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Spontaneous Baroreflex Sensitivity in Normotensive African-American Men

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Abstract

Purpose: African-American men (AAM) have a greater risk of hypertension (HTN) than Caucasian men (CM). To reduce this risk, determining the differences in mechanisms involved in HTN and understanding the relationship between these mechanisms and factors affecting blood pressure (BP) in AAM and CM is necessary. One such mechanism is spontaneous baroreflex sensitivity (sBRS) and two factors are cardiorespiratory fitness (CRF) and arterial stiffness (AS). The aims of this study were to determine, firstly, whether there are differences in sBRS between young, normotensive AAM and CM, and secondly, to determine if CRF and AS are significant predictors of sBRS in young, normotensive AAM and CM. **Methods:** Twenty-three normotensive AAM and 36 CM were recruited from Southern Connecticut State University. Measures included anthropometric, sBRS (alpha-index), and CRF (maximal oxygen consumption [VO_{2max}]), as well as AS (carotid-femoral pulse wave velocity [Cf-PWV]). Independent t-tests were used to determine differences between groups and multiple regression analysis was used to determine how much of the variation in sBRS was explained by CRF and AS. **Results:** The sBRS was significantly lower in AAM (10.3 ± 3.8 ms/mmHg) vs. CM (13.3 ± 5.7 ms/mmHg), P = 0.03. CRF and AS were not significant predictors of sBRS in AAM (P = 0.25) and CM (P = 0.30). There was no relationship between, sBRS, CRF and AS; CRF was significantly reduced in AAM vs. CM (45.1 ± 6.3 vs. 52.1 ± 7.5 $mL \cdot kg^{-1} \cdot min^{-1}$, P ≤ 0.001). **Conclusions:** Young normotensive AAM demonstrated significantly lower sBRS vs. CM, irrespective of having fair CRF and normal BP. CRF and AS are not significant predictors of sBRS in young, normotensive AAM and CM. The attenuation in sBRS in AAM did not result in AAM having higher BP versus CM. This finding underscores the need for more detailed examination of the role of sBRS in the etiology of HTN in AAM.

Keywords

African-American Men, Spontaneous Baroreflex Sensitivity, Cardiorespiratory Fitness, Arterial Stiffness, Hypertension

1. Introduction

Hypertension (HTN) is a major health problem around the world and research estimates that before 2026, more than 1.5 billion adults will be hypertensive [1]. The incidence of high blood pressure is greater in African-American men (AAM) versus their Caucasian counterparts [2], as well as all men [3]. This greater occurrence of HTN in AAM has become more noticeable since the 2017 Revised Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults [4] with an estimated 59 percent of AAM now considered being hypertensive. In an effort to reduce the prevalence of HTN in AAM, there is a great need to determine differences in the mechanisms involved in BP regulation in AAM and Caucasian men (CM), in addition to understanding the relationships among these mechanisms and factors that influence BP. One such mechanism is baroreflex sensitivity (BRS) [5] and two of the factors that affect BP are cardiorespiratory fitness (CRF) [6] [7] and arterial stiffness (AS) [8].

Rapid spontaneous changes in arterial BP are buffered by the baroreflex and the examination of BRS has been shown to impart pertinent cardiovascular prognostic information. There is a concomitant deviation from normal baroreflex activity with regards to certain cardiovascular conditions [9] [10]. This reflex is particularly important as it is involved in both the short-term and long-term regulation of BP [11] [12]. An attenuation in BRS is associated with increased BP [13]. While there are many methods of assessing BRS, the spontaneous method (sBRS) is one of the least intrusive and easiest method to administer, and has been shown to hold valuable clinical information [14].

Exercise is considered to be medicine, making CRF an important factor to consider in all health conditions, with a lack of exercise associated with negative health outcomes. CRF is a good indicator of general health and is a measure of aerobic capacity [15], but more specifically as related to BP, increased CRF is associated with an attenuation in BP [6] [7]. Conversely, AS, which is dependent on the intrinsic elasticity of the arterial wall, is associated with an augmentation of BP [8].

One study has suggested differences in BRS between AAM and other men; AAM in this study demonstrated reduced arterial compliance but similar levels of CRF [16] to other men. Another study demonstrated impairment in baroreflex in AAM versus CM using the neck chamber method; again, there was no difference in CRF between the groups [17]. Interestingly, lower BRS has also been observed in African American women versus Caucasian women [18]. Due to the greater prevalence of HTN in AAM, coupled with the relevance of BRS in BP regulation and the observation that CM have a lower incidence of HTN versus AAM, there is a need then to add to the body of knowledge in the comparisons of BRS in AAM and CM, and the relationship between BRS, CRF and AS in young, normotensive AAM and CM.

Therefore, this study aimed to determine, firstly, whether there are differences in sBRS between young, normotensive AAM and CM, and secondly, to determine if CRF and AS are significant predictors of sBRS in young, normotensive AAM and CM. We hypothesized that sBRS would be significantly diminished in AAM versus CM and that CRF and AS would be significant predictors of sBRS in young, normotensive men.

2. Methods

2.1. Subjects and Test Procedures

Participants included 23 AAM and 36 young, normotensive CM from the Southern Connecticut State University student population. Inclusion criteria included no clinical indications of cardiovascular or metabolic disease, being a nonsmoker, medication-free, and possessing normal electrocardiogram (ECG) and BP patterns. This research complied with the Helsinki Declaration and was approved by the Institutional Review Board at Southern Connecticut State University. Each participant reviewed and signed an informed consent.

Participants arrived for testing between 7:00 and 10:00 a.m. Prior to arrival they were advised not to exercise for 48 hours or consume food for 12 hours before testing but were allowed to drink water. Anthropometric measurements were taken and, after 5 minutes of seated rest, two to three BP measurements were taken; the mean value was used to indicate systolic blood pressure (SBP) and diastolic blood pressure (DBP).

2.2. Measures

2.2.1. Assessment of sBRS

The sBRS measurement was performed in an ambient temperature of 21˚C and sBRS was determined by the alpha-index, derived as the square root of the ratio of low frequency (LF_{R-R}) of heart rate variability (HRV) over the low frequency of systolic BP beat-to-beat variation (LF_{SBP}). This method was validated and seen to have a correlation of 0.94 with the phenylephrine method, considered to be the gold standard [19].

For the sBRS measurement, participants were instrumented with a Nexfin monitor (BMEYE, Netherlands), which used ECG to determine continuous R-R interval measurements, and a finger BP cuff to determine beat-to-beat BP; both LF_{R-R} and LF_{SBP} were derived from these measures. The above measures were taken for 8 minutes in a seated position at a sampling frequency of 1000 Hz. Participants were asked to breathe at 12 breaths min^{-1} (0.2 Hz), guided by a light moving up and down on a computer screen. This breathing protocol avoided the effect of a varied respiratory rate on spectral distributions [20].

Power spectral density analysis of HRV and systolic BP beat-to-beat variation via the fast Fourier transform was used to determine measures of LF_{R-R} and LF_{SBP}. Power spectra within the 0.04 - 0.15 Hz bandwidths were defined as the LF_{R-R} and LF_{SBP} components of HRV and systolic BP beat-to-beat variation.

2.2.2. Assessment of AS

Carotid-femoral pulse wave velocity (Cf-PWV) was used to determine AS. Cf-PWV was measured from a supine position with a SphygmoCor system (AtCor Medical Pty Ltd., West Ryde, Australia). Pulse measurements were taken from the carotid and femoral artery simultaneously with ECG recording. Cf-PWV was determined by measuring the time delay between two timing points on two pressure waveforms that were at a known distance apart. Here the foot of the waveform was used as an onset point for calculating the time differences between the R wave of the ECG and the pulse waveforms at each site [21]. Cf-PWV was calculated as the carotid-femoral artery distance divided by the wave traveling time between the two measuring sites [21].

2.2.3. Assessment of VO_{2max}

VO_{2max} was used as a measure of CRF; values were derived using a Parvo Medics TrueOne 2400 metabolic measuring system (Parvo Medics, Sandy, UT). VO_2max testing was performed on a computer-controlled, motorized Trackmaster Treadmill (Full Vision Inc., Newton, KS) using the Bruce Treadmill Protocol. The fatigue level of participants was assessed via the Borg rating of perceived exertion scale; this assessment was taken at the end of each stage of the protocol. The stage progressed from the previous one every three minutes by increasing the work rate (speed and grade), until VO_2max was reached. VO_2max was confirmed in all subjects through a combination of at least two of the four following criteria: a plateau in oxygen consumption despite an increased work rate; a respiratory exchange ratio (RER) > 1.10; a HR within 10 beats min^{-1} of the age-predicted maximum (220-age); or volitional fatigue.

3. Data Analysis

Means and standard deviations are presented for the descriptive characteristic variables of age (years), height (centimeters), body mass (kilograms), body mass index ($kg \cdot m^{-2}$), SBP (millimeter of mercury) and DBP (millimeter of mercury), alpha-index (ms/mmHg), pulse wave velocity (m/s), and maximal oxygen consumption ($mL \cdot kg^{-1} \cdot min^{-1}$) for AAM and CM. Independent sample t-tests were performed to determine whether differences in the aforementioned variables exist by ethnicity. Multiple regression analyses were performed to determine how much of the variation in the outcome variable (alpha-index) was explained by the predictor variables of VO_2max and Cf-PWV. Significance was set at $P < 0.05$ for all statistics and analyses were obtained using SPSS for Windows, Version 23 (IBM Corporation 2015, Armonk, NY).

4. Results

Fifty-nine participants completed the study protocol (23 AAM, 36 CM). Table 1 shows the sample descriptive statistics for participants by ethnicity. Independent sample t-tests indicated lower mean values for the alpha-index and VO_2max means in AAM vs. CM ($p < 0.05$ and $p < 0.001$, respectively) (Table 1). However, there was no significant mean difference for age, height, body mass, BMI, SBP, DBP, and Cf-PWV between groups ($p < 0.05$) (Table 1). Multiple regression analysis with the alpha-index as the dependent variable and VO_{2max} and Cf-PWV as predictors indicated that in AAM, VO_2max and Cf-PWV explained 13 percent of the variation in the alpha-index and 7 percent in CM. ANOVA indicated that VO_{2max} and Cf-PWV are not significant predictors of the alpha-index in young, normotensive AAM and CM ($p < 0.05$), and no relationship was found between the dependent variable and predictors in AAM and CM ($R = 0.35$, $R = 0.26$) respectively (Table 2).

Table 1. Participant characteristics and factors associated with HTN.

	African-American Men (N23)		Caucasian Men (N36)		P^a
	Mean	Range	Mean	Range	
Age (yrs)	21.00 ± 2.93	13.00	21.91 ± 3.33	14.00	0.27
Height (cm)	173.95 ± 8.75	35.00	176.19 ± 5.36	27.00	0.22
Body mass (kg)	76.91 ± 9.48	39.00	77.72 ± 11.35	56.00	0.76
BMI (kg/m^2)[b]	25.44 ± 2.71	10.72	25.01 ± 3.26	15.02	0.59
Alpha-index (ms/mmHg)	10.35 ± 3.80	16.86	13.36 ± 5.76	25.46	0.03
SBP (mm Hg)[c]	112.47 ± 7.00	28.00	111.80 ± 8.11	30.00	0.73
DBP (mm Hg)[d]	67.21 ± 6.76	20.00	67.22 ± 6.59	22.00	0.99
Cf-PWV (m/s)[e]	6.30 ± 0.96	3.80	6.08 ± 0.87	4.30	0.38
VO_2max ($mL·kg^{-1}·min^{-1}$)[f]	45.14 ± 6.33	28.00	52.19 ± 7.58	37.10	<0.001[g]

Data are mean values ± standard deviation; [a]*P* values from an independent t-test; [b]Body mass index; [c]Systolic blood pressure; [d]Diastolic blood pressure; [e]Carotid femoral pulse wave velocity; [f]Maximal oxygen consumption; [g]$P < 0.05$.

Table 2. Model summary for multiple regression analysis with Cf-PWV and VO_2max as predictors and the alpha-index as the outcome.

Ethnicity	Model	R	R^2	*P*
AMM	1) Cf-PWV, VO_{2max}	0.356	0.127	0.258
CM	2) Cf-PWV, VO_{2max}	0.263	0.069	0.307

$P < 0.05$.

5. Discussion

The main findings of this investigation are that young, normotensive AAM have lower sBRS than CM and that CRF and AS were not significant predictors of sBRS in both groups of men. Additionally, AAM demonstrated lower CRF and similar levels of AS to CM.

Normally, the finding of reduced sBRS in AAM would be particularly significant given the role of baroreflex in regulating BP. However, the observation of AAM having lower sBRS in the presence of similar BP to CM suggests that perhaps the reduced sBRS observed in this group of AAM was not enough to elicit a significant elevation in BP. Additionally, it could also suggest that the role of sBRS in the long-term regulation of BP might be different in young, normotensive AAM and CM. Here, it would appear that sBRS in young, normotensive men may hold different clinical cardiovascular information for AAM versus CM.

The current study demonstrated that CRF and AS were not significant predictors of sBRS in young, normotensive AAM and CM, and that AAM had significantly lower CRF versus CM. While our finding of reduced BRS in AAM was in keeping with a prior study that demonstrated an attenuation of BRS in AAM versus other men [16], and another that found impairment in baroreflex control of the pacing of the heart in AAM [17]; these studies demonstrated diminished BRS in AAM with similar levels of CRF to CM. Additionally, these studies did not examine how much of the variation in BRS was explained by CRF and AS. Conversely, the current study examined sBRS in AAM and CM with different levels of CRF, and sought to determine if CRF and AS were significant predictors of sBRS. Since CRF has been found to be positively associated with BRS in past studies, one could speculate that the attenuation in sBRS observed in AAM could be the result of them having significantly lower CRF versus CM. However, many of the studies demonstrating a positive relationship between CRF and BRS were done with various clinical populations [22] [23] [24]. The population in the current study was young, normotensive men, with no evidence of cardiorespiratory or metabolic disease, and as such the relationship between BRS, CRF and AS might be different in this group versus different clinical groups.

In an effort to gain a greater understanding of the relationship between sBRS, CRF and AS, we examined how much of the variation in sBRS was explained by CRF and AS using multiple regression analysis. Here, CRF and AS were entered into regression models as predictors of sBRS. We found that CRF and AS were not significant predictors of sBRS in both AAM and CM, explaining only 13% and 7% of the variation in sBRS, respectively. This finding of CRF and AS not being significant predictors of sBRS was not in keeping with our second hypothesis. Here, there was a lack of relationship between CRF and AS combined, and sBRS in both AAM and CM as indicated by R values of 0.35 and 0.26, respectively.

Interestingly, the mean CRF value for the AAM group was within the VO_{2max} category of "fair" (42 - 45 $mL \cdot kg^{-1} \cdot min^{-1}$) [25]. However, despite being in the category of having fair CRF, AAM still had an attenuation in sBRS. The attenuation in sBRS in AAM, despite them being in the CRF category of fair, combined with a lack of relationship between sBRS and CRF, suggest that if AAM belonged to the CRF category of fair then CRF would not be significant in predicting their sBRS. Caution should be used when interpreting the finding of CRF not being a significant predictor of sBRS in young, normotensive AAM and CM, and special consideration should be given to the observation that the mean CRF values for both groups of men was within the CRF category of fair or above. We are not sure if the lack of relationship between sBRS and CRF would still exist if the CRF levels were lower in these young, normotensive men. It would be interesting to determine whether CRF would be a significant predictor of sBRS or not if the CRF level of a group of AAM were to fall in the poor category of CRF.

The finding of lower CRF in AAM versus CM corroborated prior studies [26] [27]. There are many possible explanations for lower CRF in African Americans versus Caucasians, including reduced muscle oxidative capacity as African Americans have been found to possess more glycolytic versus oxidative muscle fiber [28], reduced ability to transport oxygen, and reduced levels of physical activity [29].

The finding of AS not being a significant predictor of sBRS in both groups of men was not expected but was corroborated by the observation that both groups of men in the current study had no significant difference in AS while AAM had significantly lower sBRS versus CM.

This study did not seek to determine the reasons for the difference in sBRS between AAM and CM, or for CRF and AS not being significant predictors of sBRS as those were not the aims of this study. While answering these questions is beyond the scope of this study, this study could serve to highlight the need for a diligent focus on the relationship among sBRS, CRF and AS, when examining sBRS in young, normotensive AAM and CM.

6. Conclusions

As corroborated by past studies and in keeping with our first hypothesis, young normotensive AAM demonstrated significantly lower sBRS versus CM. This reduced sBRS was observed irrespective of AAM having fair CRF and normal BP. CRF and AS were not shown to be significant predictors of, and were not associated with, sBRS in young, normotensive AAM and CM, who were classified as having fair or above fair CRF levels. These findings suggest that, when examining the relationship between BRS and variables that are considered to be predictors of BRS, these relationships should be examined under different conditions.

As initially stated, the attenuation of sBRS in AAM did not result in AAM having higher BP versus CM. This finding underscores the need for more detailed examinations of the role of sBRS in the etiology of HTN in AAM.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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