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Defensive coping facilitates higher blood pressure and early sub-clinical structural vascular disease via alterations in heart rate variability: The SABPA study

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ABSTRACT

Objectives: Defensive coping (AC) responses in urban African males have been associated with vascular responsiveness, partly explaining autonomic nervous system dysfunction. We therefore aimed to assess whether AC responses facilitate higher blood pressure and early sub-clinical structural vascular disease via alterations in frequency- and time-domain heart rate variability (HRV) responses.
Methods: We included 355 African and Caucasian men and women without pre-existing atrial fibrillation, aged 45 ± 9 years. Significant interaction on main effects (coping × ethnicity × gender) for left carotid intima media thickness far wall (L-CIMTf) and cross sectional wall area values necessitated selection of AC responders above mean via the Coping Strategy Indicator. We collected B-mode ultrasound L-CIMTf, ambulatory BP and−HRV data. Overnight fasting blood was obtained.
Results: Overall, Africans and AC Africans, mostly men, revealed a poorer lifestyle profile, higher prevalence of hypertensive status, disturbed sympathovagal balance and depressed HRV temporal and geometric patterns compared to the Caucasians ($P \leq 0.05$). Moderately depressed non-linear and time-domain HRV (SDNN <100 ms) was prevalent in 28% of Africans compared to 11% of Caucasians. A similar trend was shown for the AC African participants (32%) compared to Caucasians (16%). Only depressed HRV time-domain (SDNN: adj. $R^2 = 0.34$; $\beta = -0.24$; $p = 0.08$) and vagal-impaired heart rate responses (RMSSD: adj. $R^2 = 0.28$; $\beta = -0.28$; $p < 0.05$) were associated with higher blood pressure and early structural vascular changes in AC African men.
Conclusion: Defensive coping facilitated autonomic nervous system dysfunction, which was associated with higher blood pressure and sub-clinical structural vascular disease in an African male cohort.

1. Introduction

Heart rate variability or oscillation in the interval between consecutive heart beats has considerable potential to assess the function of the autonomic nervous system in health, cardiovascular and non-cardiovascular disorders [1–3]. Signs of either increased sympathetic or reduced vagal activity (sympathovagal imbalance) have encouraged the use of frequency- and time-domain 24-h ambulatory ECG recordings [4]. Depressed heart rate variability (HRV) has been associated with increased sympathetic activity, systemic inflammatory responses, and blunting of circadian patterns [5,6] and is commonly observed in participants with chronic psychosocial stress and depression [7]. Furthermore, increased vascular responsiveness and hypertension have been well documented in urban Africans and have mostly been ascribed to

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psychosocial stress and associated lifestyle changes [8]. Chronic psychosocial stress in African Americans was also shown to be responsible for a ~40% prevalence of mild to moderate hypertension as well as for cardiovascular disease risk [9,10].

In particular, high defensive problem-solving active coping (AC) and not low AC or avoidance, loss of control (passive coping) responses in urban or city dwelling, African men demonstrated pathology [11]. Dissociation between β-adrenergic behavioral being-in-control and physiological cardiometabolic responses was observed [8,11]. The physiological responses of AC African males resembled a vascular α-adrenergic "loss of control" and endothelial dysfunction profile [8,11]. Whether similar dissociated AC responses in bi-ethnic gender groups will facilitate alterations in autonomic function and early structural vascular changes in the carotid intima media, still needs to be determined.

A lack of knowledge concerning environmental influences and emotional circumstances such as appraisal of stress in black African and white African (Caucasians) gender groups on HRV also emphasizes the need for an investigation [2]. Therefore the Sympathetic activity and Ambulatory Blood Pressure in Africans (SABPA) study is ideally suited and designed for investigating HRV, as participants are drawn from the same occupation with similar working conditions within a well-controlled setting. Our principal aim was to assess whether AC facilitates higher blood pressure and early sub-clinical vascular disease via alterations in frequency- and time-domain heart rate variability in a Black (African) vs. a Caucasian gender cohort from South Africa.

2. Methods

2.1. Study population

The SABPA study has a target population comparative design and was conducted from February 2008 until May 2009. We recruited 409 teachers, aged 25–65 years, working in the Dr Kenneth Kaunda Education district in the North West Province, South Africa. The reason for this selection was to obtain a homogenous sample from a similar socio-economic class. Exclusion criteria included pregnancy, lactation, psychotropic substance users, ear temperature >37.5 °C, vaccination or blood donation within 3 months prior to participation. For purposes of our sub-study, we additionally excluded participants with atrial fibrillation ($N = 16$), anxiolytic ($N = 1$) and beta-blocker ($N = 6$) medication users, HIV positive status ($N = 19$) and clinically diagnosed diabetes ($N = 13$). The final sub-sample comprised 162 Africans and 193 Caucasians.

The SABPA study abided by the institutional guidelines and terms of the Declaration of Helsinki (2008) and was approved by the Ethics Review Board of the North-West University, Potchefstroom Campus (0003607S6). The nature, benefits, and risks of the study were explained to the participants, and their written, informed consent was obtained before participation.

2.2. Research procedure

Ambulatory cardiovascular apparatus and physical activity meters were applied between 0700 h and 0900 h every morning of the working week. At 1630 h participants were transported to the Metabolic Unit Research Facility of the North-West University for an overnight stay in a relaxed, well-controlled setting. They were familiarized with the experimental setup and commenced with the psychosocial battery at 1800h under supervision of registered clinical psychologists. Participants were advised to go to bed at 2200 h, fasting overnight. At 0545 h they were woken and the 24-h apparatuses disconnected and anthropometric measures taken. A battery of clinical assessments followed with participants in semi-recumbent position for the resting 12-lead electrocardiogram (ECG) and venous blood sampling by a registered nurse and medical doctor. General health questionnaires were completed.

2.3. Life style confounders

Anthropometric measurements were taken in triplicate by registered anthropometrists. Body weight was measured with a digital Beurer scale (Model: Typ PS 07, GmBH, Germany) to the nearest 0.1 kg with the participant wearing minimal clothing and with the weight evenly distributed. Height was measured to the nearest 0.1 cm while the participant's head was in the Frankfort plane, heels together and buttocks as well as upper back touching the stadiometer (Invicta Stadiometer, IP 1465, UK). Body surface area (BSA) was calculated with the Mosteller formula. The Actical® (Mini Mitter, Bend OR, Montréal, Québec), an omnidirectional accelerometer monitor, was used to assess physical activity over 24 h by taking into account the metabolic rate (kcal/h). Serum cotinine levels, a metabolite of nicotine, were used as a marker of smoking status where >15 μg/L was regarded as being indicative of a smoker [12]. Gamma glutamyl transferase (γ-GT) was used as a marker of alcohol abuse (≥65 μ/L for men and ≥45 μ/L for women) [13].

2.4. Cardiovascular assessment procedures

The validated Cardiotens CE120® (Meditech, Budapest, Hungary) measured 24-h blood pressure and–ECG. We applied suitable cuffs on the non-dominant arm and the Cardiotens oscillometrically measured blood pressure at 30-min intervals during the day (0800–2200 h) and 60-min intervals at night (2200–0600 h) [14]. Successful mean 24 h inflation rate was 79.2% and the 24-h ambulatory ECG was assessed by two channel ECG recordings according to a pre-set program for 20 s at 5-min intervals. Participants were requested to continue with normal daily activities and record on their diary cards any abnormalities such as visual disturbances, headache, nausea, fainting, palpitations and stress. The data was analyzed using the CardioVisions 1.19 Personal Edition software (Meditech, Budapest, Hungary).

Temporal (frequency- and time-domain) analyses were applied to assess spontaneous oscillations resulting from sinus node depolarization obtained from ~3.5 h of valid analyzable ambulatory ECG data. The software program automatically filtered out ventricular, supraventricular as well as artifacts in RR intervals, and HRV outliers had been manually removed. Fast Fourier transformation performed frequency-domain analysis identifying the components in absolute (ms^2) and normalized units (nu) for high frequency (HF), low frequency (LF) and the LF/HF ratio. The LF/HF ratio is indicative of sympathovagal balance [2]. Time-domain analyses included measures of SDNN and RMSSD. SDNN in some contexts is predictive of cardiovascular outcome [1,2] and is defined as the standard deviation of the normal-to-normal (NN) intervals between adjacent QRS complexes, which equal the square root of variance. Since variance is mathematically equal to the total power of spectral analysis, the SDNN reflects all cyclic components responsible for variability in the period of recording. SDNN is regarded as the best overall prognostic tool for values <50 ms are indicative of highly depressed HRV, those between 50–100 ms indicate moderately depressed HRV and those >100 ms are classified as normal [1]. RMSSD, the root mean square of successive differences between adjacent RR intervals, is closely related to the high frequency (HF) component of the power spectrum [3]. Both SDNN and RMSSD reflect vagus nerve-mediated autonomic control of the heart.