Age and Ethnicity Differences in Short-Term Heart-Rate Variability

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Objective: Hypertension is more frequent and more severe in older individuals and in African Americans. Differences in autonomic nervous system activity might contribute to these differences. Autonomic effects on the heart can be studied noninvasively through analysis of heart rate variability (HRV). We examined the effects of age and ethnicity on HRV. **Methods:** We studied 135 subjects (57 African Americans and 78 Caucasian Americans), aged 23 to 54 years. Using their surface electrocardiogram (ECG) data, we calculated the HRV indices with spectral analyses. High frequency (HF) power was used to index parasympathetic activity, whereas the ratio of low to high frequency power (LF/HF) was used to index sympathovagal balance. **Results:** Three HRV indices (HF, LF power, and LF/HF) were significantly related to age in Caucasian Americans but not in African Americans. The effect of age, ethnicity, and the age-by-ethnicity interaction on HF and LF power was significant, even after controlling for gender, body mass index, and blood pressure. **Conclusions:** Young African Americans manifested a pattern of HRV response similarly to older Caucasian Americans. These results suggest that young African American individuals might show signs of premature aging in their autonomic nervous system. **Key words:** age, ethnicity, heart rate variability.

HRV = heart rate variability; **HF** = high frequency; **LF** = low frequency; **AA** = African Americans; **CA** = Caucasian Americans; **BP** = blood pressure; **ECG** = electrocardiogram; **BMI** = body mass index; **ARIC** = Atherosclerosis Risks in Communities.

INTRODUCTION

Studies of heart rate variability (HRV) offer a noninvasive and quantitative method of investigating autonomic effects on the heart. HRV refers to the complex beat-to-beat variation in heart rate produced by the interplay of sympathetic and parasympathetic neural activity at the sinus node of the heart (1,2). The use of this technique in defining physiological response in normals, as well as in patients with diverse cardiovascular diseases, has been studied extensively.

Spectral analysis techniques can distinguish among the intrinsic sources of HRV, as these rhythms occur at different frequencies. Typically, relative power in high frequency (HF) areas (>0.15 Hz) has been used to infer parasympathetic nervous system activity. The low frequency (LF) component (0.05–0.15 Hz) reflects inputs from both branches of the autonomic nervous system (3–5). The ratio of the LF to HF components represents a measure of sympathovagal balance (6–8).

It is generally accepted that sympathetic activity increases and parasympathetic activity decreases progressively with aging. The plasma concentration of norepinephrine, as well as efferent sympathetic nerve traffic to skeletal muscle measured by microneurography, increase with age (9,10). In spectral analysis of HRV, a decrease in both LF and HF bands with increasing age has been demonstrated (11,12).

A significant ethnic difference has been documented between African Americans (AA) and Caucasian Americans (CA) in the prevalence of hypertension (13,14). The existence of greater sympathetic outflow in AA, as a potential mechanism for enhanced cardiovascular response, and consequently hypertension, has often been suggested (15,16). These studies have utilized various ways of characterizing sympathetic nervous system physiology, such as plasma catecholamines (17), norepinephrine spillover (18), and muscle sympathetic nerve activity (19).

The literature on ethnic differences in HRV between AA and CA is sparse and inconclusive. Liao and colleagues (20) reported AA had a lower LF and higher HF than CA, whereas a recent study in young male subjects showed that AA had lower LF and HF power and higher LF/HF ratio than non-AA (21).

The present study examined both age and ethnicity differences in autonomic tone as measured by indices of HRV. Our hypothesis was that ethnicity differences exist in the correlations between age and HRV in AA and CA.

METHODS

Subjects

One hundred thirty-five subjects (57 AA and 78 CA) were recruited from the local community via public advertisements and word of mouth referrals from December 2000 to April 2004. Participants were between the ages of 23 and 54, between 85% and 150% of ideal body weight as determined by Metropolitan Life Insurance Standards (22), and had resting blood pressure (BP) <180/110 mm Hg at screening. Screening BP was defined as the average of three seated BPs. Ethnicity was determined via self-report. Social class was determined using the clinician-rated Hollingshead two-factor index (23).

Individuals were excluded from the study if they had major medical problems (history of or current evidence of heart disease except hypertension), liver or renal disease, diabetes, psychosis, severe asthma, cerebrovascular disease or cancer, current drug or alcohol abuse, creatinine levels more than 1.4 mg/dl, renal bruit on physical examination, fasting blood glucose >120 mg/dl, and known sleep disorders, or if they were shift workers. In addition, women were excluded if postmenopausal, diagnosed with premenstrual syndrome, taking oral contraceptives, or pregnant. Hypertensive patients taking antihypertensive medication were weaned off the drug(s) and closely monitored. If their BP remained >140/90 but <180/110 mm Hg for 3 weeks, they were enrolled in the study. The study was approved by the University of California, San Diego institutional review board.

HRV

All tests were done in the morning between the hours of 9:00 AM and 11:00 AM. Subjects sat quietly for 30 minutes for habituation to the instrumentation and testing environment before the testing began. They were

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Received for publication August 20, 2005; revision received January 17, 2006.

This research was supported by NIH Grants HL36005 and RR00827.

DOI: 10.1097/01.psy.0000221378.09239.6a

0033-3174/06/6803-0421

instrumented with an electrocardiogram (ECG) (model 78352C; Hewlett-Packard, Andover, MA) that relayed ECG data to an analog-to-digital converter (DT2801; Data Translation) sampling at 1 kHz. Three-minute data were collected during resting seated baseline condition using Global Lab software (Data Translation) and stored in a computer for subsequent review, artifact rejection, and calculation. The review and calculation were performed using a program developed at the University of Miami, Behavioral Medicine Research Center (24). Spectral power analyses were performed on these data according to the standard guidelines to obtain HF power (>0.15 Hz) and LF power (0.05–0.15 Hz). The ratio of LF/HF was also calculated.

Statistical Analysis

A natural logarithm transformation was used to normalize distributions of the HRV indices (LF, HF, LF/HF). We compared the differences of all variables between AA and CA with independent *t* tests. We examined the Pearson correlations between the HRV indices (LF, HF, LF/HF) and age both overall and in each ethnic (AA and CA) group. We compared the correlations between age and HRV indices by ethnic groups using Fisher's *z* transformation and Gaussian theory. Then, we performed hierarchical regression analyses with HRV indices (LF, HF, LF/HF) as dependent measures to examine the age by ethnicity interaction on HRV after controlling for gender, body mass index (BMI), and systolic BP. Gender can influence the variability of HRV (12,20) and BMI and systolic BP were significantly different between the two ethnic groups; thus, gender, BMI, and systolic BP were entered in the first step. Age and ethnicity were entered in the second step, and the age-by-ethnicity interaction was entered in the third step. Statistical analyses were performed using SPSS 12.0 for Windows, and statistical significance was determined at the α level of 0.05; all tests were two-tailed.

RESULTS

Subject characteristics are presented in Table 1. Of 135 subjects, 57 were AA (25 men and 32 women) and 78 were CA (44 men and 34 women). *t* Tests revealed that AA had greater BMI ($p < .01$), higher SBP ($p < .05$), less LF power ($p < .01$), and less HF power ($p < .05$), and more AA were hypertensive ($p < .05$).

Pearson correlation coefficients were calculated to examine associations between the HRV indices and age. HF ($r = -0.416$, $p < .01$) and LF ($r = -0.313$, $p < .01$) were significantly related to age, and LF/HF was weakly related to age ($r = 0.146$, $p = .093$). When the correlations between the HRV indices and age were examined in each ethnic group, HF was significantly related to age only in CA ($r = -0.614$, $p < .01$), but not in AA ($r = -0.181$, $p = .18$, Figure 1). LF was also significantly related to age in CA ($r = -0.469$, $p < .01$), but not in AA ($r = -0.091$, $p = .501$, Figure 2). Furthermore, LF/HF was significantly related to age in CA ($r = 0.233$, $p < .05$), but not in AA ($r = 0.106$, $p = .433$). Fisher's *z* transformation, test for comparing two correlation coefficients, showed that the correlation between age and HF ($p < .01$) and age and LF ($p < .05$) differed by ethnic group. However, the correlation between age and HF/LF was not significantly different across ethnic groups ($p = .466$).

TABLE 1. Ethnic Differences in Sample Characteristics

Variables	African American (*N* = 57) Mean ± SD	Caucasian American (*N* = 78) Mean ± SD
Age (yr)	37.7 ± 8.5	36.1 ± 7.4
Male gender (%)	43.9	56.4
BMI (kg/m^2)**	28.9 ± 6.0	25.1 ± 4.5
Hypertensive (%)*	28.1	12.8
Social class	3.3 ± 1.1	3.0 ± 0.9
Systolic BP*	129.2 ± 16.0	122.4 ± 16.6
Diastolic BP	73.1 ± 12.3	69.4 ± 12.6
LF power**	4.2 ± 3.1	7.8 ± 6.4
HF power*	3.9 ± 3.2	5.3 ± 4.7
LF/HF	1.8 ± 1.7	2.0 ± 1.6

BMI = body mass index; BP = blood pressure; LF = low frequency; HF = high frequency.
* $p < .05$, ** $p < .01$.

We then analyzed these data using three hierarchical linear regression models with the HRV indices (log LF, log HF, log LF/HF) as dependent measures (Table 2). We entered gender, BMI, and systolic BP at step 1 to control for these variables. These three variables accounted for 21.3% of the variance in HF, 14.8% of the variance in LF (both $p < .01$), and 7.6% of the variance in LF/HF ($p < .05$). At step 2 in each model, we entered age and ethnicity. They significantly accounted for an additional 14.0% of HF, 10.7% of LF, and 4.2% of LF/HF (all *p* values <.01). At step 3 in each model, we entered the age by ethnicity interaction, which significantly accounted for an additional 2.1% of HF and 2.6% of LF (both *p* values <.01) but did not account for a significant amount of the variance in LF/HF.

DISCUSSION

As individuals age, the prevalence of cardiovascular diseases also increases (25). In addition, cardiovascular diseases are not only more prevalent in AA but also present at an earlier age compared with CA (13,14). Differences in autonomic nervous system activity might help explain these age and ethnicity differences in cardiovascular disease prevalence and onset. It is generally accepted that sympathetic activity increases progressively with aging (9,10,26). However, little is known about the effects of ethnicity on age-related changes in autonomic nervous system activity. Thus, we examined both age and ethnicity differences in autonomic tone as measured by indices of HRV.

In the present study, older age was associated with decreased HF power and increased LF/HF. These findings suggest that parasympathetic activity decreases and sympathovagal balance increases progressively with aging, which is consistent with previous studies on the age-dependent changes of autonomic nervous function and HRV (9–12).

We found significant ethnic differences in the correlations between age and HRV indices in AA and CA. Older age was associated with decreased HF and LF power; however, there was no clear age-HRV association in AA. These results suggest that parasympathetic activity decreases progressively with aging only in CA and not in AA. The younger AA in our sample already had a lower parasympathetic activity than did comparable-aged CA: young AA had a parasympathetic activity equivalent to that of older CA. For instance, Figure 1 shows that the HF power, a marker of parasympathetic activity, of a 25-year-old AA individual was similar to that of a

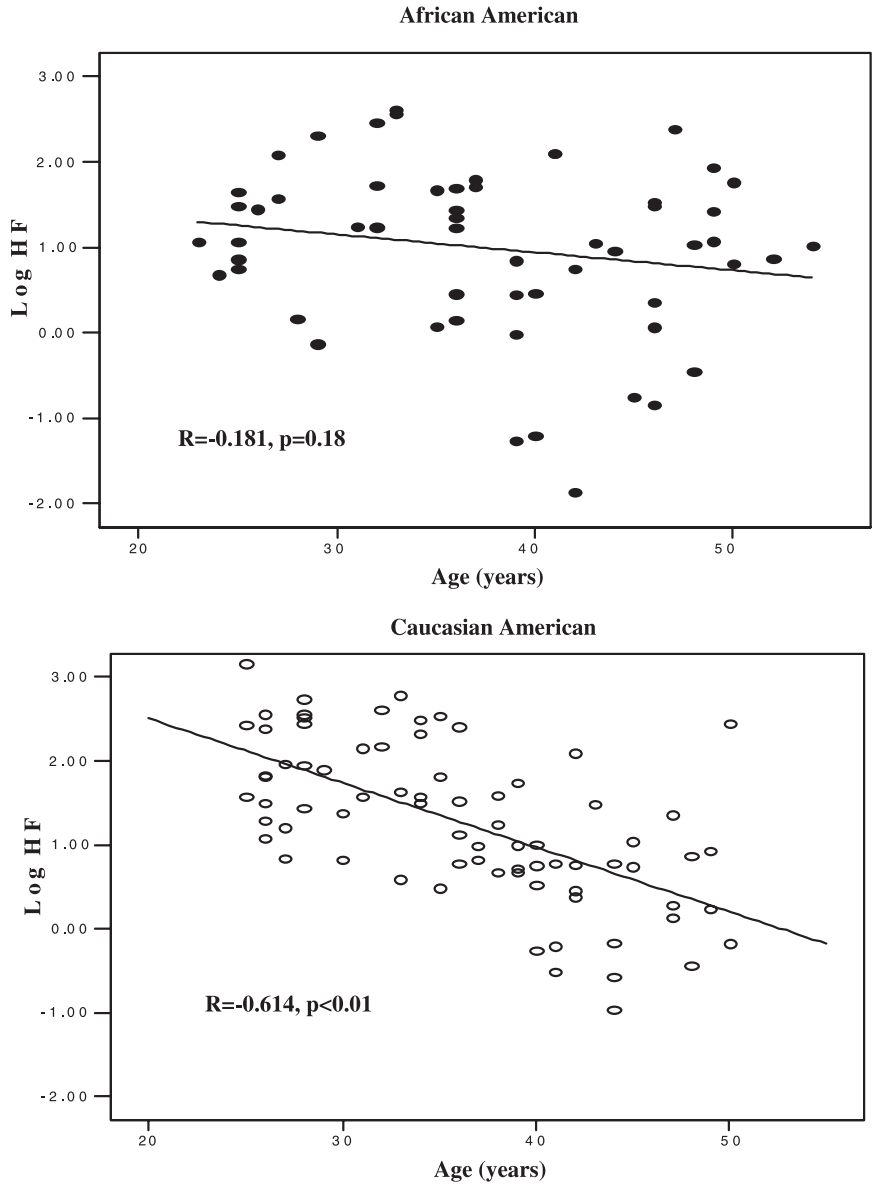

Figure 1. Correlation between log HF and age in African American (upper) and Caucasian American (lower).

35-year-old CA individual. This finding suggests that AA might exhibit premature aging in terms of their parasympathetic activity.

Our results are in line with recent studies in young healthy subjects. A study (21) of younger AA males (mean ages were 21.6 years for AA, 23.9 years for non-AA) found that AA had lower HF power and higher LF/HF ratios than non-AA. Their non-AA subjects included other ethnicities (e.g., 31% Asian, 14% Hispanic), and the study only included males. The other study (27) of healthy adolescents also showed that AA had lower HF power and LF power than CA.

On the other hand, in the Atherosclerosis Risks in Communities (ARIC) study cohort, Liao and colleagues (20) reported that AA had a lower LF and higher HF than did CA. However, it should be noted that the ARIC study only included middle-aged subjects (45–64 years). An analysis using the older individuals in our study revealed similar results. Another recent study (28) showed that older AA (49–66 years) had a higher HF than younger AA (41–48 years). This may be a chance observation. On the other hand, if it is replicated, one can speculate that the higher amount of parasympathetic activity in older AA may reflect a survival effect, i.e., younger AA with low parasympathetic activity might have died before reaching middle age. In addition, the higher HF among older AA may be due to increased randomness in HR patterns (29). Regardless, these results imply ethnic differences in age-autonomic activation relationships. Thus, age may be a critical factor in examining ethnic differences in HRV.

The mechanisms underlying these age and ethnicity differences in HRV should be investigated. Altered vascular reactivity has been one postulated mechanism for explaining the high incidence of hypertension in AA (30,31). This could be explained by genetic differences linked to polymorphic vari-

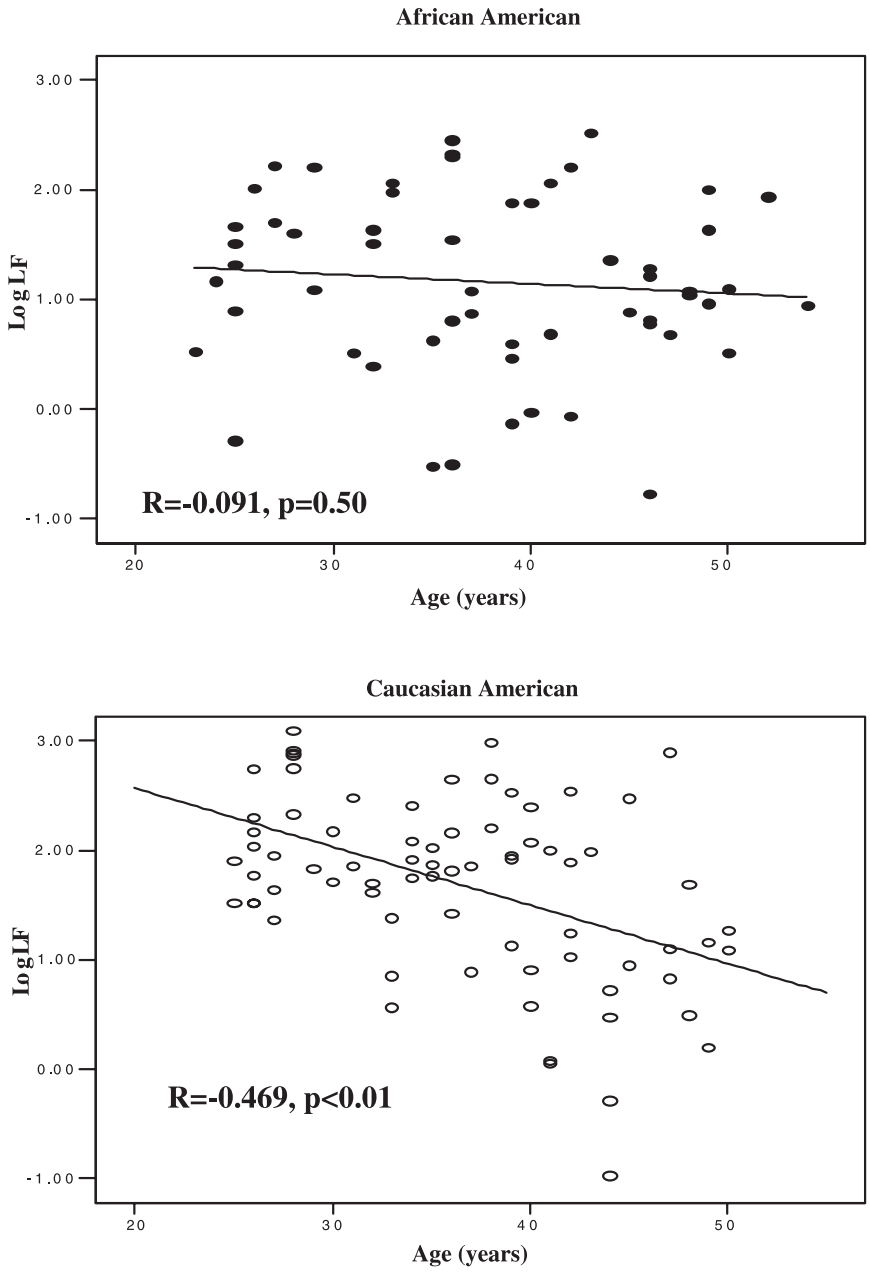

Figure 2. Correlation between log LF and age in African American (upper) and Caucasian American (lower).

ations in α-adrenergic receptors (32) and attenuations in β-adrenergic receptor-mediated vasodilation (33,34). In terms of social and environmental factors, chronic stressors like racial discrimination (35,36), unfair treatment (37), and reduced social support (38) in AA may cast a long physiologic shadow. More prevalent weight problems in AA may also contribute to sympathetic overactivity and hypertension (30).

Our findings could provide a clue to the higher incidence of hypertension in AA and suggest why ethnicity-related differences in the prevalence of hypertension are already noted by age 25 (14). Our results demonstrate a decrease of parasympathetic activity rather than an increase of sympathetic activity in younger AA. Regardless of which branch of the autonomic nervous system has changed, the outcome leads to a disturbance in autonomic nervous function, a common pathway in the future development of hypertension (39–42).

One limitation of this study is that hypertensive patients were not excluded. Schroeder et al. (43) recently reported that HRV was lower among hypertensives than normotensives. However, in secondary analyses which excluded hypertensive patients, our findings were similar, i.e., a significant age-by-ethnicity interaction for HF power.

The HRV information obtained from short-term recordings is somewhat limited, as short-term recordings are unable to measure accurately some of the very low oscillations observed in longer recordings. However, short-term recordings do have several advantages. First, they are quick to perform and to analyze. Second, short-term recordings can be made under

TABLE 2. Final Models of the Effects of Gender, BMI, Systolic BP, Age, Ethnicity, and the Age-by-Ethnicity Interaction on HRV Indices

HRV Indices	*R*	R^2	*p*	Variables	β	*p* Value
Log HF[a]	0.611	0.374	<.01	Gender	0.082	.290
				BMI	−0.385	<.001
				Systolic BP	0.047	570
				Age	−0.536	<.001
				Ethnicity	−0.698	.047
				Age × Ethnicity	0.731	.043
Log LF[b]	0.530	0.281	<.01	Gender	−0.109	.191
				BMI	−0.261	.003
				Systolic BP	0.038	.666
				Age	−0.453	<.001
				Ethnicity	−0.946	.013
				Age × Ethnicity	0.811	.036
Log LF/HF[c]	0.343	0.118	<.05	Gender	−0.205	.028
				BMI	0.166	.082
				Systolic BP	−0.014	.889
				Age	0.140	.254
				Ethnicity	−0.183	.659
				Age × Ethnicity	0.007	.986

Abbreviations: See Table 1.

[a] At step 1, entering Gender, BMI, and Systolic BP, $R^2 = 0.213$, $p < .01$. At step 2, entering Age and Ethnicity, $R^2 = 0.353$, $p < .01$. At step 3, entering Age × Ethnicity, $R^2 = 0.374$, $p < .01$.

[b] At step 1, entering Gender, BMI, and Systolic BP, $R^2 = 0.148$, $p < .01$. At step 2, entering Age and Ethnicity, $R^2 = 0.255$, $p < .01$. At step 3, entering Age × Ethnicity, $R^2 = 0.281$, $p < .01$.

[c] At step 1, entering Gender, BMI, and Systolic BP, $R^2 = 0.076$, $p < .05$. At step 2, entering Age and Ethnicity, $R^2 = 0.118$, $p < .01$. At step 3, entering Age × Ethnicity, $R^2 = 0.118$, $p < .05$.

controlled conditions to ensure standardization. Third, they can be made under a variety of conditions such as before and after tilt or other postural, psychological or pharmacologic interventions (44).

This study relied on a voluntary sample. It is possible that individuals who are concerned about their cardiovascular health because of previous diagnosis or family history may be more likely to volunteer. Respiration has an influence on estimates of HRV and HF measures of vagal control of HR (45); however, respiratory data were not available. It would be helpful to include such information in future studies.

A future study with a larger sample size would also allow investigating psychosocial variables (e.g., depression, stress, socioeconomic status) that may be associated with age and ethnicity. In addition, we only examined individuals between the ages of 23 and 54 years; this restriction might limit the generalizability of these observations to younger or older individuals. Therefore, replication of the study in younger and older individuals would allow for a more complete evaluation of age and ethnicity differences in HRV. Finally, the study of age and ethnicity differences of HRV could be done with methods based on the phase domain, such as complexity measures (46), which might supply deeper insight into these matters.

In conclusion, we found significant ethnic differences in the correlations between age and HRV indices in AA and CA. Older age was associated with decreased HF and LF power only in CA and not in AA. In terms of HRV, young AA manifested a pattern of response that was similar to older CA. These results suggest that young AA individuals might exhibit signs of premature aging in their autonomic nervous system.

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