Carotid baroreflex responsiveness is impaired in normotensive African American men

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Holwerda SW, Fulton D, Eubank WL, Keller DM. Carotid baroreflex responsiveness is impaired in normotensive African American men. Am J Physiol Heart Circ Physiol 301: H1639–H1645, 2011. First published August 12, 2011; doi:10.1152/ajpheart.00604.2011.—There are important differences in autonomic function and cardiovascular responsiveness between African Americans (AA) and Caucasian Americans (CA). This study tested the hypothesis that carotid baroreflex (CBR) responsiveness is impaired in normotensive AA compared with normotensive CA at rest. CBR control of heart rate (HR) and mean arterial blood pressure (MAP) was assessed in 30 nonhypertensive male subjects (15 AA; 15 CA; age 18–33 yr) with 5–s periods of neck pressure (NP; simulated hypotension) and neck suction (NS; simulated hypertension) ranging from +45 to −80 Torr during rest. Carotid-cardiac stimulus-response curves revealed a significantly lower minimum HR response in the CA compared with AA (40.8 ± 2.4 vs. 49.8 ± 2.9 beats/min, respectively; P < 0.05). In addition, the magnitude of the mean HR response to all trials of NS (−20, −40, −60, and −80 Torr) was attenuated in the AA group (AA, −10.1 ± 1.7 vs. CA, −14.9 ± 2.2 beats/min; P < 0.05), while no significant differences were found in the magnitude of the mean HR response to NP (+15, +30, and +45 Torr) between racial groups. There were no significant differences in the carotid-vasomotor stimulus-response curves between racial groups. Also, while no racial differences were found in the magnitude of the mean MAP response to all trials of NS, the magnitude of the mean MAP response to all trials of NP was attenuated in the AA group (AA, 7.2 ± 1.3 vs. CA, 9.3 ± 1.1 mmHg; P < 0.05). Together, these findings support inherent differences in short-term blood pressure regulation between racial groups that exhibit different relative risk for the development of hypertension.

African Americans (AA) are at markedly higher risk than their Caucasian American (CA) counterparts for the development of hypertension, with hypertension affecting >40% of the AA adult population (11). Additionally, AAs are at 1.8 times greater risk of fatal stroke related to hypertension and are over 4 times more likely to develop end-stage renal disease associated with hypertension than CAs (24). Despite the life-threatening implications and alarming prevalence of this disease in AAs, little is known regarding dynamic blood pressure control (i.e., arterial baroreflex function) in this group.

Numerous investigations have demonstrated physiological differences between AAs and CAs by examining the acute blood pressure responses to emotional and physical stimuli (e.g., mental stress, cold pressor test, etc.; Refs. 4–6, 8–10, 20, 22, 38, 40). Furthermore, AAs exhibited greater blood pressure responses to dynamic exercise (2, 13, 39, 41) and static exercise (12, 23) than CAs.

The arterial baroreflex is the primary short-term modulator of arterial blood pressure in humans (14, 18, 30). Baroreflex-mediated neural adjustments alter both cardiac output, primarily via changes in heart rate (HR; Refs. 26, 27), and peripheral vascular conductance in an effort to maintain arterial blood pressure around a “prevailing” blood pressure. In addition, the importance of intact arterial baroreflex function in long-term blood pressure control has been demonstrated in humans with both increased baseline blood pressure and increased blood pressure variability upon carotid sinus denervation (32). Using lower-body negative pressure (LBNP), Ray and Monahan (31) demonstrated an enhanced sympathetic vascular transduction for a given change in sympathetic nerve activity (i.e., MSNA) in AAs. In addition, Franke et al. (16) demonstrated smaller declines in cardiac output and total peripheral conductance during LBNP in AAs. While supportive of inherent differences between these racial groups, a comparison of arterial baroreflex function over a wide range of pressures has not been made between AAs and CAs.

This study tested the hypothesis that carotid baroreflex (CBR) responsiveness is impaired in normotensive AAs compared with normotensive CAs. To test this hypothesis, we measured CBR-mediated changes in HR and mean arterial pressure (MAP) to wide range of simulated hypertensive and hypotensive stimuli in normotensive AAs and age, body mass index (BMI), and fitness-matched normotensive CAs at rest.

METHODS AND ANALYSIS

Methods

Subjects. Thirty adult, nonhypertensive male subjects (15 AA; 15 CA; age 18–33 yr) participated in the study. Before participation, all subjects were familiarized with the testing protocols. Subjects were healthy, nonsmokers, free of known cardiovascular and respiratory diseases, and not using prescription or over-the-counter medications. Family history of hypertension was recorded for all subjects except for one CA subject. Following the recruitment of each AA subject, a CA subject matched for fitness [maximal oxygen consumption (V̇O2max) within 7 ml·kg−1·min−1], age (within 3 yr) and BMI (within 15%) was recruited for investigation. Subjects were advised to not consume alcohol within the 24 h before and not to consume caffeine within 12 h before the scheduled experiment. Subjects were also advised not to vigorously exercise for 48 h before the scheduled experiment. Each subject signed an informed consent that was approved by the Institutional Review Boards at the University of Texas at Arlington. Subject characteristics are described in Table 1. There were no significant group differences in age, height, weight, V̇O2max, systolic blood pressure, diastolic blood pressure, and BMI between racial groups.

Experimental measurements. Subjects were instrumented with electrocardiogram (ECG) leads and an arterial blood pressure cuff (Tango+; Suntech) for continuous heart rate and steady-state arterial blood pressure measurements, respectively. Arterial blood pressure was measured continuously using servo-controlled finger photople
ethysmograph (Finometer Pro; Finapres Medical Systems, Amsterdam, The Netherlands). An automated sphygmomanometer recorded blood pressure by the auscultation of the brachial artery of the right arm for measurements of absolute blood pressure. CBR control of HR and MAP was assessed through the use of 5-s periods of neck pressure (NP; simulated hypotension) and neck suction (NS; simulated hypertension) delivered to the region of the carotid sinuses encased by a properly sized malleable neck chamber. Pressure and suction pulses were generated by a variable pressure source and delivered to the neck chamber through two-way solenoid valves and controlled using custom software (NS3). Before the experimental day testing, subjects underwent a maximal exercise test on a leg cycle ergometer using continuous measurement of respiratory gases (TrueOne 2400; Parvo Medics) to determine maximal oxygen uptake. The anatomical locations of each subject’s carotid sinuses were confirmed as appropriate for the neck chamber by Doppler ultrasound. Data were recorded using AqKnowledge Software (BioPac Systems, Goleta, CA).

Experimental procedures. After being instrumented with ECG leads and fitted for an arterial blood pressure cuff and a finger-cuff photoplethysmograph on the experimental day, subjects were positioned supine on a table for 20 min to ensure resting HR and MAP was assessed through the use of 5-s periods of neck pressure (NP; simulated hypotension) and neck suction (NS; simulated hypertension) delivered to the region of the carotid sinuses encased by a properly sized malleable neck chamber. Pressure and suction pulses were generated by a variable pressure source and delivered to the neck chamber through two-way solenoid valves and controlled using custom software (NS3). Before the experimental day testing, subjects underwent a maximal exercise test on a leg cycle ergometer using continuous measurement of respiratory gases (TrueOne 2400; Parvo Medics) to determine maximal oxygen uptake. The anatomical locations of each subject’s carotid sinuses were confirmed as appropriate for the neck chamber by Doppler ultrasound. Data were recorded using AqKnowledge Software (BioPac Systems, Goleta, CA).

CBR responsiveness was assessed by applying multiple trials of random-ordered single 5-s pulses of NP and NS ranging from +45 to −80 Torr (i.e., +45, +30, +15, −20, −40, −60, and −80). Each pressure stimulus was delivered to the carotid sinus during a 15-s breath hold at normal end-expiration to minimize respiratory-related modulation of HR and MAP. The generated pressures within the neck collar were manually controlled, and a pressure transducer (model DP45; Validyne Engineering, Northridge, CA) was connected to a port on the collar to accurately quantify the stimulus applied. At least four trials of each magnitude of NS and NP were administered with a minimum of 45 s of recovery between trials to allow variables to return to prestimulus values (26).

Data Analysis

Peak MAP and HR responses. The peak MAP response was determined by assessing the three cardiac cycle interval with the largest change in MAP relative to prestimulus (3 cardiac cycle average) for each trial of NP and NS. This analysis has been described previously (19). For HR, the cardiac cycle peak was compared with prestimulus (3 cardiac cycle average) for each trial of NP and NS.

CBR function curves. Carotid-cardiac and carotid-vasomotor stimulus-response curves were determined by plotting the peak changes in HR and MAP, respectively, elicited by NP and NS against the estimated carotid sinus pressure (ECSP), which was calculated as mean blood pressure minus neck chamber pressure. CBR stimulus-response data were fit for each subject to the logistic function model described by Kent et al. (20a):

$$G_{op} = A_1 A_2 \exp[A_2(\text{ECSP}_{op} - A_3)] / \left[1 + \exp[A_2(\text{ECSP}_{op} - A_3)]\right]^2$$

where the dependent variable is HR or mean blood pressure, $A_1$ is the range of response of the dependent variable (maximum − minimum), $A_2$ is the gain coefficient (i.e., slope), $A_3$ is the centering point or carotid sinus pressure required to elicit equal pressor and depressor responses, and $A_4$ is the minimum response.

The CBR operating point gain and maximal gain were calculated using the equations:

$$G_{op} = A_1 A_2 \exp[A_2(\text{ECSP}_{op} - A_3)] / \left[1 + \exp[A_2(\text{ECSP}_{op} - A_3)]\right]^2$$

$$G_{max} = -A_1 A_2 / 4$$

where $G_{op}$ is the gain of the CBR function curve at the operating point, $G_{max}$ is the maximal gain of the CBR function curve, and ECP_{op} is the ECSP at the operating point (i.e., prestimulus MAP). The $G_{op}$ was calculated as the gain at the operating point and used to provide a measure of responsiveness at the operating point of the CBR function curve, whereas the $G_{max}$ was calculated as the gain at the centering point and used as an index of overall CBR responsiveness. The threshold and saturation, described as the minimum and maximum ECSP, respectively, that elicit a reflex change in HR or MAP, were calculated using the following equation:

$$\text{threshold} = -2.944 / A_3 + A_1 \text{ and}$$

$$\text{saturation} = 2.944 / A_3 + A_1$$

These calculations are the ECSP at which HR and MAP were within 5% of the maximal or minimal response (21). The parameters for all subjects within an experimental condition were averaged to provide group mean responses.

Statistical Analysis

Comparisons for baseline HR, MAP, and descriptive characteristics (e.g., height, weight, BMI, and $V_{O2max}$) were made between racial groups using unpaired t-tests. The statistical comparisons of the baroreflex and cardiovascular response variables between racial populations (factor 1) and the various magnitudes of NP and NS (factor 2) at rest were made using a two-way ANOVA. For comparison of carotid-cardiac and carotid-vasomotor response curve parameters between racial groups, one-way ANOVA was used. Analysis of covariance (ANCOVA) was also used to determine if differences existed between racial groups after controlling for known family history of hypertension. Each subject’s corresponding covariate data were determined as either negative (no parental hypertension) or positive (one or more cases of parental hypertension). Family history was determined for all AA subjects and 14 of 15 CA subjects. For the missing subject data (the one CA subject with no family history), separate analyses were performed using both a negative value and a positive value of family history for this subject. Regardless of the value used for this subject, there were no differences in the significance of the covariate or the main effect outcomes between those two analyses. The results presented are from the test in which a negative family history was used for this subject’s missing data. When required, multiple comparison procedures were performed using the Holm-Sidak method. Statistical significance was set at $P < 0.05$.

RESULTS

Carotid-Cardiac Stimulus-Response Curves

The stimulus-response relationship for the CBR control of HR in both racial groups is shown in Fig. 1A. The calculated

### Table 1. Subject characteristics

<table>
<thead>
<tr>
<th></th>
<th>AA (n = 15)</th>
<th>CA (n = 15)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>22.3 ± 3.7</td>
<td>21.9 ± 3.3</td>
<td>0.76</td>
</tr>
<tr>
<td>Height, m</td>
<td>1.79 ± 0.08</td>
<td>1.79 ± 0.06</td>
<td>0.9</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>77.3 ± 14.0</td>
<td>79.1 ± 12.5</td>
<td>0.71</td>
</tr>
<tr>
<td>$V_{O2max}$ ml·kg$^{-1}$·min$^{-1}$</td>
<td>41.3 ± 7.5</td>
<td>43.3 ± 7.3</td>
<td>0.47</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>24.3 ± 4.5</td>
<td>24.6 ± 3.1</td>
<td>0.79</td>
</tr>
<tr>
<td>Heart rate, beats/min</td>
<td>63 ± 9</td>
<td>61 ± 10</td>
<td>0.48</td>
</tr>
<tr>
<td>SBP, mmHg</td>
<td>121 ± 8</td>
<td>119 ± 8</td>
<td>0.57</td>
</tr>
<tr>
<td>DBP, mmHg</td>
<td>76 ± 7</td>
<td>74 ± 7</td>
<td>0.49</td>
</tr>
<tr>
<td>MAP, mmHg</td>
<td>89 ± 6</td>
<td>89 ± 5</td>
<td>0.41</td>
</tr>
<tr>
<td>Family history HTN</td>
<td>7(+) and 8(−)</td>
<td>6(+) and 9(−)</td>
<td></td>
</tr>
</tbody>
</table>

Values expressed as means ± SE. AA, African American; CA, Caucasian American; $V_{O2max}$, maximal oxygen consumption; HTN, hypertension; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure.
variables describing the stimulus-response curve can be found in Table 2. The maximal gain (i.e., sensitivity) of the carotid-cardiac stimulus response curves was not different between AA and CA groups. In addition, threshold carotid sinus pressure (CSPthr) and saturation carotid sinus pressure (CSPsat) for the carotid-cardiac stimulus response curves were not different between AA and CA groups. The four logistic parameters describing carotid-cardiac components are presented in Table 2. No significant differences were seen between groups in the range of HR (A1), gain coefficient (A2), and centering point (A3; P > 0.05). The minimal HR response (A4) was attenuated in the AA group compared with the CA group (P < 0.05). Figure 2 depicts individual carotid-cardiac function curves for representative subjects from each racial group. Similar findings were observed for the minimal HR response when controlling for family history of hypertension as a covariate despite there being a significant main effect for family history only for the minimal HR response (P < 0.05).

**Carotid-Vasomotor Stimulus-Response Curves**

The stimulus-response relationship for the CBR control of MAP in both racial groups is shown in Fig. 1B. The calculated variables describing the stimulus-response curve can be found in Table 2. The maximal gain of the carotid-vasomotor stimulus response curves was not different between AA and CA groups. In addition, threshold carotid sinus pressure (CSPthr) and saturation carotid sinus pressure (CSPsat) for the carotid-vasomotor stimulus response curves were not statistically different between AA and CA groups at rest. The four logistic parameters describing carotid-vasomotor components are presented in Table 2. No significant difference was seen between groups in the range of MAP (A1), gain coefficient (A2), centering point (A3), and minimal MAP response (A4; P > 0.05). Similar findings were observed when controlling for family history of hypertension as a covariate despite there being a significant main effect for family history only for the minimal MAP response (P < 0.05).

**Table 2. Logistic model parameters and derived variables describing the stimulus-response relationship for the carotid baroreflex control of HR and MAP**

<table>
<thead>
<tr>
<th></th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>CSPthr</th>
<th>CSPsat</th>
<th>OP</th>
<th>Max Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carotid-cardiac</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>AA</td>
<td>9.3 ± 0.5</td>
<td>0.06 ± 0.03</td>
<td>95.2 ± 0.7</td>
<td>46.0 ± 0.2</td>
<td>66.1 ± 0.5</td>
<td>124.2 ± 0.8</td>
<td>63.2 ± 0.3</td>
<td>-0.49 ± 0.06</td>
</tr>
<tr>
<td>CA</td>
<td>10.3 ± 0.6</td>
<td>0.06 ± 0.03</td>
<td>95.0 ± 0.7</td>
<td>46.0 ± 0.2</td>
<td>66.1 ± 0.5</td>
<td>124.2 ± 0.8</td>
<td>63.2 ± 0.3</td>
<td>-0.49 ± 0.06</td>
</tr>
<tr>
<td><strong>Carotid-vasomotor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>AA</td>
<td>20.1 ± 0.7</td>
<td>0.10 ± 0.02</td>
<td>84.6 ± 0.4</td>
<td>70.7 ± 0.3</td>
<td>81.2 ± 0.5</td>
<td>112.8 ± 0.7</td>
<td>89.1 ± 0.4</td>
<td>-0.47 ± 0.04</td>
</tr>
<tr>
<td>CA</td>
<td>23.8 ± 0.4</td>
<td>0.08 ± 0.01</td>
<td>84.5 ± 0.2</td>
<td>70.7 ± 0.3</td>
<td>81.2 ± 0.5</td>
<td>112.8 ± 0.7</td>
<td>89.1 ± 0.4</td>
<td>-0.47 ± 0.04</td>
</tr>
</tbody>
</table>

Values expressed as mean ± SE. HR, heart rate; A1, response range (maximum-minimum); A2, gain coefficient; A3, carotid sinus pressure (CSP) at midpoint (centering point); A4, minimal response; CSPthr, carotid sinus threshold pressure; CSPsat, carotid sinus saturation pressure; OP, operating point (prestimulus); Max Gain, point of greatest slope on first derivative curve of logistic function. *Significantly different than CA.
Simulated Hypertension

Figure 4 describes group peak HR (Fig. 4A) and MAP (Fig. 4B) responses to varying intensities of simulated hypertension (i.e., NS). Across all NS stimuli (−20, −40, −60, and −80 Torr), the magnitude of the HR response was attenuated in the AA group (average value for all HR responses to NS stimuli at all pressures, −10.1 ± 1.7 beats/min) compared with the CA group [−14.9 ± 2.2 beats/min; F(1,112) = 14.935; main effect \( P < 0.001 \)]. No significant differences (\( P > 0.05 \)) were found in the magnitude of the MAP response to NS between racial groups (AA, −7.3 ± 0.8; CA, −8.1 ± 0.9 mmHg). Similar findings were observed for HR and MAP responses to NS when controlling for family history of hypertension as a covariate with no main effect for family history (\( P > 0.05 \)). No differences (\( P > 0.05 \)) were seen in estimated carotid sinus pressure between groups during each level of NS stimulation (−20 Torr: AA, 111 ± 2; CA, 109 ± 1 mmHg; −40 Torr: AA, 131 ± 2; CA, 129 ± 2 mmHg; −60 Torr: AA, 151 ± 2; CA, 148 ± 1 mmHg; −80 Torr: 170 ± 2; CA, 169 ± 1 mmHg).

Simulated Hypotension

Figure 3 describes group peak HR (Fig. 3A) and MAP (Fig. 3B) responses to simulated hypotension (i.e., NP). No significant differences (\( P > 0.05 \)) were found in the magnitude of the HR response to NP between racial groups (AA, 7.2 ± 1.2; CA, 7.5 ± 0.9 beats/min). Across all NP stimuli (45, 30, and 15 Torr), the magnitude of the MAP response was attenuated in the AA group (7.2 ± 1.3 mmHg) compared with the CA group [9.3 ± 1.1 mmHg; \( F(1,84) = 5.750 \); main effect \( P = 0.019 \)]. Similar findings were observed for HR and MAP responses to NP when controlling for family history of hypertension as a covariate despite there being significant main effect for family history (\( P < 0.05 \)) only for the MAP response to NP. No differences (\( P > 0.05 \)) were seen in estimated carotid sinus pressure (i.e., prevailing blood pressure – chamber pressure) between groups during each level of NP stimulation (+15 Torr: AA, 76 ± 2; CA, 74 ± 1 mmHg; +30 Torr: AA, 60 ± 2; CA, 59 ± 1 mmHg; and +45 Torr: AA, 47 ± 2; CA, 45 ± 1 mmHg).

history of hypertension as a covariate with no main effect for family history (\( P > 0.05 \)).
DISCUSSION

The primary findings of this investigation are that normotensive AA subjects demonstrated differential CBR responsiveness compared with age, BMI, and fitness-matched, normotensive CA counterparts. Specifically, CBR-mediated changes in HR (to simulated hypertension, i.e., NS) and MAP (to simulated hypotension, i.e., NP) were smaller in AAs compared with CAs at rest. These findings support inherent differences in short-term blood pressure regulation between racial groups that exhibit different relative risk for the development of blood pressure disease (e.g., hypertension).

In the current study, the AA group exhibited an attenuated HR response to simulated hypertension (i.e., NS) compared with the CA group (see Fig. 4A). Not only was this change in HR smaller in the AA group in response to the trials of NS, but the minimum HR detected from the CBR function curves (i.e., $A_m$, see Table 2) was greater in the AA group. That is, the CA group achieved a lower HR at the point of saturation of the carotid-cardiac function curve than the AA group by approximately nine beats per minute. Despite this clear discrepancy between HR responsiveness to simulated carotid hypertension in AAs and CAs, the MAP response to simulated hypertension was not different between racial groups in this study (see Fig. 4B). The latter finding was evident in both the separate responses to the trials of NS (see Fig. 4B) and the parameters of the CBR-vasomotor curves. Therefore, despite the different baroreflex-mediated reduction in HR, the baroreflex-mediated changes in MAP were similar. It appears then at rest, AA men are able to adequately buffer transient hypertensive stimuli via the CBR. This finding is particularly interesting in that it supports unique aspects of arterial blood pressure control between racial groups and suggests a potential difference between the reliant mechanisms by which acute hypertension is buffered (e.g., cardiac output vs. vascular tone) in AA and CA men.

The underlying mechanism for the attenuated CBR control of HR in AAs is likely related to altered CBR control of parasympathetic nerve activity. Considering that CBR control of HR has shown to be virtually abolished after full cardiac vagal blockade (28), CBR-mediated changes in HR using the 5-s NP/NS technique appear exclusive to vagal control. Zion et al. (43) demonstrated a significantly greater sympathetic-vagal balance (i.e., relatively greater sympathetic outflow vs. vagal tone) among AA subjects compared with non-AA subjects, as indicated by the ratio of low-frequency and high-frequency component of the power spectrum of HR variability. Future studies are warranted to further understand the CBR control of the heart in AAs and during conditions in which the vagal and/or sympathetic control of HR and cardiac output are altered (e.g., gravitational challenge, dynamic exercise, etc.).

Previous studies have reported exaggerated pressor responses among AAs to cold stimuli (4, 6, 9, 10, 22, 40) and vasoactive drug infusion (12, 35) compared with CAs. Also, racial differences in responses to LBNP have also been previously detected (16, 17, 31). In the present study, the magnitude of the MAP response to simulated hypotension (NP) was subtly attenuated, albeit statistically significant, in the AA group (see Fig. 3B). This difference, although “physiologically” small, further supports differential arterial baroreflex function between the racial groups studied. Therefore, it appears that AA men are less able to buffer acute hypotension, at least based on the magnitude of the CBR-mediated MAP responses, compared with their CA counterparts. While Hinds and Stachenfeld (17) recently demonstrated marked differences in orthostatic tolerance between AA and CA women, Franke et al. (16) demonstrated no racial differences in orthostatic tolerance using graded LBNP testing in AA and CA men. That said, throughout LBNP testing, AA subjects did exhibit reduced cardiac output and total vascular conductance responses compared with CA subjects. Ray and Monahan (31) demonstrated an attenuated MSNA response to graded LBNP in normotensive AA men and women. Additionally, AAs demonstrated greater increases in peripheral resistance per unit increase in sympathetic nerve activity (enhanced sympathetic vascular transduction) during LBNP compared with normotensive CAs. However, the extrapolation between findings from graded LBNP, which engages both cardiopulmonary and arterial baroreceptor populations, and isolated carotid baroreceptor stimulation (used in the current study) must be done cautiously as the nature of the stimuli are clearly different.

Data analyses within the present study included that of peak HR and MAP responses to the separate 5-s trials of NP and NS, as well as the parameters of the CBR function curves. Analyses from the carotid-cardiac function curves (HR$_{min}$) and the separate trials NS were supportive of reduced CBR responsiveness. In addition, while no significant differences were detected between groups for the carotid-vasomotor curve parameters, separate analysis of the MAP response to NP revealed significant racial differences. It is very likely that when the small, albeit a statistically significant, MAP response to NP in AA was combined with the MAP response to NS for the overall function curve analysis, the comparison between the overall curve parameters was unable to detect any differences. A more detailed understanding of baroreflex function may be unveiled through these separate analyses of sympatho-inhibitory and sympatho-excitatory stimuli, as well as the associated directionally different changes in vagal activity.

Limitations

The baroreflex-mediated changes in MSNA in response to simulated hypertension and hypotension were not quantified in the present study. Previous findings (31) have demonstrated increased vascular responses in AAs for a given change in MSNA compared with CAs. Therefore, the reduced arterial blood pressure control seen in the AAs in the present study could manifest as a significantly reduced CBR control of MSNA. That is, if sympathetic vascular transduction is indeed greater among AA (31), CBR control of MSNA would likely be markedly impaired to still result in reduced responsiveness to NP (i.e., a sympato-excitatory stimuli). Future studies using simultaneous assessment of CBR-mediated changes in MSNA and vascular responses (e.g., changes in conductance and/or resistance) in AAs are warranted to better understand racial differences in the reflex arc within the studied populations.

Due to the established consequence of family history on vascular responsiveness (36), we provided additional statistical analyses to account for the potential influence in the current study (i.e., two-way ANCOVA with family history as the covariate). Notably, even with a statistically significant main effect for family history as a covariate in some cases, the
statistical significance for main effects of both race and chamber pressure (factors 1 and 2, respectively) remained unchanged compared with the findings from the two-way ANOVA.

Potential limitations imposed by the technique used in the present study, i.e., 5-s trials of NP and NS, may include an abbreviated range of HR and MAP responses. It has previously been demonstrated that a carotid sinus perturbation of ~20 s is required to develop a full response for MAP (25). In regards to the technique used in the present study, administration of 5-s periods of NP and NS provides reflex activation independent of extra-carotid baroreceptors (i.e., the elimination of reflex blood pressure adjustments elicited via pressure changes sensed by aortic and cardiopulmonary baroreceptors). Previous findings (33) suggest that aortic and CBR arcs operate over the same range of arterial pressures, implying that the aortic and carotid baroreceptors likely work in parallel. Although the use of other techniques to assess baroreflex function (e.g., the modified Oxford, sequence techniques, etc.) might enhance our understanding of racial differences in dynamic blood pressure control, the carotid sinus stimulation in the present study (5-s trials of NP and NS) was adequate to establish significant differences between racial groups.

In the current study, only men were used to examine potential racial differences in CBR function. Previous findings support a reduced cardiovagal baroreflex gain in women (7), as well as altered baroreflex sensitivities throughout the menstrual cycle (37). Future studies investigating the interaction between race and gender on arterial baroreflex function may be warranted, particularly as Hinds and Stachenfeld (17) reported differential orthostatic tolerance between AA and CA women.

**Perspectives**

Several hypotheses have been tested in an effort explain the greater prevalence of hypertension among AAs relative to CAs. Some mechanisms, including elevated salt sensitivity, a blood pressure elevating condition (42), has been reported in nonhypertensive AAs (34). Further evidence supports altered function of the amiloride-sensitive epithelial sodium channel (ENaC) among AAs (3, 29) that may be linked to racial differences in the risk for hypertension. Also, a small nuclear polymorphism coding for potassium dependent sodium/calci- um exchanger has recently been reported as reaching genome-wide significance for systolic blood pressure among AAs (33). Another small nuclear polymorphism that correlates with systolic blood pressure and diastolic blood pressure (15). Li and colleagues (21) demonstrated the predictive nature of systolic blood pressure in AA children to carotid artery intima-media thickness in adulthood, an index of coronary artery disease. While these mechanisms account for and/or could be related to some of the racial differences in long-term blood pressure control, they do not account for other, neural-related mechanisms that may contribute to the prevalence and/or progression of vascular disease. Whether or not impaired CBR function among AAs can be introduced to the list of potential contributing factors to the development of hypertension is currently unknown. However, our findings are fundamental to future investigations of neural control of dynamic blood pressure regulation within the AA population.

In summary, AA individuals, a racial group that is at increased risk for the development of hypertension and hypertension-related death compared with CAs, exhibited impaired baroreflex control of HR and, to a lesser extent, impaired baroreflex control of MAP. Interestingly, these differences manifest somewhat differently for the control of HR and MAP (i.e., in response to hypotensive stimuli vs. hypertensive stimuli). While the mechanism for the impaired baroreflex control of HR is likely due to altered control of vagal activity, the mechanism(s) responsible for the impaired control of MAP remains elusive. Future studies examining baroreflex control of MSNA and vascular responsiveness will be vital in furthering our understanding of racial differences in dynamic blood pressure control. These findings provide an important first-step in understanding CBR function in AAs at rest.

**GRANTS**

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**DISCLOSURES**

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**REFERENCES**


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