?

- Further investigation is needed to understand the pathway between goal-striving stress and cardiovascular disease to inform targeted interventions.

Nonstandard Abbreviations and Acronyms

CVD	cardiovascular disease
GSS	goal-striving stress
CHD	coronary heart disease
HF	heart failure
JHS	Jackson Heart Study
HR	hazard ratio

experience multiple dimensions of stress (eg, racial discrimination, social disadvantage, and daily irritants), which may contribute to higher CVD prevalence and risk.[10–13] Knowledge of the specific types of stressors that influence CVD can inform future interventions to prevent CVD.

One neglected dimension of stress that may be important in the cause of CVD is goal-striving stress (GSS), which is defined as "the discrepancy between aspiration and achievement, weighted by the subjective probability of success, and the level of disappointment experienced if goals are not reached."[14,15] GSS is a psychological phenomenon related to striving for upward mobility and awareness of having little success.[16] GSS has likely affected blacks for decades as they have experienced sociopolitical barriers, given the history of segregation and Jim Crow laws,[17] and even structural barriers, such as workplace and residential segregation.[18] Even today, many young blacks strive for upward mobility by enrolling in major colleges and universities,[19] but will likely face challenges (ie, being a first-generation college student and lack of financial support) that may create a strain between their goals and actual achievement.[20] The tension created from not achieving personal goals of upward socioeconomic mobility is a unique stressor that derives from pernicious structural and economic inequities that subsequently influence upward mobility of blacks. GSS has not yet been investigated as a stressor related to CVD, even though it may be a novel contributor to CVD disparities among blacks.

In this study, we investigated the association between GSS and incident CVD (stroke, coronary heart disease [CHD], and heart failure [HF]) among blacks in the JHS (Jackson Heart Study) from 2000 to 2015. We hypothesize that GSS is positively associated with new cases of CVD over time. Because the literature has found differences in CVD by sex,[21] we also examined these associations separately in men and women.

METHODS

The data used for this study can be requested for purposes of reproducing results. Request to access this data set (or other data in the JHS) may be directed to the qualified researchers trained in human subject confidentiality within the JHS Coordinating Center at jhsccrc@umc.edu.

Study Population

The JHS is the largest prospective cohort study of CVD among blacks (3371 women and 1935 men; aged 21–95 years old). Eligible participants were noninstitutionalized black adults residing in the Jackson, MS, metropolitan statistical area (N=76420). The target sample size for the cohort study was 5500 participants. Participants were sampled from 4 recruitment pools at baseline (2000–2004): (1) Jackson participants of the ARIC (Atherosclerosis Risk in Communities) study (30%); (2) participants randomly sampled from the Mississippi Department of Transportation Driver's License and Identification List (17%); (3) volunteers that signed up for the study (22%); and (4) family members of participants who agreed to be a part of the study (31%). The total sample was 5306 participants. Participants completed in-home interviews, self-administered questionnaires, and in-clinic examinations to obtain demographic, socioeconomic, psychosocial, behavioral, anthropometric, health history, and clinical data.[22,23] The JHS includes 2 additional examinations: examination 2 (2005–2008) and examination 3 (2009–2013). The institutional review boards of the University of Mississippi Medical Center, Jackson State University, and Tougaloo College approved the study. All participants provided informed consent.

Measures

Goal-Striving Stress

GSS is defined as the difference between "aspiration" (10-point scale) and "achievement" (10-point scale), weighted by one's "disappointment" (eg, importance of the goal) if a goal was not achieved the following year [(aspiration−achievement)×importance of goal].

At examination 1, participants were prompted to imagine a ladder consisting of 10 possible steps, where the tenth step represented the best possible way of life and the first step represented the worst possible way of life. Then, participants were asked to describe the step number where they were now (achievement), and the step they would like to be by the following year (aspirations). Participants were then asked how disappointed they would be if they found out they could never reach their aspiration step (not at all disappointed [1], slightly disappointed [2], fairly disappointed [3], and very disappointed [4]).[24] The GSS score ranges from 0 to 36, indicating the lowest possible response to be: aspiration=1, achievement=1, and their disappointment=1 [(1−1)×1=0], whereas the highest possible response would be: aspiration=10, achievement=1, and disappointment=4 [(10−1)×4=36]. A score was calculated for each participant, resulting in a right-skewed distribution. To examine possible nonlinear associations and discontinuous effects, the scores were categorized into low (0–1), moderate (2–4), and high (5–36) using tertiles, and in SD units. The continuous GSS score was also log transformed to make the skewed distribution more normal (Tables S1 through S3).

Dependent Variables

Trained and certified personnel performed surveillance and monitoring of incident CVD events, defined as stroke, CHD, and HF, after baseline examination through December 31, 2015 (average of 12 years). Participants were contacted by telephone to identify health events (diagnostic tests, hospitalizations, or death), and then subsequently, the medical record abstraction unit obtained data (discharge lists and death certificates) from hospitals and state offices for verification.[25,26] Eligible events were classified as first definite or probable fatal or nonfatal CHD, HF, and stroke events by a computer algorithm and follow-up review and adjudication by 2 independent physician reviewers. Any disagreements in diagnoses were adjudicated by another reviewer. Details on the quality assurance for ascertainment and classification of CVD events in JHS have been previously published and are similar to procedures conducted in the ARIC study.[26] All deaths that were not CVD related were censored.

Incident stroke events were defined as definite or probable stroke from neuroimaging studies and autopsy based on classification from the National Survey of Stroke.[27] The minimum criterion for a definite or probable stroke was sudden or rapid onset of neurological symptoms lasting for >24 hours or leading to death. Neurologic symptoms that did not last >24 hours or symptoms seen before or during admission to the hospital were not considered to be a definite or probable stroke event. Stroke events that occurred outside of the hospital or without medical diagnosis were also not considered definite or probable.

Incident CHD events were characterized as a definite or probable hospitalized myocardial infarction or fatal CHD (or cardiac procedure). Classification of definite or probable myocardial infarction was based on combinations of chest pain symptoms, ECG changes, and cardiac enzyme levels. Fatal CHD was based on chest pain symptoms, underlying cause of death from the death certificate, and other associated hospital information or medical history. The criterion for cardiac procedure was based on receipt of angiography and any revascularization procedures, as indicated in the medical records.

Incident HF was defined as the first occurrence of either inpatient or outpatient diagnosis of unspecified failure of the heart, according to the *International Classification of Diseases, Ninth Revision* (*ICD-9*) code 428, and/or an underlying cause of death code of 150. The definition of HF also included, but was not limited to, radiographic findings that were similar with congestive HF, increased venous pressure >16 mmHg, dilated ventricle/left ventricular function <40% by echocardiography/multiple gated acquisition, or autopsy finding of pulmonary edema. HF events were adjudicated beginning in 2005; thus, the index year for HF was also in 2005.

Covariates

Covariates were evaluated on the basis of previous literature, availability of variables, and a directed acyclic graph that predicted relationships between GSS, covariates, and heart disease outcomes. After evaluating variables as confounders or mediators, baseline age, educational attainment, physical activity, smoking, dietary intake, alcohol consumption, hypertension, diabetes mellitus, obesity, and global perceived stress were considered potential confounders to hold constant. On the other hand, depressive symptoms and anger were considered mediators that are in the pathway between reporting GSS and experiencing a CVD event downstream. Age was measured as a continuous variable in years. Educational attainment categories included less than high school, high school graduate/general equivalency diploma, and college degree or more. Physical activity, smoking, and nutrition categories were defined as “poor,” “intermediate,” and “ideal” health based on the American Heart Association’s Life’s Simple 7.[28] Specifically, physical activity was defined by weekly physical activity in minutes: poor, no moderate or vigorous activity; intermediate, between 0 and 150 minutes of moderate activity or between 0 and 75 minutes of vigorous activity; and ideal, ≥150 minutes of moderate activity or ≥75 minutes of vigorous activity. Poor smoking health was defined as current smoking, intermediate smoking health was defined as quitting <12 months, and ideal smoking health was defined as never smoking or quitting smoking ≥12 months. Nutrition health was based on dietary recommendations of fruits, vegetables, fish, sodium, sugary beverages, and whole grains; participants were classified as having poor health if they followed 0 to 1 recommendation, intermediate health if they followed 2 to 3 recommendations, and ideal health if they followed 4 to 5 of the recommendations. Alcohol use was defined as any alcohol intake within the past 12 months (yes or no) when asked at baseline. Hypertension was defined as baseline systolic blood pressure ≥140 mm Hg and diastolic blood pressure ≥90 mm Hg, taking antihypertensive medications, or answering "yes" to "Have you ever been told by a physician that you had high blood pressure?"[29] Obesity was defined as body mass index ≥30 kg/m^2.[30] Diabetes mellitus was defined as a fasting glucose ≥126 mg/dL, hemoglobin A1c ≥6.5%, or use of diabetic medication (actual or self-reported) within 2 weeks before the clinic visit.[31] High cholesterol was defined as having a total cholesterol level of ≥200 mg/dL.[32] In addition to these variables, we adjusted for psychosocial confounding by including global perceived stress scores (range, 0–24), which considers perceived chronic stress from factors such as employment, home environment, relationships, and meeting basic needs (α=0.72).

Statistical Analysis

After excluding those with missing GSS (n=113) and those with CVD (n=545) at baseline, there were 4648 participants in our sample. Of the 4648 participants, there were 558 missing data for CVD risk factors (hypertension, obesity, diabetes mellitus, and cholesterol) and 487 missing other covariate data. This restricted our analytic sample to 3603 participants (n=2342 women, and n=1261 men). Descriptive statistics examined the baseline characteristics in the total sample and by sex using χ^2 tests for categorical variables and the Kruskal-Wallis tests for the nonparametric continuous variables. The Kaplan-Meier method was used to calculate the cumulative incidence of each CVD end point by levels of GSS (1, low; 2, medium; and 3, high) among participants. *P* values were calculated from log-rank tests.

Cox proportional hazards regression analysis estimated multivariable associations of GSS levels with incident CVD events through 2015 in the total sample and by sex, where hazard ratios (HRs) estimated the risk of stroke, CHD, and HF. The proportional hazards assumption was checked for each model, and a nonproportional hazards approach was used for models in which the proportionality assumption was violated (diabetes mellitus in the stroke model, age and nutrition in the CHD model, and cholesterol in the HF model). Sequential adjustment was performed where model 1 adjusted for age, sex, and education; model 2 was adjusted for model 1 plus physical activity, smoking, nutrition, and alcohol use; model 3 adjusted for model 2 plus hypertension, diabetes mellitus, body mass index, and cholesterol; and model 4 adjusted for model 3 plus global perceived stress. Effect measure modification was tested by sex and educational attainment. All reported *P* values correspond to 2-tailed tests and were significant at the 0.05 level. Analyses were performed using SAS 9.4.

RESULTS

Table 1 presents baseline characteristics of the sample population by sex (65.0% women). The mean age was higher among women (54 versus 53 years; *P*=0.002). Global perceived stress and total cholesterol were higher among women than men. Women were more likely than men to report high (versus moderate or low) GSS. Other covariates were significantly different by sex, with women having greater percentages for each characteristic, except for graduating college. Cumulative incidences of stroke (Figure S1A) and HF (Figure S1C) were significantly different between the GSS levels. Participants who reported low GSS had a greater cumulative incidence of stroke and HF, followed by those who reported medium and high GSS (log-rank test *P*<0.01) (Figure S1B and S1C).

From baseline examination (2005 for HF) to 2015, there were 140 incident stroke events, 164 CHD events, and 194 HF events. In Table 2, there were no significant associations between GSS levels and incident stroke in the total sample or among men. For women, high (versus low) GSS was associated with a lower HR for stroke in models 1 to 4. After full adjustment, the HR for incident stroke was 0.38 (95% CI, 0.17–0.83). In Table 3, there was no significant association between GSS and incident CHD among men (high versus low GSS: HR, 1.04; 95% CI, 0.52–2.06); however, for women, there was an increased HR for all levels of GSS in all models. In the fully adjusted model, high (versus low) GSS was associated with an HR of 1.91 (95% CI, 1.10–3.33). In addition, a 1-SD unit increase in GSS was associated with a 31% greater hazard of CHD after full adjustment (HR, 1.31; 95% CI, 1.10–1.56). Among the total sample, GSS was only significantly associated with incident CHD after adjustment for perceived stress in model 4 (high versus low GSS: HR, 1.54; 95% CI, 1.54–2.37). A 1-SD unit increase in GSS score was associated with a 21% greater hazard of CHD in the

Table 1. Baseline Characteristics by Sex, JHS (2000–2004)

Characteristics	Total(n=3603)	Men(n=1261 [35%])	Women(n=2342 [65%])	*P* Value
Mean±SD				
Age, y	53.85±12.54	53.00±12.56	54.32±12.51	0.002
Goal-striving stress (0–36)	3.57±4.73	3.37±4.43	3.67±4.88	0.236
Global perceived stress (0–22)	5.08±4.27	4.36±4.01	5.47±4.36	<0.001
Total cholesterol, mg/dL	200.39±39.17	199.11±39.44	201.08±39.01	0.128
No. (%)				
Goal-striving stress				0.076
Low	1469 (40.77)	516 (40.92)	953 (40.69)	
Moderate	1224 (33.97)	452 (35.84)	772 (32.96)	
High	910 (25.26)	293 (23.24)	617 (26.35)	
College degree	2364 (65.61)	838 (66.46)	1526 (65.16)	0.257
Poor physical activity	1679 (46.60)	555 (44.01)	1124 (47.99)	<0.001
Poor smoking status	397 (11.02)	195 (15.59)	202 (8.70)	<0.001
Alcohol use	1669 (46.32)	756 (59.95)	913 (38.98)	<0.001
Hypertensive	1888 (52.40)	606 (48.06)	1282 (54.74)	<0.001
Diabetic	639 (17.74)	202 (16.02)	437 (18.66)	<0.001
Obese	489 (13.57)	209 (16.57)	280 (11.96)	0.001

P value calculated using Kruskal-Wallis tests or χ^2 tests, as appropriate. JHS indicates Jackson Heart Study.

total sample. There were no significant associations of GSS with incident HF in the total sample or by sex (Table 4). Interaction terms by GSS and sex and GSS and educational attainment in each of the CVD models were not statistically significant (*P*>0.05).

DISCUSSION

The present study examined the associations of GSS with incident CVD among a large sample of blacks. We found evidence of a significant

Table 2. HRs (95% CIs) for Incident Stroke Events (n=140) by GSS Levels, JHS

Model	GSS Level	Total (n=3477)*	Men (n=1232)	Women (n=2245)
1	Low		1.0	
	Moderate	1.08 (0.74, 1.57)	1.00 (0.52, 1.91)	1.12 (0.71, 1.77)
	High	0.66 (0.39, 1.12)	1.11 (0.52, 2.37)	0.45 (0.21, 0.95)†
	SD units	0.83 (0.64, 1.06)	0.92 (0.62, 1.35)	0.78 (0.56, 1.09)
2	Low		1.0	
	Moderate	1.10 (0.76, 1.61)	1.05 (0.55, 2.00)	1.14 (0.72, 1.80)
	High	0.65 (0.38, 1.10)	1.02 (0.47, 2.20)	0.44 (0.21, 0.95)†
	SD units	0.81 (0.63, 1.05)	0.86 (0.59, 1.26)	0.78 (0.56, 1.09)
3	Low		1.0	
	Moderate	1.18 (0.81, 1.72)	1.15 (0.59, 2.23)	1.17 (0.73, 1.86)
	High	0.66 (0.38, 1.12)	1.15 (0.53, 2.52)	0.41 (0.19, 0.89)†
	SD units	0.82 (0.64, 1.04)	0.89 (0.62, 1.29)	0.76 (0.55, 1.06)
4	Low		1.0	
	Moderate	1.15 (0.78, 1.68)	1.14 (0.59, 2.22)	1.12 (0.70, 1.80)
	High	0.62 (0.35, 1.07)	1.12 (0.50, 2.52)	0.38 (0.17, 0.83)†
	SD units	0.80 (0.61, 1.02)	0.87 (0.59, 1.28)	0.73 (0.52, 1.03)

Model 1, adjusted for age, sex, and education. Model 2, model 1+physical activity+smoking+nutrition+alcohol use. Model 3, model 2+hypertension+diabetes mellitus+body mass index+cholesterol. Model 4, model 3+global perceived stress. GSS indicates goal-striving stress; HR, hazard ratio; and JHS, Jackson Heart Study.

*Event surveillance through 2015 via medical record review starting in 2000. Nonproportional hazard model used to account for covariates that violated the proportional hazards assumption (diabetes mellitus). A total of 126 observations were removed because of history of stroke.

†Statistical significance (*P*<0.05).

Table 3. HRs (95% CIs) for Incident CHD Events (n=164) by GSS Levels, JHS

Model	GSS Level	Total (n=3461)*	Men (n=1226)	Women (n=2235)
1	Low	1.0		
	Moderate	1.39 (0.97, 1.98)	0.95 (0.54, 1.68)	1.82 (1.13, 2.90)†
	High	1.49 (0.99, 2.24)	1.09 (0.57, 2.10)	1.83 (1.08, 3.11)†
	SD units	1.23 (1.07, 1.43)	1.08 (0.81, 1.43)	1.33 (1.12, 1.58)†
2	Low	1.0		
	Moderate	1.41 (0.98, 2.02)	0.95 (0.54, 1.69)	1.84 (1.15, 2.94)†
	High	1.47 (0.98, 2.22)	1.07 (0.56, 2.07)	1.80 (1.06, 3.06)†
	SD units	1.22 (1.06, 1.42)	1.07 (0.80, 1.41)	1.35 (1.13, 1.60)†
3	Low	1.0		
	Moderate	1.47 (1.03, 2.12)	0.94 (0.53, 1.70)	1.99 (1.24, 3.20)†
	High	1.52 (1.01, 2.30)	1.06 (0.54, 2.05)	1.86 (1.09, 3.17)†
	SD units	1.22 (1.06, 1.40)	1.07 (0.83, 1.39)	1.31 (1.11, 1.54)†
4	Low	1.0		
	Moderate	1.48 (1.03, 2.14)†	0.94 (0.52, 1.69)	2.02 (1.25, 3.26)†
	High	1.54 (1.00, 2.37)†	1.04 (0.52, 2.06)	1.91 (1.10, 3.33)†
	SD units	1.21 (1.05, 1.40)†	1.06 (0.81, 1.39)	1.31 (1.10, 1.56) †

Model 1, adjusted for age, sex, and education. Model 2, model 1+physical activity+smoking+nutrition+alcohol use. Model 3, model 2+hypertension+diabetes mellitus+body mass index+cholesterol. Model 4, model 3+global perceived stress. CHD indicates coronary heart disease; GSS, goal-striving stress; HR, hazard ratio; and JHS, Jackson Heart Study.

*Event surveillance through 2015 via medical record review starting in 2000. Nonproportional hazard model used to account for covariates that violated the proportional hazards assumption (age and nutrition). A total of 142 observations were removed because of history of CHD.

†Statistical significance (P<0.05).

association between high GSS and risk of CHD among women; however, we also found a significant association between high GSS and a lower risk of stroke among women. No associations were found for men. GSS was not associated with HF among women or men. Therefore, we found partial support for our hypothesis.

Few studies have examined the relation between GSS and chronic disease. Sellers et al[33] examined the association of GSS with prevalent hypertension, body

Table 4. HRs (95% CIs) for Incident HF Events (n=194) by GSS Levels

Model	GSS Level	Total (n=3172)*	Men (n=1120)	Women (n=2052)
1	Low	1.0		
	Moderate	1.15 (0.83, 1.60)	0.89 (0.50, 1.58)	1.27 (0.86, 1.89)
	High	1.08 (0.72, 1.61)	0.90 (0.45, 1.80)	1.21 (0.74, 1.99)
	SD units	1.13 (0.96, 1.33)	1.07 (0.80, 1.45)	1.16 (0.97, 1.40)
2	Low	1.0		
	Moderate	1.16 (0.84, 1.61)	0.90 (0.51, 1.60)	1.26 (0.84, 1.87)
	High	1.07 (0.71, 1.60)	0.88 (0.44, 1.77)	1.19 (0.72, 1.96)
	SD units	1.12 (0.96, 1.32)	1.06 (0.78, 1.44)	1.16 (0.97, 1.39)
3	Low	1.0		
	Moderate	1.19 (0.86, 1.66)	0.92 (0.51, 1.67)	1.23 (0.83, 1.84)
	High	1.04 (0.70, 1.57)	0.90 (0.45, 1.83)	1.13 (0.68, 1.86)
	SD units	1.10 (0.94, 1.28)	1.08 (0.80, 1.46)	1.13 (0.84, 1.35)
4	Low	1.0		
	Moderate	1.17 (0.84, 1.63)	0.88 (0.49, 1.60)	1.24 (0.83, 1.87)
	High	1.00 (0.65, 1.53)	0.80 (0.39, 1.65)	1.14 (0.68, 1.94)
	SD units	1.08 (0.92, 1.27)	1.02 (0.75, 1.40)	1.14 (0.94, 1.37)

Model 1, adjusted for age, sex, and education. Model 2, model 1+physical activity+smoking+nutrition+alcohol use. Model 3, model 2+hypertension+diabetes mellitus+body mass index+cholesterol. Model 4, model 3+global perceived stress. GSS indicates goal-striving stress; HF, heart failure; and HR, hazard ratio.

*Event surveillance through 2015 via medical record review starting in 2005. Nonproportional hazard model used to account for covariates that violated the proportional hazards assumption (cholesterol). A total of 431 observations were removed because of history of HF.

mass index, and self-reported physical health among a sample of US blacks, US whites, and Caribbean blacks. In the pooled sample, they found that GSS was positively associated with hypertension and physical health problems; GSS was negatively associated with optimal health after adjusting for stressors (personal problems and lifetime and everyday racial discrimination). Associations were strongest for Caribbean blacks. Cain et al[34] investigated the association of GSS with chronic kidney disease among blacks from the JHS. After adjustment for demographics, risk factors, and global perceived stress, high GSS was associated with a greater odds of chronic kidney disease. The current study extends both studies by reporting associations of GSS with incident CVD, including stroke, CHD, and HF.

Associations were only significant for women and not men, which may indicate that GSS is not a prominent stressor for men as it is for women (noted by the slightly lower prevalence in Table 1) or may reflect the smaller sample size for men. Other psychosocial factors may instead be more salient risk factors for heart disease among black men. Prior studies have found that women report higher levels of psychosocial stressors than men. One national study of chronic stress and mortality among blacks and whites (n=24 439) found that women reported greater levels of high stress than men, which was associated with all-cause mortality.[35] Research in the JHS found that women (versus men) report greater levels of moderate-to-high financial stress, which is associated with increased risk of CHD.[6] Sims et al also noted that women (compared with men) reported higher levels of chronic stress, which was inversely associated with health behaviors in the JHS.[36] Finally, Spruill et al found that women in the JHS reported higher perceived stress over time than men, and the association between stress and incident hypertension was only significant in women.[37]

Interestingly, although high GSS was associated with a greater risk of CHD among women, it was associated with a lower risk of stroke among women, a finding we did not expect. Research has shown that black women are more likely to have a stroke than any other women in the United States[38]; however, research on the impact of stress and stroke among black women is sparse.[39] Higher educational attainment has been reported to be protective of stroke,[40] and it is possible that higher GSS was found among those with greater educational attainment, which offered protection against stroke in this study. We tested the interaction of GSS and educational attainment in this sample and found the interaction terms were not significant ($P>0.05$). It is possible that the manner by which women in this sample cope with low achievement of desired goals may also provide protection against developing stroke. Specifically, resilience mechanisms may include more social support and networks that may indirectly mitigate the negative effect GSS would otherwise have on stroke risk. Further research is warranted that explores the association of GSS and stroke incidence among black women. In addition, we did not find evidence of a significant association between GSS and incident HF for women or men. It is plausible that factors, other than GSS, are associated with HF in this sample.

Notable pathways by which GSS may increase the risk of CHD are supported by the literature. GSS has the potential to cause mental and emotional responses, like other forms of stress. Previous studies have shown that anxiety, anger, and fear, which are emotional states that are possibly a consequence of failed aspirations, are associated with a higher risk of cardiovascular dysfunction.[41,42] Psychosocial stress (ie, depression), a nontraditional risk factor, also affects CHD through a risk factor pathway (high blood pressure, inflammation, and oxidative stress).[43] In addition, a physiological pathway may be evident, in that stress exposure may activate the dysregulation of physiological systems (eg, the hypothalamic-pituitary-adrenal-cortisol axis, autonomic nervous system, and allostasis), which over time could lead to vascular damage, inflammation and plaque formation, and ultimately CHD.[44]

There are noted strengths of this study. This is the first study to examine the association of GSS with incident stroke, CHD, and HF. This dimension of stress is rarely studied in large samples of racial and ethnic minorities but is particularly relevant to blacks. Other notable strengths include the longitudinal study design and the use of a large sample of socioeconomically diverse blacks. Also, incident cardiovascular events were carefully verified and adjudicated through surveillance and medical record abstraction. Limitations include loss to follow-up/missing data, use of self-reported data, generalizability, and possible selection bias. Of the 4648 participants with complete GSS and no CVD at baseline, 3603 were included in the analyses. It is possible that losses to follow-up/those with missing data could induce bias. The self-reported measure of GSS has the potential to produce biased results because of misclassification. The results of this study may not be generalizable to blacks in other regions of the United States because the participants were sampled from Jackson. Although standard methods were used for sampling, it is plausible that rural parts of the tricounty area were not sampled as heavily, which may contribute to selection bias.

In sum, GSS was associated with lower incident stroke and higher incident CHD among black women in the JHS. Additional research that examines associations of GSS with related risk factors and subclinical outcomes among blacks may provide a better understanding of factors that are upstream in the stress-CVD pathway, specifically among black women. Further studies may also elucidate additional mechanisms that are in the pathway between GSS and CVD, including depression and other psychosocial states, which would enable targeted interventions that would help to reduce the burden of CVD risk among black women. Findings from this study should be replicated in other black samples to validate our initial results.

ARTICLE INFORMATION

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Disclosures

None.

Supplementary Materials

Tables S1–S3
Figure S1

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SUPPLEMENTAL MATERIAL

Table S1. Hazard Ratios (95% Confidence Intervals) for Incident Stroke Events (n=140) by GSS Levels, Jackson Heart Study.

	Goal-Striving Stress	Total*	Men	Women
		n=3477	n=1232	n=2245
Model 1	Low	1.0		
	Moderate	1.08 (0.74, 1.57)	1.00 (0.52, 1.91)	1.12 (0.71, 1.77)
	High	0.66 (0.39, 1.12)	1.11 (0.52, 2.37)	**0.45 (0.21, 0.95)**
	Log Transformed GSS	0.78 (0.56, 1.09)	0.94 (0.56, 1.59)	0.70 (0.46, 1.08)
Model 2	Low	1.0		
	Moderate	1.10 (0.76, 1.61)	1.05 (0.55, 2.00)	1.14 (0.72, 1.80)
	High	0.65 (0.38, 1.10)	1.02 (0.47, 2.20)	**0.44 (0.21, 0.95)**
	Log Transformed GSS	0.77 (0.56, 1.07)	0.88 (0.53, 1.46)	0.71 (0.46, 1.08)
Model 3	Low	1.0		
	Moderate	1.18 (0.81, 1.72)	1.15 (0.59, 2.23)	1.17 (0.73, 1.86)
	High	0.66 (0.38, 1.12)	1.15 (0.53, 2.52)	**0.41 (0.19, 0.89)**
	Log Transformed GSS	0.79 (0.57, 1.09)	0.95 (0.57, 1.58)	0.69 (0.46, 1.06)
Model 4	Low	1.0		
	Moderate	1.15 (0.78, 1.68)	1.14 (0.59, 2.22)	1.12 (0.70, 1.80)
	High	0.62 (0.35, 1.07)	1.12 (0.50, 2.52)	**0.38 (0.17, 0.83)**
	Log Transformed GSS	0.75 (0.54, 1.05)	0.93 (0.55, 1.57)	0.65 (0.42, 1.01)

Boldface indicates statistical significance (p <0.05).

*Events surveillance through 2015 via medical record review starting in 2000. Non-proportional hazard model used to account for covariates that violated the proportional hazards assumption (diabetes). 126 observations were removed due to history of stroke.

Model 1 – adjusted for age, sex, education

Model 2 – Model 1 + physical activity + smoking + nutrition + alcohol use

Model 3 – Model 2 + hypertension + diabetes + BMI + cholesterol

Model 4 – Model 3 + global perceived stress

Table S2. Hazard Ratios (95% Confidence Intervals) for Incident Coronary Heart Disease Events (n=164) by GSS Levels, Jackson Heart Study.

	Goal-Striving Stress	Total*	Men	Women
		n=3461	n=1226	n=2235
Model 1	Low		1.0	
	Moderate	1.39 (0.97, 1.98)	0.95 (0.54, 1.68)	**1.82 (1.13, 2.90)**
	High	1.49 (0.99, 2.24)	1.09 (0.57, 2.10)	**1.83 (1.08, 3.11)**
	Log Transformed GSS	**1.17 (1.01, 1.35)**	1.05 (0.82, 1.34)	**1.25 (1.04, 1.49)**
Model 2	Low		1.0	
	Moderate	1.41 (0.98, 2.02)	0.95 (0.54, 1.69)	**1.84 (1.15, 2.94)**
	High	1.47 (0.98, 2.22)	1.07 (0.56, 2.07)	**1.80 (1.06, 3.06)**
	Log Transformed GSS	1.15 (0.99, 1.33)	1.03 (0.80, 1.31)	**1.23 (1.03, 1.47)**
Model 3	Low		1.0	
	Moderate	1.47 (1.03, 2.12)	0.94 (0.53, 1.70)	**1.99 (1.24, 3.20)**
	High	1.52 (1.01, 2.30)	1.06 (0.54, 2.05)	**1.86 (1.09, 3.17)**
	Log Transformed GSS	1.14 (0.99, 1.32)	1.03 (0.81, 1.32)	**1.22 (1.02, 1.45)**
Model 4	Low		1.0	
	Moderate	**1.48 (1.03, 2.14)**	0.94 (0.52, 1.69)	**2.02 (1.25, 3.26)**
	High	**1.54 (1.00, 2.37)**	1.04 (0.52, 2.06)	**1.91 (1.10, 3.33)**
	Log Transformed GSS	**1.16 (1.00, 1.35)**	1.05 (0.81, 1.36)	**1.24 (1.03, 1.49)**

Boldface indicates statistical significance (p <0.05).
*Events surveillance through 2015 via medical record review starting in 2000. Non-proportional hazard model used to account for covariates that violated the proportional hazards assumption (age and nutrition). 142 observations were removed due to history of coronary heart disease.
Model 1 – adjusted for age, sex, education
Model 2 – Model 1 + physical activity + smoking + nutrition + alcohol use
Model 3 – Model 2 + hypertension + diabetes + BMI + cholesterol
Model 4 – Model 3 + global perceived stress

Table S3. Hazard Ratios (95% Confidence Intervals) for Incident Heart Failure Events (n=194) by GSS Levels.

	Goal-Striving Stress	**Total***	**Men**	**Women**
		n=3172	n=1120	n=2052
Model 1	Low		1.0	
	Moderate	1.15 (0.83, 1.60)	0.89 (0.50, 1.58)	1.27 (0.86, 1.89)
	High	1.08 (0.72, 1.61)	0.90 (0.45, 1.80)	1.21 (0.74, 1.99)
	Log Transformed GSS	1.12 (0.87, 1.45)	0.96 (0.61, 1.53)	1.23 (0.91, 1.68)
Model 2	Low		1.0	
	Moderate	1.16 (0.84, 1.61)	0.90 (0.51, 1.60)	1.26 (0.84, 1.87)
	High	1.07 (0.71, 1.60)	0.88 (0.44, 1.77)	1.19 (0.72, 1.96)
	Log Transformed GSS	1.12 (0.87, 1.44)	0.95 (0.60, 1.51)	1.23 (0.91, 1.67)
Model 3	Low		1.0	
	Moderate	1.19 (0.86, 1.66)	0.92 (0.51, 1.67)	1.23 (0.83, 1.84)
	High	1.04 (0.70, 1.57)	0.90 (0.45, 1.83)	1.13 (0.68, 1.86)
	Log Transformed GSS	1.11 (0.87, 1.43)	1.01 (0.63, 1.60)	1.20 (0.88, 1.62)
Model 4	Low		1.0	
	Moderate	1.17 (0.84, 1.63)	0.88 (0.49, 1.60)	1.24 (0.83, 1.87)
	High	1.00 (0.65, 1.53)	0.80 (0.39, 1.65)	1.14 (0.68, 1.94)
	Log Transformed GSS	1.08 (0.83, 1.41)	0.92 (0.57, 1.49)	1.21 (0.88, 1.68)

*Events surveillance through 2015 via medical record review starting in 2005. Non-proportional hazard model used to account for covariates that violated the proportional hazards assumption (cholesterol). 431 observations were removed due to history of heart failure.

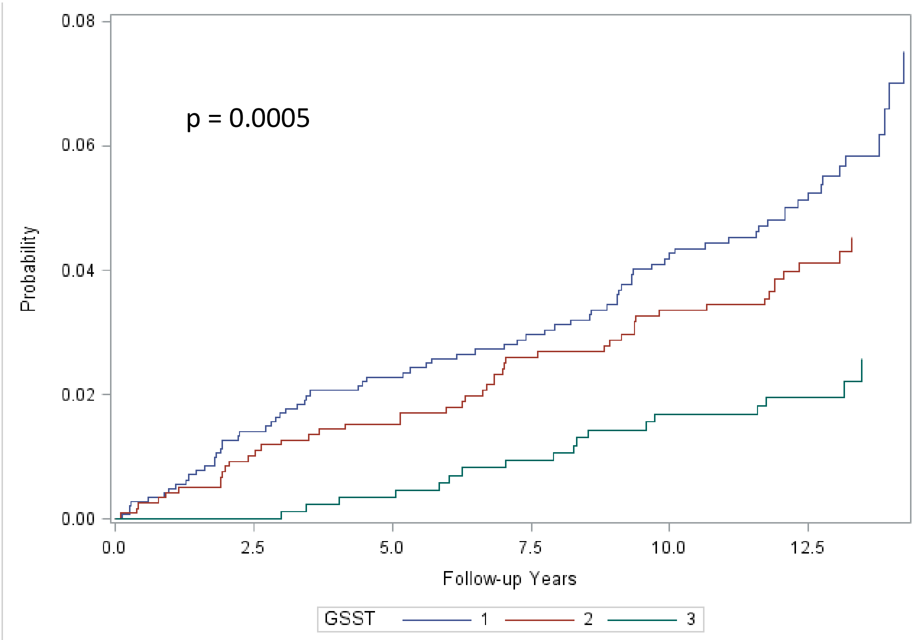
Model 1 – adjusted for age, sex, education

Model 2 – Model 1 + physical activity + smoking + nutrition + alcohol use

Model 3 – Model 2 + hypertension + diabetes + BMI, cholesterol

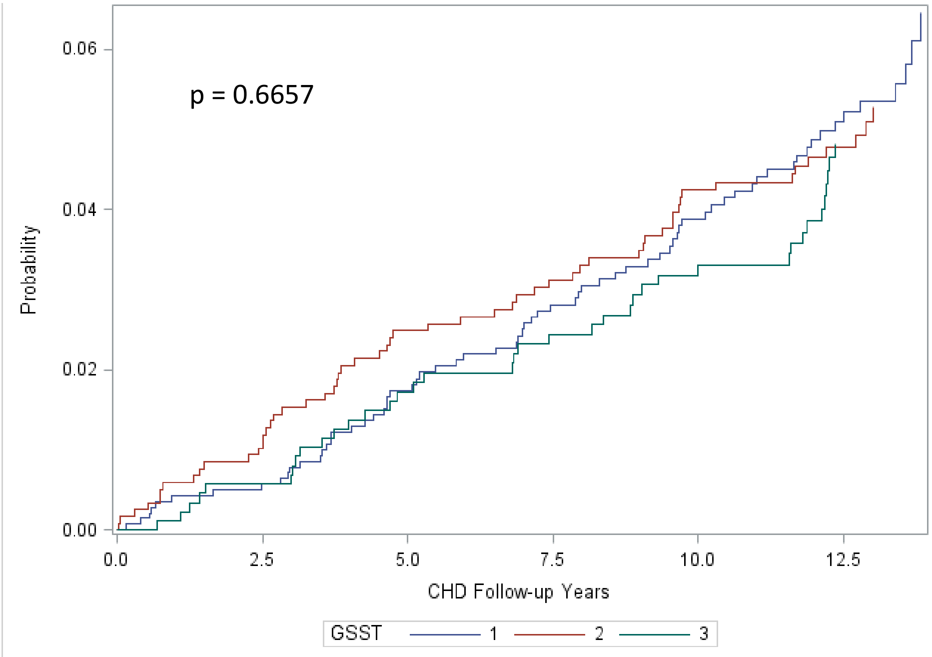
Model 4 – Model 3 + global perceived stress

Figure S1A. Kaplan-Meier figures of cumulative incident of first Stroke by GSS level.



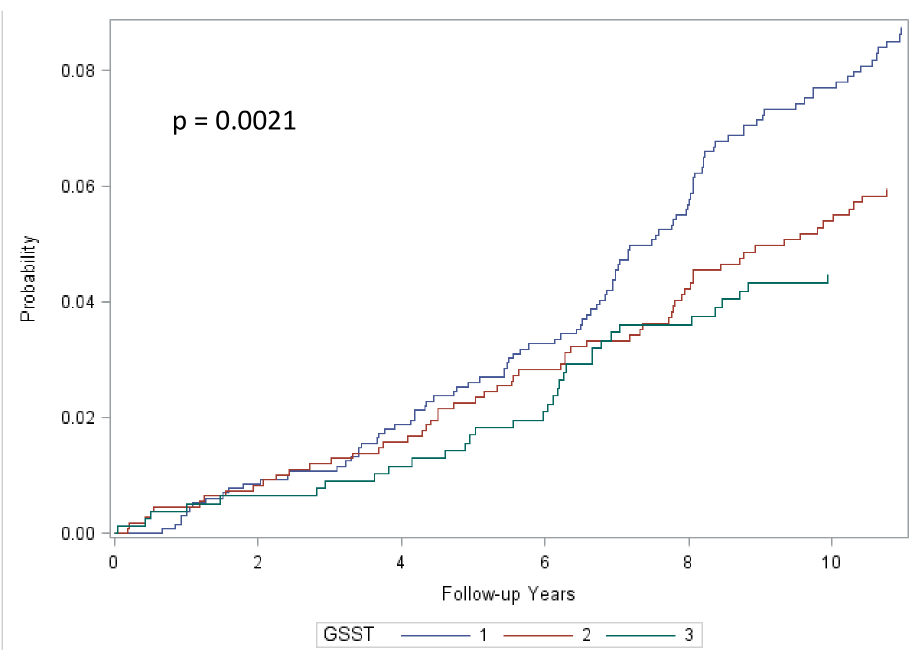
GSST= Goal-Striving Stress tertiles; 1= low, 2=moderate, 3= high; p-value is from log-rank test.

Figure S1B. Kaplan-Meier figures of cumulative incident of first Coronary Heart Disease event by GSS level.



GSST= Goal-Striving Stress tertiles; 1= low, 2=moderate, 3= high; p-value is from log-rank test.

Figure S1C. Kaplan-Meier figures of cumulative incident of first Heart Failure by GSS level.



GSST= Goal-Striving Stress tertiles; 1= low, 2=moderate, 3= high; p-value is from log-rank test.