Associations of conscientiousness with cardiac troponin T and stress coping responses in a teacher cohort: the SABPA prospective cohort study

Catharina Elizabeth Myburgh, Leoné Malan, Roland von Känel, Hendrik Stefanus Steyn, Nicolaas Theodor Malan

Abstract

Background: In a South African bi-ethnic cohort, defensive (DefS)/social support/avoidance coping strategies have been shown to influence cardiac troponin T (cTnT) levels through different stress signalling pathways. Personality traits (extraversion, neuroticism, conscientiousness, openness to experience, agreeableness) partially control stress coping responses and may affect prospective cardiac responses. Hence in this cohort, we aimed to examine relationships between personality traits and coping strategies, and to assess associations between cTnT changes over time, personality traits and coping strategies.

Methods: A cohort of African and Caucasian male and female teachers (n = 359) participating in both phases of the Sympathetic activity and Ambulatory Blood Pressure in Africans (SABPA) study, was prospectively followed for three years. Personality traits (Basic Traits Inventory) and coping (Coping Strategy Indicator) scores were determined. Fasting serum samples for cTnT determination were collected. Established hypertension-related cTnT cut-off points of 4.2 pg/ml (Africans) and 5.6 pg/ml (Caucasians) were applied.

Results: Higher neuroticism and lower conscientiousness scores were found in the Africans than in the Caucasians (p < 0.05). Both traits correlated with all three coping strategies in Caucasians, but only with DefS and avoidance coping in Africans. Over a period of three years, cTnT levels decreased in both races. Compared to Africans, Caucasians showed a greater recovery from the ethnic-specific cTnT cut-off point over time. In the Africans with high DefS scores, cTnT level changes were inversely associated with conscientiousness (adjusted R² = 0.14; β = –0.26). In Caucasians scoring high in avoidance coping, conscientiousness (odds ratio 0.84) and neuroticism (odds ratio 0.90) showed a lower likelihood of predicting the cTnT cut-off point.

Conclusion: In both races, conscientiousness may contribute to healthier stress coping responses and protect against cardiac ischaemia and risk of hypertension.

Keywords: personality traits, coping, cardiac ischaemia, troponin T

Stress has an impact on many bodily systems through neuroendocrine changes [sympathetic adrenal–medullary (SAM) and the hypothalamic–pituitary–adrenal (HPA) axes] that accompany the stress response. The heart is especially vulnerable to the effects of the stress response, as the autonomic nervous system directly innervates and controls the heart. Peripheral vascular changes in response to SAM- and HPA-axis activity may also alter loading conditions of the heart. Associations between myocardial ischaemia and injury, left ventricular dysfunction, coronary perfusion deficits and mental stress have been reported.

Cardiac troponin T (cTnT) is a cardiac-specific protein found in the contractile apparatus of the cardiomyocytes. Detection of this protein in blood samples has been ascribed to myocardial ischaemia with or without necrosis, left ventricular wall stress and a catecholamine overload following severe stress. In a South African cohort of Africans and Caucasians, a cTnT cut-off point of 4.2 pg/ml in the Africans and a higher cut-off point of 5.6 pg/ml in the Caucasians were predictive of 24-hour systolic hypertension. Moreover, in the African men, cTnT levels as low as 4.2 pg/ml were related to silent cardiac ischaemia and were proposed as a potential biomarker thereof.

According to the transactional stress theory, the magnitude of the stress response and consequent health outcomes are greatly influenced by cognitive appraisal of a stressor. Primary appraisal of a stressor as either a threat or a challenge is followed
by a secondary appraisal where coping options are evaluated to overcome the stressor.\textsuperscript{14,15} The three main coping strategies usually employed to deal with stress are active problem solving or defensive coping (DeS), seeking social support coping and avoidance coping.\textsuperscript{16} Effective management of stress and health promotion is usually associated with DeS and seeking social support coping.\textsuperscript{16} DeS involves the direct confrontation of the stressor in a highly action-orientated manner,\textsuperscript{14,16} whereas seeking social support coping usually involves approaching another individual or group for advice and comfort in the midst of stress.\textsuperscript{16,17} Avoidance coping on the other hand is more passive, directed at ignoring the stressful situation, facilitating negative health outcomes.\textsuperscript{14,19}

Avoidance coping, but not DeS or seeking social support coping, has been associated with greater incidence of and mortality from various cardiovascular diseases, including ischaemic heart disease.\textsuperscript{18} On the other hand, chronic DeS utilisation and sympatho-adrenal dysregulation responses in Africans predicted the hypertension-related cTnT cut-off point, thus indicating possible ineffectiveness of this coping strategy.\textsuperscript{1} Similar findings were not evident in their Caucasian counterparts who applied effective DeS.\textsuperscript{4,13} DeS is said to be ineffective when an individual loses control over the stressor, resulting in exaggerated stress responses, with subsequent negative health outcomes.\textsuperscript{19}

Coping or stress appraisal is partly determined by personality traits.\textsuperscript{19,20} The most widely accepted model used in personality trait research is the big five model of personality, which includes extraversion, neuroticism, conscientiousness, openness to experience and agreeableness.\textsuperscript{21-24} Viewing a stressor as a challenge and engaging in DeS have been ascribed to conscientiousness, extraversion and openness to experience,\textsuperscript{25} whereas threat appraisal of a stressor and engaging in avoidance coping have been related to higher scores in neuroticism.\textsuperscript{19} Both extraversion and agreeableness were also positively related with seeking social support coping.\textsuperscript{21,26}

Furthermore, personality traits have been found to be prospectively linked to health outcomes, including cardiac health.\textsuperscript{25,26} Despite a controversy regarding the specific relationship between personality traits and cardiac health, neuroticism and conscientiousness have proven to be more consistent in outcome prediction.\textsuperscript{27} Neuroticism, characterised by affect instability, anxiety and depression,\textsuperscript{28} was found to be a risk factor for cardiac morbidity, especially in relation to depressed heart rate variability\textsuperscript{29} and ischaemic heart disease.\textsuperscript{30,31} By contrast, high conscientiousness is usually associated with better cardiovascular health\textsuperscript{32} because these individuals experience higher levels of control over life stressors by finding taxing situations less demanding.\textsuperscript{33}

To the best of our knowledge, the effect of personality traits on stress coping responses and future cardiac health has not been investigated in a South African population. This investigation may also shed light on previous findings of DeS contributing to cardiac stress and ischaemia in Africans but not in Caucasians. As cTnT levels are indicative of cardiac morbidity risk in Africans and Caucasians from South Africa,\textsuperscript{29,30} studying this biomarker in relation to stress coping and personality traits may provide potential novel brain–heart link mechanisms. Therefore, in a bi-ethnic South African cohort, we aimed to (1) examine the relationships between personality traits and coping strategies, (2) assess associations between baseline personality traits and longitudinal changes in cTnT levels, and (3) examine hypertension-related cTnT cut-off points with regard to coping strategies.

**Methods**

The current study is nested in the SABPA prospective cohort study, of which a detailed protocol has been published elsewhere.\textsuperscript{16} Phase I of the SABPA study was conducted in 2008/2009 and the follow-up (phase II) data collection commenced three years later (2011/2012). The study complied with the guidelines of the Declaration of Helsinki on research in humans (2004).

The SABPA study included urban-dwelling African and Caucasian teachers of both genders, between the ages of 20 and 65 years at baseline. The teachers were recruited from the Dr Kenneth Kaunda district in the North-West province of South Africa. Except for cultural diversity, socio-economic status and occupational environment were similar for both races. During phase I, there were 409 participants after excluding individuals who were pregnant, lactating, had tympanum temperatures \( \geq 37.5^\circ \text{C} \) and were vaccinated or had donated blood three months prior to the commencement of the study. Furthermore, individuals who abused or were dependent on psychotropic substances were excluded.

All of the participants were invited three months prior to phase II and a high follow-up rate of 87.8% was achieved. For the current study, only participants who participated in both phases of the SABPA study (\( n = 359 \)) were included. Additional exclusion criteria were \( \beta \)-blocker use, history of myocardial infarction or stroke and left ventricular hypertrophy (\( n = 11 \)) at baseline. Participants with missing data (\( n = 8 \)) and outliers for three-year percentage change (\( \% \Delta \)) in cTnT level (\( n = 4 \)) were also excluded. The final study sample included 336 participants.

From Monday to Thursday between 07:00 and 08:00, four participants were fitted daily with 24-hour blood pressure (BP) and electrocardiogram (ECG) (Cardiotens CE120\textsuperscript{2}, Meditech, Budapest, Hungary) as well as 24-hour physical activity (Actical\textsuperscript{2} accelerometers, Montréal, Québec) apparatuses at the school. Thereafter participants continued with their normal daily activities. They had to report any irregularities on the issued 24-hour BP diary cards.

Participants were transported to the Metabolic Unit Research Facility of North-West University that afternoon, where they were each allocated a private bedroom. They were requested to refrain from smoking, the intake of caffeine or alcohol, as well as exercise within 12 hours prior to data sampling. In addition, they were introduced to the experimental set-up, completed the general health and demographic questionnaires and received HIV/AIDS pre-counselling.

The participants were served a standardised evening meal and completed the Coping Strategy Indicator (CSI), as well as the Basic Traits Inventory (BTI) questionnaire, all of which were done under the supervision of registered clinical psychologists. The participants were requested to go to bed at 22:00, fasting overnight.

At 06:00 the next day, the 24-hour apparatuses were disconnected after the last BP recording. Anthropometric measurements were taken, and participants remained in a semi-recumbent resting position for 30 minutes, with a 12-lead ECG and blood sampling starting after the resting phase.
Feedback was given to the participants on immediately available clinical measures in the privacy of their rooms, by a registered nurse, and referrals were made if deemed necessary. After breakfast the participants were transported back to their respective schools.

The CSI questionnaire was validated for use in ethnic groups and used to determine the coping strategies utilised during stressful situations. Before the participants started with the written questionnaire, they had to recall a stressful problem or incident they had encountered in the past six months, while bearing in mind their manner of coping therewith.

Each participant’s coping strategy was assessed using both deductive and inductive methodologies. The three coping strategies that formed part of the 33-item CSI questionnaire included: active problem solving or DefS, avoidance or loss of control, and seeking social support. The three sub-scales were assessed by dividing the 33 items into three sets of 11 questions. These questions were randomly ordered in the questionnaire.

According to the answer, every item was assigned a numerical value, namely: a lot (three points), a little (two points), or not at all (one point). A maximum score out of 33 was calculated for each sub-scale. The above-median coping scores included: 16 26–33 for DefS, 23–25 for social support coping and 19–22 for avoidance coping. High scores within each coping strategy sub-scale (≥ 31 for DefS, ≥ 28 for social support, ≥ 23 for avoidance coping) indicated preferred use of that strategy. The reliabilities, as measured by Cronbach α-coefficients for the SABPA study, were 0.83 for DefS, 0.84 for seeking social support coping and 0.69 for avoidance coping.

The BTI questionnaire was developed by Taylor and de Bruin for a South African context and measures the ‘big five’ factors of personality. The use of the BTI questionnaire was validated across different culture and language groups in South Africa. The five factors consist of certain facets and include the following: extraversion (positive affectivity, gregariousness, excitement seeking, ascendance, liveliness), neuroticism (anxiety, self-consciousness, depression, affective instability), conscientiousness (self-discipline, order, effort, dutifulness, prudence), openness to experience (actions, aesthetics, ideas, values, imagination) and agreeableness (compliance, straightforwardness, tenderness, modesty, pro-social tendencies).

The questionnaire includes 193 written statements covering the different facets for each factor. The participants had to indicate the degree to which they agreed with the statement that was measured on a five-point Likert scale ranging from ‘strongly disagree’ to ‘strongly agree’. These items were alternated with a 13-item social desirability scale, which also forms part of the BTI. Scores of 40–60 for individual personality traits were considered to be average, while low and high scores were the BTI. Scores of 40–60 for individual personality traits and three-year percentage change (Δ%) in cTnT level, independent of a priori selected covariates were tested with a three-way analysis of covariance (ANCOVA). The a priori covariates included age, and cotinine and GGT levels at baseline.

Independent t-tests were performed to compare general and clinical characteristics between the two races. Pearson’s chi-squared (χ²) test was used for determining prevalence and proportions. Mean differences in cTnT levels between baseline and three-year follow up were determined by means of dependent

Statistical analyses

All data analyses were done with Statistica version 13.3 (TIBCO Software Inc, Palo Alto, USA, 2018). Visual inspection of Q-Q plots, followed by Kolmogorov–Smirnov and Lilliefors tests, were performed to test normality of data, and non-normally distributed data were Box–Cox transformed. Before continuing with any analyses, interactions were computed to determine how groups should be divided. Interactions on main effects [race × gender × high DefS/seeking social support coping/avoidance coping] for each of the personality traits and three-year percentage change (Δ%) in cTnT level, independent of a priori selected covariates were tested with a three-way analysis of covariance (ANCOVA). The a priori covariates included age, and cotinine and GGT levels at baseline.

Independent t-tests were performed to compare general and clinical characteristics between the two races. Pearson's chi-squared (χ²) test was used for determining prevalence and proportions. Mean differences in cTnT levels between baseline and three-year follow up were determined by means of dependent...
sample t-tests within independent and African and Caucasian groups. Effect sizes for independent and dependent sample t-tests were determined by calculating Cohen’s $d$ (0.2 = small effect, 0.5 = medium effect and 0.8 = large effect), while phi ($\phi$)-values for Pearson’s chi-squared tests indicated effect sizes (0.1 = small effect, 0.3 = medium effect and 0.5 = large effect).4,46,47

McNemar case–control tests determined three-year incidence (negative at baseline becomes positive at follow up) and recovery (positive at baseline recovers to negative at follow up) frequencies for ethnic-specific cTnT cut-off points in Africans and Caucasians.4,46 The following formula was used to calculate $%\Delta$ over a period of three years:

$$%\Delta = \frac{(follow-up\ value - baseline\ value)}{baseline\ value} \times 100.$$  

Table 1. Baseline characteristics of a bi-ethnic South African cohort

<table>
<thead>
<tr>
<th>Variables</th>
<th>Africans ($n=155$)</th>
<th>Caucasians ($n=181$)</th>
<th>p-value</th>
<th>Cohen’s $d$</th>
<th>$\phi$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>$44.25 \pm 7.40$</td>
<td>$46.46 \pm 9.95$</td>
<td>0.023</td>
<td>-0.25</td>
<td></td>
</tr>
<tr>
<td>Men, $n$ (%)</td>
<td>$79 (50.97)$</td>
<td>$88 (48.62)$</td>
<td>0.931</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Women, $n$ (%)</td>
<td>$76 (49.03)$</td>
<td>$93 (51.38)$</td>
<td>0.668</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Lifestyle and biochemical measurements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotinine (ng/ml)</td>
<td>$26.11 \pm 60.52$</td>
<td>$24.72 \pm 82.03$</td>
<td>0.861</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>GGT (U/l)</td>
<td>$42.94 (27.67–74.54)$</td>
<td>$18.00 (12.00–30.00)$</td>
<td>&lt;0.001</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>$92.90 \pm 14.86$</td>
<td>$93.43 \pm 16.18$</td>
<td>0.754</td>
<td>-0.03</td>
<td></td>
</tr>
<tr>
<td>Physical activity (kcal/day)</td>
<td>$2584.94 (2156.28–3118.10)$</td>
<td>$2966.95 (2384.84–3528.59)$</td>
<td>&lt;0.001</td>
<td>-0.35</td>
<td></td>
</tr>
<tr>
<td>Total cholesterol:HDL cholesterol</td>
<td>$4.14 (3.22–5.03)$</td>
<td>$4.79 (3.67–6.25)$</td>
<td>0.002</td>
<td>-0.35</td>
<td></td>
</tr>
<tr>
<td>HbA1c (measured as %)</td>
<td>$7.62 \pm 7.28$</td>
<td>$7.87 \pm 9.30$</td>
<td>0.001</td>
<td>0.36</td>
<td></td>
</tr>
<tr>
<td>HbA1c (measured as %)</td>
<td>$7.30 \pm 3.74$</td>
<td>$7.60 \pm 5.12$</td>
<td>&lt;0.001</td>
<td>-0.52</td>
<td></td>
</tr>
<tr>
<td>Oestriadiol (pmol/l)</td>
<td>$101.30$</td>
<td>$79.13$</td>
<td>0.286</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>Coping scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defensive coping</td>
<td>$28.28 \pm 4.13$</td>
<td>$28.93 \pm 3.87$</td>
<td>0.134</td>
<td>-0.16</td>
<td></td>
</tr>
<tr>
<td>Defensive coping ≥ 31, $n$ (%)</td>
<td>$61 (39.35)$</td>
<td>$78 (43.09)$</td>
<td>0.488</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Seeking social support coping</td>
<td>$25.82 \pm 4.88$</td>
<td>$18.79 \pm 4.91$</td>
<td>&lt;0.001</td>
<td>1.44</td>
<td></td>
</tr>
<tr>
<td>Seeking social support coping ≥ 28, $n$ (%)</td>
<td>$61 (39.35)$</td>
<td>$8 (4.42)$</td>
<td>&lt;0.001</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>Avoidance coping</td>
<td>$21.34 \pm 3.74$</td>
<td>$23.70 \pm 5.12$</td>
<td>&lt;0.001</td>
<td>-0.52</td>
<td></td>
</tr>
<tr>
<td>Avoidance coping ≥ 23, $n$ (%)</td>
<td>$55 (35.48)$</td>
<td>$105 (68.01)$</td>
<td>&lt;0.001</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>Personality trait scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extraversion</td>
<td>$43.26 \pm 7.62$</td>
<td>$44.64 \pm 6.44$</td>
<td>0.077</td>
<td>-0.19</td>
<td></td>
</tr>
<tr>
<td>Neuroticism</td>
<td>$32.54 \pm 9.30$</td>
<td>$29.30 \pm 8.70$</td>
<td>0.001</td>
<td>0.36</td>
<td></td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>$44.90 \pm 7.87$</td>
<td>$47.87 \pm 6.70$</td>
<td>&lt;0.001</td>
<td>-0.40</td>
<td></td>
</tr>
<tr>
<td>Openness to experience</td>
<td>$44.96 \pm 7.32$</td>
<td>$44.92 \pm 6.63$</td>
<td>0.966</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Agreeableness</td>
<td>$52.83 \pm 6.45$</td>
<td>$52.29 \pm 5.59$</td>
<td>0.833</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Cardiac risk markers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cTnT (pg/ml)</td>
<td>$4.14 (2.99–5.42)$</td>
<td>$4.87 (3.19–7.03)$</td>
<td>0.001</td>
<td>-0.37</td>
<td></td>
</tr>
<tr>
<td>cTnT ≥ 4.2 pg/ml, $n$ (%)</td>
<td>$73 (47.71)$</td>
<td>$111 (61.67)$</td>
<td>0.011</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>NT-proBNP (pg/ml)</td>
<td>$33 (21.57)$</td>
<td>$70 (38.89)$</td>
<td>0.001</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>Haemodynamic measurements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24-h SBP (mmHg)</td>
<td>$131 \pm 14.53$</td>
<td>$125 \pm 12.52$</td>
<td>&lt;0.001</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>24-h DBP (mmHg)</td>
<td>$83 \pm 10.03$</td>
<td>$77 \pm 8.16$</td>
<td>&lt;0.001</td>
<td>0.65</td>
<td></td>
</tr>
<tr>
<td>24-h hypertension, $n$ (%)</td>
<td>$100 (64.52)$</td>
<td>$78 (43.09)$</td>
<td>&lt;0.001</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>Medication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-hypertensive drugs, $n$ (%)</td>
<td>$51 (32.90)$</td>
<td>$23 (12.71)$</td>
<td>&lt;0.001</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Thiazides, $n$ (%)</td>
<td>$19 (12.26)$</td>
<td>$9 (4.97)$</td>
<td>0.016</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>ACE inhibitor, $n$ (%)</td>
<td>$18 (11.61)$</td>
<td>$4 (2.21)$</td>
<td>0.001</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>Diabetes medication, $n$ (%)</td>
<td>$5 (5.81)$</td>
<td>$2 (1.10)$</td>
<td>0.016</td>
<td>0.13</td>
<td></td>
</tr>
</tbody>
</table>

Results of t-tests of independent groups are displayed as arithmetic mean ± standard deviation or as median (interquartile range) for variables that were not normally distributed. Chi-squared ($\chi^2$) tests were used to determine proportions and prevalence and are indicated as frequencies (%).

GTG, gamma glutamyl transferase; total cholesterol:HDL cholesterol, total cholesterol to high density lipoprotein cholesterol ratio; HbA1c, haemoglobin A1c; cTnT, cardiac troponin T; NT-proBNP, N-terminal pro-brain natriuretic peptide; SBP, systolic blood pressure; DBP, diastolic blood pressure; ACE, angiotensin converting enzyme.

Effect sizes are indicated by Cohen’s $d$ or $\phi$-values. Cohen’s $d$ for independent t-tests: 0.2 = small effect, 0.5 = medium effect and 0.8 = large effect. $\phi$-values for chi-squared tests: 0.1 = small effect, 0.3 = medium effect and 0.5 = large effect.
traits were never added simultaneously into the models to avoid co-linearity.

Logistic multiple regressions were used to indicate the probability or odds of personality traits (exposure) to increase or decrease the likelihood of meeting ethnic-specific cTnT cut-off points (outcome) with and without considering specific coping styles. An odds ratio (OR) > 1 is indicative of a higher likelihood of an outcome upon exposure, whereas an OR < 1 is indicative of a lower likelihood of an outcome upon exposure. An OR = 1 indicates that the outcome is not affected by the exposure. A statistical level of $p < 0.05$ indicated significance in all analyses.

To ensure that the outcome of our regression analyses was not influenced by cases with atrial fibrillation ($n = 4$) and other lifestyle factors (waist circumference, physical activity), we repeated the regressions by excluding these cases and adjusting for waist circumference and physical activity.

**Results**

All three coping strategies and race showed interaction effects for neuroticism [race $\times$ DefS $\geq$ 31, ($F_{1,325}$ = 4.60; $p = 0.033$)]; [race $\times$ seeking social support coping $\geq$ 28, ($F_{1,325}$ = 4.18; $p = 0.042$)]; [race $\times$ avoidance coping $\geq$ 23 ($F_{1,325}$ = 21.73; $p < 0.001$)]. An interaction term was fitted for conscientiousness in DefS $\geq$ 31 groups ($F_{1,325}$ = 6.43; $p = 0.012$). No significant interactions were evident between gender and personality traits. We therefore stratified our groups according to race, but also divided each race into the respective coping strategies when associations were assessed in regression analyses, additionally adjusting for gender.

In Table 1, Cohen’s $d$ showed small to large effect sizes when comparing lifestyle and biochemical markers, mean coping and personality scores, as well as cardiac risk markers and medication usage. Only those variables showing statistically significant differences are now reported.

Compared to Caucasians, Africans were younger ($d = -0.25$), consumed more alcohol ($d = 0.63$), engaged in less physical activity ($d = -0.35$), had less dyslipidaemia ($d = -0.35$), albeit higher hyperglycaemic values ($d = 0.63$). Although the number of Africans and Caucasians scoring high inDefS was similar, more Africans scored high on the seeking social support coping scale ($\phi = 0.43$), whereas a greater number of Caucasians scored high on the avoidance coping scale ($\phi = 0.23$). Africans also scored higher in neuroticism ($d = 0.36$), but lower in conscientiousness ($d = -0.40$) than Caucasians.

When comparing cardiac and haemodynamic risk markers, Africans demonstrated lower cTnT levels ($d = -0.37$) and were more hypertensive ($\phi = 0.21$), with higher 24-hour SBP ($d = 0.50$) and DBP ($d = 0.65$) than the Caucasians. Almost half of the African participants (48%) and 39% of the Caucasian participants showed cTnT values similar to or greater than the ethnic-specific cut-off points (Africans: 4.2 pg/ml; Caucasians: 5.6 pg/ml) that were previously shown to be predictive of 24-hour hypertension. Furthermore, $\phi$-values for medication use showed low to medium effect sizes, which included greater usage of anti-hypertensives ($\phi = 0.24$), thiazides ($\phi = 0.13$), angiotensin converting enzyme inhibitors ($\phi = 0.19$) and diabetes medication ($\phi = 0.13$) in the Africans.

Unadjusted longitudinal changes are presented in Table 2, where cTnT levels over time decreased in both races. Africans showed no significant three-year frequency variance in the ethnic-specific cTnT cut-off point of 4.2 pg/ml, while Caucasians showed low incidence (7%), with greater recovery (18%) from the 5.6 pg/ml cut-off point (OR: 2.67, $p = 0.003$).

Table 3 presents correlations between coping scores and personality traits. In both Africans and Caucasians, DeS was correlated positively with conscientiousness but inversely with neuroticism. A positive correlation was evident between DeS and openness to experience in Africans. The seeking social support coping score correlated positively with extraversion in the African group, but inversely in the Caucasian group. Furthermore, seeking social support coping in Caucasians was positively correlated with neuroticism, but inversely with conscientiousness. A positive correlation in the African group but an inverse relationship in the Caucasian group was evident between avoidance coping and neuroticism. In both the Africans and Caucasians, linear relationships did not exist ($p > 0.05$; $r = 0$) between personality traits and gene data (mitochondrial DNA, tyrosine hydroxylase C-824T SNP and telomere length).

Caucasians showed no significant associations between %Δ cTnT and the independent variables in Table 4. In Africans, %Δ cTnT was inversely associated with conscientiousness (adjusted $R^2 = 0.14$; $\beta = -0.26$, $p = 0.034$) in individuals scoring high in DeS. These coefficients show that when conscientiousness
increases by one standard unit, %Δ cTnT will decrease by 0.26 (i.e. 0.26 standard deviations on the %Δ cTnT scale).

Logistic multiple regression analyses (Table 5) in the Caucasian group showed that conscientiousness was associated with a lower likelihood of meeting a previously defined cTnT cut-off point of 5.6 pg/ml [OR 0.91 (0.84–0.97), p = 0.007], thereby indicating that conscientiousness lowered the probability of meeting the cut-off point by 9%. In Caucasians with high avoidance coping scores, both neuroticism [OR 0.90 (0.83–0.98), p = 0.021] and conscientiousness [OR 0.84 (0.74–0.96), p = 0.013] also lowered the probability of meeting this cut-off point by 10 and 16%, respectively. No significant associations were seen in the African group.

Multiple linear and logistic regressions were not performed in Caucasians seeking social support coping at scores ≥ 28, because the sample size was too small (n = 8). Excluding atrial fibrillation cases and adjusting for waist circumference and physical activity did not change the results of the regression analyses.

### Discussion

In a bi-ethnic South African cohort, we aimed to examine relationships between personality traits and coping strategies, and to assess associations between established hypertension-related cTnT cut-off points, personality traits and coping strategies. We

#### Table 4. Forward multiple regression analyses indicating associations between three-year changes in cardiac troponin T and personality traits in a bi-ethnic cohort with and without considering coping style

<table>
<thead>
<tr>
<th></th>
<th>Africans (n = 155)</th>
<th>Defensive coping score ≥ 31 (n = 61)</th>
<th>Seeking social support coping score ≥ 28 (n = 61)</th>
<th>Avoidance coping score ≥ 23 (n = 55)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjusted R²</td>
<td>β (95% CI)</td>
<td>β (95% CI)</td>
<td>β (95% CI)</td>
</tr>
<tr>
<td>Extraversion</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Openness to experience</td>
<td>-0.16 (-0.32; -0.00)</td>
<td>0.050</td>
<td>-0.24 (-0.48; 0.00)</td>
<td>0.056</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

Forward stepwise regression analyses showing standardised regression coefficients β (95% confidence interval). We applied case-wise deletion with F to enter 2.5 and F to remove 0.5. Additional independent variables included gender, age, cotinine and log gamma-glutamyl transferase. %Δ, percentage change; cTnT, cardiac troponin T; NS, not significant.

#### Table 5. Probability of personality traits to predict hypertension-related cTnT cut-off points in Africans and Caucasians with and without considering coping style

<table>
<thead>
<tr>
<th></th>
<th>Without considering coping style</th>
<th>Defensive coping score ≥ 31</th>
<th>Seeking social support coping score ≥ 28</th>
<th>Avoidance coping score ≥ 23</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR (95% CI)</td>
<td>p</td>
<td>OR (95% CI)</td>
<td>p</td>
</tr>
<tr>
<td>Extraversion</td>
<td>0.97 (0.91–1.04)</td>
<td>0.244</td>
<td>0.99 (0.89–1.10)</td>
<td>0.860</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>1.01 (0.97–1.06)</td>
<td>0.515</td>
<td>0.94 (0.85–1.03)</td>
<td>0.175</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>0.99 (0.93–1.06)</td>
<td>0.807</td>
<td>0.90 (0.77–1.05)</td>
<td>0.469</td>
</tr>
<tr>
<td>Openness to experience</td>
<td>0.98 (0.91–1.06)</td>
<td>0.618</td>
<td>1.00 (0.86–1.16)</td>
<td>0.972</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>1.07 (1.00–1.13)</td>
<td>0.064</td>
<td>1.06 (0.93–1.21)</td>
<td>0.383</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Total (n = 155)</th>
<th>Defensive coping score ≥ 31 (n = 61)</th>
<th>Seeking social support coping score ≥ 28 (n = 61)</th>
<th>Avoidance coping score ≥ 23 (n = 55)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjusted R²</td>
<td>β (95% CI)</td>
<td>β (95% CI)</td>
<td>β (95% CI)</td>
</tr>
<tr>
<td>Extraversion</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Openness to experience</td>
<td>-0.16 (-0.32; -0.00)</td>
<td>0.050</td>
<td>-0.24 (-0.48; 0.00)</td>
<td>0.056</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

Forward stepwise regression analyses showing standardised regression coefficients β (95% confidence interval). We applied case-wise deletion with F to enter 2.5 and F to remove 0.5. Additional independent variables included gender, age, cotinine and log gamma-glutamyl transferase. %Δ, percentage change; cTnT, cardiac troponin T; NS, not significant.

#### cTnT cut-off point of 4.2 pg/ml

<table>
<thead>
<tr>
<th></th>
<th>Africans (n = 181)</th>
<th>Defensive coping score ≥ 31 (n = 78)</th>
<th>Seeking social support coping score ≥ 28 (n = 8)</th>
<th>Avoidance coping score ≥ 23 (n = 105)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR (95% CI)</td>
<td>p</td>
<td>OR (95% CI)</td>
<td>p</td>
</tr>
<tr>
<td>Extraversion</td>
<td>0.97 (0.90–1.04)</td>
<td>0.376</td>
<td>0.92 (0.79, 1.07)</td>
<td>0.275</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>0.96 (0.90–1.01)</td>
<td>0.92</td>
<td>0.91 (0.81, 1.03)</td>
<td>0.129</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>0.91 (0.84–0.97)</td>
<td>0.807</td>
<td>0.93 (0.82, 1.07)</td>
<td>0.307</td>
</tr>
<tr>
<td>Openness to experience</td>
<td>1.05 (0.97–1.14)</td>
<td>0.225</td>
<td>1.13 (0.95–1.35)</td>
<td>0.157</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>1.02 (0.93–1.11)</td>
<td>0.692</td>
<td>1.02 (0.86–1.22)</td>
<td>0.800</td>
</tr>
</tbody>
</table>

Data adjusted for gender and a priori covariates (age, cotinine and gamma-glutamyl transferase). Odds ratio (OR) > 1: higher likelihood of an outcome upon exposure; OR < 1: lower likelihood of an outcome upon exposure; OR = 1: outcome is not affected by the exposure. cTnT, cardiac troponin T.
found that conscientiousness may protect against prospective
cardiac ischaemia and hypertension risk by contributing to
healthier DeS and avoidance coping responses in Africans and
Caucasians respectively.

Decreases in cTnT levels over a period of three years were
observed in both races. Even though cTnT levels decreased over
time in Africans, their mean cTnT levels after three years were
still similar to 4.2 pg/ml (4.15 pg/ml), the cut-off point that has
previously been related to hypertension risk in this cohort.4,53

It was proposed that these low cTnT levels may be reflective
of silent cardiac ischaemic events in Africans, as positive
associations were observed among these variables in a previous
study.10

In the current investigation, the African group showed no
frequency changes for incidence or recovery from this cut-off
point, therefore showing ongoing silent cardiac ischaemia and
hypertension risk at low levels of cTnT. Furthermore, a previous
study indicated that this risk appears to be stress related as DeS
was associated with cTnT levels above this cut-off point in the
African cohort.1 Indeed, the manner of coping with mental stress
has been shown to differ in the cardiovascular changes it brings
about.19,23

Coping strategy selection and the ultimate efficacy of the stress
response, with subsequent negative mental and physical health
outcomes,19,23

Avoidance coping, on the other hand, rather evokes an
β-adrenergic vasodilation of the coronary arteries
accompanies an in-control stress response, to meet the increased
oxygen demand.11 A β-adrenergic profile upon stress exposure is
usually associated with DeS and accompanying social support,
and was also previously reported in Caucasians from the SABPA
study.52 This is indicative of successful coping, as the coping
resulted in stress reduction by preventing an exaggerated stress
response, with subsequent negative mental and physical health
outcomes.19,23

In the current study, results were significant in only Africans
with high DeS scores and also in Caucasians who reported high
avoidance coping scores, therefore strengthening the statement
that coping strategies form an integral part of the stress response.
Coping strategy selection and the ultimate efficacy of the stress
coping process is further partly dependent on personality traits,
as these traits greatly determine the cognitive appraisals forming
part of the transactional stress theory.20,21 Furthermore, while
personality traits are more stable, flexibility in coping behaviour
is possible.19 Investigating relationships between personality
traits and coping strategy scores provided us with a better view
of why the two races engaged in different coping behaviours,
with different cardiac health outcomes.

Although high scores within each coping strategy sub-scale
indicated preferred use of that specific strategy, scoring high
on multiple sub-scales is permitted by the CSI.19 High scores
on multiple sub-scales are an indication of flexibility in coping
strategies rather than the fixed use of one strategy for all stressors.16
The amount of Africans scoring high in DeS and
seeking social support coping were similar, although fewer
individuals scored high in avoidance coping, indicating that
Africans rely on the former two strategies for stressor encounters.
This is in agreement with other findings that social support
networks can increase the efficacy of DeS.53,54 As a collectivist
culture, Africans tend to depend more on each other, explaining
their tendency to make use of social support systems.3,6,53,54

The Caucasians by contrast showed flexibility with regard to
DeS and avoidance coping, rather than utilising social
support seeking coping. In the Caucasians’ individualistic
culture, independency is regarded as important and may
therefore explain why these individuals do not rely on social
support coping.6,53,54 For Africans, the decrease in social support
systems and individualism that accompanies an urbanised
Western culture may leave them more emotionally distressed,
which may explain their higher neuroticism score, compared to
Caucasians.16,20

Despite a higher neuroticism score, Africans also scored lower
in conscientiousness compared to Caucasians. In both races,
neuroticism was associated inversely and conscientiousness
positively with DeS. High conscientiousness in particular has
been related to increased problem-solving coping, also known as
DeS abilities, likely because these individuals experience higher
levels of control over life stressors by finding taxing situations
less demanding and viewing them as challenges rather than
threats.19

Neuroticism rather refers to the overall tendency to view
stressors as threats with inadequate coping resources to overcome
it, and includes facets of anxiety, self-consciousness, depression
and affective instability.39 Therefore it is clear that higher
neuroticism may prevent effective DeS as coping efforts are
focused at regulating emotions.19 It is therefore not surprising
that neuroticism also related positively with passive emotional or
avoidance coping in Africans.

Zwir et al.20 proposed that organised interactions among
700 genes influence self-regulatory personality traits despite
different cultures and environments. Unfortunately, the gene
for the serotonin transporter polymorphism (5-HTTLPR),20,37
which is known to make a person more emotional,49 was not
determined in the SABPA cohort. However, the genetic data
available in the SABPA study did not suggest any relationship
between BTI personality traits and mitochondrial DNA tyrosine
hydroxylase C-824T SNP or telomere length.80

In the Caucasians, neuroticism was inversely associated with
avoidance coping, but positively with social support coping.
Furthermore, in the Caucasian group, conscientiousness also
 correlated inversely with social support coping. The discrepancy
observed in the Caucasians may be explained by their
individualistic culture, as they appear to only turn to social support
systems in the event of intense negative feelings (neuroticism)
and low problem-solving abilities (conscientiousness).

Despite conscientiousness and neuroticism being among the
personality traits that were mostly related to the utilisation of
coping strategies in our investigation, these traits have also been
shown to be mostly associated with different cardiac health
outcomes in other studies.17,18,29,30,31,33 Our results also showed that
conscientiousness was inversely related to three-year cTnT level
changes in Africans with high DeS. Furthermore, both
conscientiousness and neuroticism decreased the likelihood of
meeting the ethnic-specific cTnT cut-off point (OR < 1.00) in the
Caucasians with high avoidance coping.

Personality traits such as conscientiousness and neuroticism
may facilitate certain lifestyle choices, such as engaging in
physical activity.79,84 Interestingly, Caucasians from the current
study were more physically active than the Africans. There is a possibility that the combination of high conscientiousness but low neuroticism in Caucasians could have contributed to the chosen lifestyle choice, with beneficial effect for their emotional well-being and cardiac health.29,42

The engagement in physical activity has been shown to buffer prolonged emotional stress by enhancing self-esteem and feelings of competence, and appraising stressors as less threatening.22 Besides buffering the detrimental downstream cardiovascular effects of the stress response, physical activity has also been related to nitric oxide-mediated vasodilation, reduced blood pressure and suppression of atherogenesis.34 However, in both Africans and Caucasians, physical activity was not associated with cardiac injury, nor was it associated with certain BTI traits or the use of specific coping strategies.

Our findings may also be partially explained by looking at the role of conscientiousness and neuroticism in the brain–stress circuitry. Indeed, these traits are dependent on the integrity of the dorsolateral prefrontal cortex (DLP):41 This region is very important for decision making, problem solving and top-down regulation of emotion and behaviour,64,65 therefore forming an integral part of DeS success. During an in-control DeS stress response, the DLPC can suppress activity in the anterior cingulate cortex and decrease activity in subcortical areas such as the amygdala.65 Higher conscientiousness has been associated with greater activity in this area.65 However, a loss of DLPC integrity was associated with higher scores in neuroticism, but lower scores in conscientiousness.65

Individuals scoring high in neuroticism tend to experience psychological stress as uncontrollable and threatening, resulting in greater emotional reactivity upon stress exposure,66,67 which is also characteristic of avoidance coping.62,43 In fact, uncontrollable stress has been found to weaken the connectivity between the DLPC and the anterior cingulate cortex, which increases activity in the amygdala.44 Indeed, increased amygdalar drive towards the prefrontal cortex (bottom-up regulation) during stress exposure may also decrease the conscientious-based cognitive processes that accompany DeS, resulting in more emotion-focused avoidance coping.64 A change in the threshold for effective DeS may emerge, which can sensitise future stress DeS responsiveness, with detrimental effect on cardiac health. As a result, increased input from the central nucleus of the amygdala may exaggerate sympathetic activity in the cardiovascular system, and which may contribute to higher cTnT levels.

Neuroticism may prevent effective DeS,30 and this notion corresponds with our findings in Africans, where DeS was inversely related to neuroticism scores. The potential of DLPC integrity loss induced by ineffective DeS might therefore increase. Additionally, neuroticism did not associate positively with cTnT levels over time in the Africans who utilised DeS, whereas in the Caucasians, neuroticism, together with conscientiousness were associated with a lower likelihood to predict a hypertension-related cTnT cut-off point. Conscientiousness may thus contribute to better DeS and decrease the greater emotional reactivity that usually accompanies neuroticism and avoidance coping. This may hold true as both Africans and Caucasians had conscientiousness scores that were considered average according to the BTI.43,37

Although Africans scored higher in neuroticism than the Caucasians, the scores of both races were still considered low according to the BTI.34,37 Therefore, the greater conscientiousness scores in both races may contribute to greater activity in the DLPC, which could suppress activity in subcortical areas such as the amygdala for a more controlled stress response.

Limitations and recommendations

The data presented stem from a relatively small cohort and conclusions can therefore not be generalised to the entire South African population. Investigation of study aims must therefore be expanded to other cohorts in South Africa. More expanded personality inventories such as the revised NEO personality inventory (NEO PI-R) may be incorporated to gain greater insight regarding the different facets of personality traits.

It is recommended that information be obtained on the serotonin transporter gene SNP, 5-HTTLPR, which has been related to higher neuroticism.65,57 The SABPA design also did not meet the requirements of a behavioural genetic study, which requires information about family, twins and adopted children. Because both the BTI and NEO PI-R are self-report questionnaires, next-generation sequencing will advance the analysis and interpretation of the relationships between genes and personality traits.

Conclusion

In both Africans and Caucasians, scoring high in DeS and avoidance coping, respectively, have previously been associated with greater emotional vascular hyper-responsiveness and subsequent risk of cardiac ischaemia. Greater emotional reactivity is usually associated with higher scores in neuroticism. However, in the current study, higher conscientiousness reflected healthier stress coping responses and improved cardiac health.

We are grateful to all the participants who volunteered to participate in the SABPA study, as well as for in-kind analyses from collaborators. Funding was obtained from North-West University and the North-West Education Department of South Africa, South African Medical Research Council, National Research Foundation, ROCHE Diagnostics, Heart and Stroke Foundation South Africa (HSFSA2019/01) and the Metabolic Syndrome Institute, France. Any opinion, findings and conclusions or recommendations expressed in this material are those of the author(s) and therefore funding bodies do not accept any liability in regard thereto.

References

Psychoneuroendocrinology 2017; 85: 20–27.


