THE ROLE OF PERCEIVED STRESS REACTIVITY IN THE RELATIONSHIP AMONG RACE, DISCRIMINATION, AND HEART RATE VARIABILITY

by

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ABSTRACT

BRITTANY C. PRICE. The role of perceived stress reactivity in the relationship among race, discrimination, and heart rate variability. (Under the direction of DR. VIRGINIA GIL-RIVAS and DR. JEANETTE BENNETT)

Despite having a greater risk for developing chronic health conditions like cardiovascular disease, overall African Americans have been found to have higher, healthier heart rate variability (HRV) compared to European Americans. This study sought to examine whether perceived stress reactivity mediated the relationship between perceived discrimination and HRV and whether race moderated the association between perceived discrimination and perceived stress reactivity. A total of 85 healthy undergraduates were recruited (42 African American and 43 European American). Participants were 18-24 years old, *M*=20.56 and *SD*=1.66 and included 46 females and 39 males. Following a pre-screen, eligible participants were invited into the lab where height, weight, body temperature, and blood pressure measurements were taken. Participants then completed a paced breathing exercise while their HRV was recorded. Afterwards participants completed questionnaires that included the perceived stress reactivity scale and the everyday discrimination scale. The analyses revealed that none of the study variables were associated with HRV within either group. Given that perceived stress reactivity was not significantly associated with either perceived discrimination or HRV, mediational and moderation analyses were not conducted. The perplexity of African Americans having higher HRV than European Americans despite the higher risk of developing poor health outcomes remains.

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LIST OF ABBREVIATIONS

AA	African American
ANOVA	analysis of variance
ANS	autonomic nervous systems
BMI	body mass index
EA	European American
EDS	everyday discrimination scale
HF	high frequency
HPA	hypothalamic-pituitary-adrenal
HRV	heart rate variability
IPAQ	international physical activity questionnaire
LF	low frequency
PEDQ-CV	perceived ethnic discrimination questionnaire – community version
PNS	parasympathetic nervous system
PSRS	perceived stress reactivity scale
RMSSD	root mean square of the successive differences
SA	sinoatrial node
SES	socioeconomic status

CHAPTER 1: INTRODUCTION

One means of measuring health and disease status is via physiological functioning (Sturmberg, Bennett, Picard, & Seeley, 2015). Specifically, physiological variability correlates with illness severity wherein the degree of variability loss correlates with severity of the illness (Sturmberg et al., 2015). In healthy individuals, adaptive bodily systems show a high degree of variation and fluctuate to accommodate bodily demands (Sturmberg et al., 2015). Therefore, as one encounters stressors or changes in the environment, the physiological systems adjust to prepare the body for action whether that be decreasing digestive activity, increasing blood flow, or increasing heart rate. Lack of physiological variability is linked to disease and may be an indicator of health risks in healthy populations (Sturmberg et al., 2015). Heart rate variability (HRV) is gaining popularity as a sensitive indicator of overall physiological functioning and physical health (Nicolini, Ciulla, Asmundis, Magrini, & Brugada, 2012).

HRV is one measure used to assess cardiovascular health and other health risks. Specifically, lower high frequency HRV is associated with poorer health outcomes (Hill et al., 2015). HRV is defined as the "variation over time between consecutive heartbeats and is primarily dependent on the extrinsic regulation of heart rate" (Acharya, Joseph, Kannathal, Lim, & Suri, 2006, p. 1031). Extrinsic regulation entails the brain detecting a change in the environment and subsequently sending a signal or hormone to facilitate change in an organ or system (Acharya et al., 2006). Specific to the heart, the autonomic nervous system converges on the sinoatrial (SA) node to regulate its rhythm; the sympathetic nervous system releases norepinephrine on the SA node to increase the heart

rate, while the parasympathetic nervous system (PNS) uses acetylcholine on the SA node to slow the heart rate (Thayer, Ahs, Fredrikson, Sollers, & Wager, 2012). In particular, resting HRV reflects changes in the duration of a single heart beat during inhalation and exhalation while a person is at rest (i.e. not engaging in physical activity). HRV may be an indicator of aging in healthy populations free of heart disease. For instance, Antelmi and colleagues (2004) found that in a sample with no history or evidence of cardiac disease, there was a decrease in HRV as age increased. In addition, individuals with higher functional capacity had higher HRV (Antelmi et al., 2004).

Measures of HRV have also been found to be more sensitive in detecting disease than standard clinical examinations (Ziegler, Laude, Akila, & Elghozi, 2001). For example, HRV measures were more accurate in discriminating diabetic patients with 0 or 1 abnormal test results from healthy controls, compared to autonomic function tests (Ziegler et al., 2001). In patients with compromised immune systems, HRV was found to decrease 60 hours before sepsis was detected and given a clinical diagnosis (Bravi, Green, Longtin, & Seely, 2012). These findings provide evidence that HRV is a promising measure for assessing a prematurely aging system in healthy populations in addition to its utility in potentially detecting early or mild stages of pathology. As HRV is arguably an indicator of overall bodily functioning, Sturmberg and colleagues (2015) encourage the use of HRV in medical settings as a “diagnostic or prognostic indicator.” Higher HRV is also an indicator of lower mortality and HRV decreases during the development of acute and chronic disease which further supports the value of its use in clinical settings (Sturmberg et al., 2015).

African Americans (AAs) disproportionately suffer from poorer health outcomes, especially in regards to cardiovascular health, and have greater morbidity and mortality than European Americans (EAs: Kahn & Fazio, 2005). Therefore, it would be expected that AAs would have lower HRV in comparison to EAs. However, after conducting a systematic review and meta-analysis including samples ranging from adolescents to older adults, Hill and colleagues (2015) found that AAs had higher resting HRV in comparison to EAs. This association remained after controlling for health status, medication use, and subgroup stratification by age and gender (Hill et al., 2015). To date, there is no consensus as to why AAs have a higher HRV in comparison to EAs given their overall greater risk for cardiovascular disease and poor health.

The social determinants of health framework can help identify factors and conditions that may contribute to health disparities (Price, McKinney, & Braun, 2010) and understand the unexpected finding of higher resting HRV among AAs. From this perspective, age, the conditions in which people are born, grow, work, live, as well as social norms and political systems are important contributors to health outcomes (WHO, 2016). Although, education and socioeconomic status (SES) are related to adverse health outcomes, health disparities are still present among AAs and EAs with equivalent education and SES. Furthermore, after adjusting for income, education, sex, health behaviors, and age, AAs have a higher risk for systemic inflammation and developing elevated blood pressure compared to EAs (Crimmins, Kim, Alley, Karlamangla, & Seeman, 2007). AAs also had a higher risk for developing elevated blood pressure after adjusting for negative health behaviors such as smoking, poor diet, lack of physical activity, and access to care (Crimmins et al., 2007). In the case of AAs, experiences of

racism and discrimination have been found to negatively impact their quality of life and health (Price et al., 2010). Hence, understanding of AAs unique perception of racial discrimination and perceived reactivity to racial discrimination could provide insight to the unexpected findings regarding HRV and race.

1.1 Racial Discrimination and Health

Racism results in negative attitudes and beliefs towards certain racial groups and these beliefs and attitudes influence the structure of institutions and policies in a particular society (Williams & Mohammed, 2009). Racism is present in a variety of contexts such as interpersonal, environmental, institutional, and cultural (Brondolo, ver Halen, Pencille, Beatty, & Contrada, 2009). At the institutional and policy level, racism involves viewing certain groups as inferior and others as superior, leading to preferential treatment towards the superior group (Williams & Mohammed, 2009). For example, members of the superior group are more likely to receive resources necessary for their societal progression. These ideas often lead to discriminatory behaviors at the interpersonal level (Williams & Mohammed, 2009).

Racial discrimination at the interpersonal level involves differential treatment of members of those groups by individuals and institutions and includes behaviors such as ignoring and rejecting individuals, social exclusion, stigmatization via verbal and non-verbal demeaning behaviors, and having lower expectations for members of these groups (Brondolo et al., 2009). These behaviors can be present in a variety of settings such as the housing and labor markets, and the criminal justice and education systems (Williams & Mohammed, 2009). Recipients of discriminatory actions are often aware that they are being targeted; therefore, these interactions constitute a major source of stress in their life

(Clark, Anderson, Clark, & Williams, 1999). Given the pervasive nature of discrimination, and that AAs report experiencing more discrimination compared to EAs and other minority groups, discrimination can be viewed as a chronic stressor in the lives of AAs (Salomon & Jagusztyn, 2008; Williams & Mohammed, 2009).

Experiencing chronic discrimination (everyday discrimination) can negatively impact access to resources such as monetary gains and quality health care and is associated with the development of chronic illnesses, heart disease, and pain (Gee, Spencer, Chen, & Takeuchi, 2007; Williams & Mohammed, 2009). Indeed, a literature review by Williams and Mohammed (2009) found that perceived discrimination is associated with health concerns such as hypertension, substance use, poor physical functioning, and higher health care utilization. Further, minorities who experience stress due to discrimination in addition to general stress are at a higher risk of poor mental health and various physical health problems such as stomachaches, headaches, and a sore throat (Flores et al., 2008).

Pascoe and Richman (2009) posit that experiencing prolonged discrimination can trigger physiological responses such as elevated blood pressure and heart rate that negatively impact cardiovascular health. Perception and frequency of exposure to discrimination, in particular, could explain racial differences in physiological responses to these stressors and their impact on cardiovascular health. Identified differences in cardiovascular reactivity to discrimination may be expressed in the unexpected racial differences in HRV. Specifically, in a cohort study consisting of black, brown, and white Brazilians, Kemp and colleagues (2016) found that perceived discrimination had a small mediating effect in the relationship between race and HRV. Specifically, discrimination

contributed significantly to race-related differences in HRV (Kemp et al., 2016). Black participants exhibited higher resting HRV, followed by brown and then white participants (Kemp et al., 2016). Black participants also reported experiencing more discrimination followed by brown, and then white participants (Kemp et al., 2016). Similar to the American population, black Brazilians are at an increased risk for morbidity and mortality (Kemp et al., 2016). However, the paradox remains that despite having higher HRV, AAs are at a greater risk of developing cardiovascular diseases. Exploring the role of perceived stress and chronic physiological activation associated with perceived discrimination could further explain the unexpected findings regarding HRV among AAs.

1.2 Stress and Chronic Physiological Activation

Experiencing significant amounts of perceived racial discrimination is associated with greater reports of perceived stress (Sellers, Caldwell, Schmeelk-Cone, & Zimmerman, 2003). Experiencing high levels of perceived stress can result in chronic physiological activation which disrupts allostasis and contributes to poor health (McEwen, 1998). The autonomic nervous system (ANS) is one system impacted by chronic physiological activation and is associated with somatic and mental conditions (Thayer & Sternburg, 2006). Importantly, the ANS is one of the primary systems that influences heart rate and thereby impacts HRV (Thayer & Sternburg, 2006).

The ANS regulates functions of internal organs such as the brain, kidneys, eyes, sweat glands, bladder, and the heart (Buijs, 2013; Porges, 1995). Functions of the ANS include respiration, digestion, urination, and heart rate (Porges, 1995). The ANS consists of the sympathetic and parasympathetic nervous system, which collaborate in maintaining homeostasis within the body (Thayer, Yamamoto, & Brosschot, 2009).

Specifically, the PNS maintains homeostasis when the body is at rest while the sympathetic nervous system is responsible for the body's response to a perceived threat (Thayer & Sternburg, 2006). HRV is an indicator of both sympathetic and parasympathetic activity (Thayer et al., 2009). Specifically, low frequency (LF) HRV is an indicator of sympathetic and parasympathetic activity, higher frequency (HF) HRV is primarily an indicator for parasympathetic activity, while the LF/HF ratio is an indicator of autonomic balance (Thayer et al., 2009). Environmental changes and chronic stressors can cause autonomic imbalance (a hyperactive sympathetic system and a hypoactive parasympathetic system; Thayer et al., 2009). Increased and decreased activity of these systems influences the speed of heart rate, thereby influencing HRV (Acharya et al., 2006).

Variability of the parasympathetic and sympathetic activity is essential to survival as decreased variability is linked to pathology (Thayer & Sternburg, 2006; Sturmberg et al., 2015). Decreased variability in the two systems can occur when one endures conditions of chronic stress, which can disrupt homeostasis, and negatively impact allostasis (Thayer & Sternburg, 2006). Allostasis is essential for survival, as it is the body's ability to support homeostasis despite changes in the environment (McEwen, 1998). Specifically, the ANS, cardiovascular, metabolic, and immune systems are involved in the body's attempt to maintain homeostasis (McEwen, 1998). "Wear and tear" of these systems (allostatic overload) can range from hypo to hyper-activation and cause negative health effects. For instance, excessive "wear and tear" on the body could lead to cardiovascular diseases, heart attack, stroke, and increase the risk of developing anxiety or depressive disorders (McEwen, 2008). Poor glucose regulation, hypothalamic-

pituitary-adrenal (HPA) axis system dysregulation, and increased inflammation are associated with decreased HRV (Thayer & Sternburg, 2006). These factors are also associated with poor health and allostatic overload; therefore Thayer and Sternburg (2006) posit that vagal activity is involved in allostasis functioning.

Notably, exposure to stressors such as racial discrimination has a harmful impact on parasympathetic reactivity, but not sympathetic reactivity (Wagner, Lampert, Tennen, & Feinn, 2015), suggesting the need to evaluate the parasympathetic system. The vagus nerve has a pivotal role in parasympathetic function. High frequency HRV is a measure of the effect of the PNS on heart rate and the vagal tone reflects the activity of the vagus nerve (Porges, 1995). Vagally-mediated HRV is associated with cardiovascular outcomes, and the ability to acclimate to a change in environmental demands such as discrimination (Hill et al., 2015).

Experiencing discrimination would assumedly result in chronic physiological activation, causing “wear and tear” on bodily systems such as the ANS, especially the withdrawal of the parasympathetic system. The consequent dysfunction of the ANS system, due to the stress caused by experiences of discrimination should result in lower HRV. Since AAs report experiencing more discrimination, this adds to the perplexity of the finding that AAs have higher HRV compared to EAs. Therefore, merely exploring the role of stress exposure is not adequate in explaining the paradoxical HRV findings. Exploring the role of perceived stress reactivity in the relationship between perceived discrimination and HRV could provide further insight to the relationship between race and HRV.

1.3 Perceived Stress Reactivity

Lazarus and Folkman (1984) define stress as a relationship between a person and their environment wherein the demands of this interaction exceed coping capacity. When a situation is appraised as being potentially harmful and uncontrollable, it is appraised as stressful and threatening (Folkman, 2013). Therefore, cognitive appraisal and subjective reaction are salient components of the stress process (Schlotz, Hammerfald, Ehlert, & Gaab, 2011). Not all individuals who experience a chronic stressor develop disease or experience negative health outcomes (Schlotz, Yim, Zoccola, Jansen, & Schulz, 2011a). It may also be that not all individuals who experience a chronic stressor develop abnormal physiological variability.

Recently, Schlotz and colleagues (2011a) proposed that perceived stress reactivity, defined as a "disposition that underlies individual differences in physiological and psychological stress responses that is relatively stable over time (pp.81)", may help explain the differential impact of stress on individuals' health. Specifically, perceived stress reactivity refers to the tendency of a person to respond to a stressor (Limm et al., 2010). Situational factors in addition to the subjective reaction constitute perceived stress reactivity rather than physiological stress reactivity (Limm et al., 2010), implying that there is some degree of individual variability in the perception of a stressor depending on the nature of the stressor. Schlotz and colleagues (2011) state that perceived stress reactivity is stable, however, it is variable to the extent that an individual can have situation specific changes in perceived stress reactivity. Regardless of the situation, an individual is expected to remain in the range of perceived stress reactivity that is characteristic of that person (Schlotz et al., 2011).

High perceived stress reactivity is considered a risk factor for the development of disease independent of other well-known risk factors such as obesity, smoking, and family history (Schlotz, 2013). It is also associated with higher rates of psychosomatic and physical complaints, poorer psychological health, negative health behaviors, musculoskeletal and cardiovascular complaints, and higher levels of anxiety and depression (Limm et al., 2010). Like perceived stress, perceived stress reactivity is believed to be shaped by genetic and environmental factors, however, the influence of these factors is further shaped by frequency of exposure to a stressor (Federenko et al., 2006; Schlotz, 2013). Moreover, predictors of perceived stress reactivity include lower levels of education, chronic stress, and cardiovascular complaints (Limm et al., 2010). Perceived stress reactivity also has a positive, moderate correlation with neuroticism, chronic stress, perceived stress, and general self-efficacy (Schlotz et al., 2011a), factors that have been associated with poor health.

Exposure to a chronic stressor, such as discrimination, in addition to higher perceived stress reactivity increases the likelihood of developing poor health outcomes such as cardiovascular diseases (Schlotz, 2013). However, perceived stress reactivity may partially explain individual differences in the relationship between stress and disease and racial differences in the relationship between perceived discrimination and HRV (Schlotz et al., 2011a). Specifically, given that perceived discrimination partially explains the relationship between race and HRV (Kemp et al., 2016), perceived stress reactivity could be the underlying factor that further explains the paradoxical relationship between race and HRV.

1.4 Present Study

Kemp and colleagues (2016) found that discrimination contributes significantly to race-related differences in HRV. Further, perceived discrimination is described as a chronic stressor and low HRV is associated with higher levels of perceived stress. As previously stated, AAs report being exposed to more discrimination than EAs (Salomon & Jagusztyn, 2008), however, at this point, it has reliably been found that AAs have higher HRV compared to EAs (Hill et al., 2015). Therefore, exposure to discrimination falls short in explaining the paradoxical findings that AAs have higher HRV in comparison to EAs. Subjective experiences of racial discrimination and perceived stress reactivity could help explain these findings.

To date, no study has tested if perceived stress reactivity mediates the relationship between exposure to racial discrimination and HRV. Further, the proposed study will examine the degree to which the influence of perceived discrimination on perceived stress reactivity will vary by race. Assessing these relationships can provide insight to racial differences in HRV and explain differences in psychological and physiological responses to stressors.

1.5 Hypotheses

Hypothesis 1. Perceived stress reactivity will fully mediate the association between perceived discrimination and HRV, such that higher reports of perceived discrimination will be associated with lower perceived stress reactivity which will in turn be associated with higher HRV.

Hypothesis 2. Race will moderate the association between perceived discrimination and perceived stress reactivity, such that there will be a stronger

association between perceived discrimination and perceived stress reactivity for AAs compared to EAs. Specifically, more reports of perceived discrimination will be associated with lower perceived stress reactivity for AAs, while there will be little to no relationship between perceived discrimination and perceived stress reactivity for EAs.

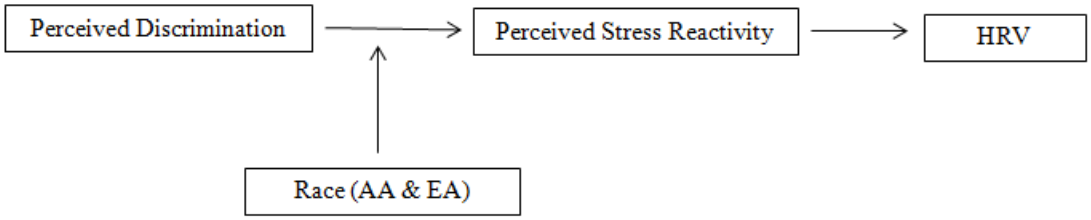

Figure 1. The figure depicts the proposed hypotheses.

CHAPTER 2: METHOD

2.1 Participants

Undergraduate students who self-identified as African American or European American were recruited. Age was limited to 18-24 years old given that age influences HRV more than sex and mood in healthy samples (Jensen-Urstad et al., 1997; Zhang, 2007) and the greatest decrease in HRV due to age occurs between the second and third decades of life (Umetani, Singer, McCraty, & Atkinson, 1998). Exclusion criteria included the following: self-identified race other than EA and AA, individuals who used any tobacco products, e-cigarettes, or illicit drugs, lived with someone who was a tobacco smoker, had any health concern including any cardiac-related issues, individuals who were heavy alcohol users (5 or more drinks on the same occasion on each of 5 or more days in the past 30 days), individuals who use sleeping or antihypertensive medication and any psychotropic medications (e.g., stimulants, antiepileptics, antipsychotics), women who were pregnant, and women who were breastfeeding, and individuals with mental health concerns such as depression, anxiety, or attention deficit hyperactive disorder.

2.2 Design

A convenience sampling method was used to recruit participants. Email recruitment and Psychology's SONA research pool were used to recruit across the university with information about the study and the lab’s contact information. Approval was obtained from the UNC Charlotte Institutional Review Board and participants completed an informed consent form prior to initiating their participation in this study. During the consent process, participants received information on expectations and their

responsibilities. Participants not receiving SONA credit received a $10 Target gift card for their participation.

2.3 Procedures

Potential participants were given a pre-screen online to determine their eligibility for the study. Eligible participants were notified by email and offered to schedule a lab visit at their convenience (within a week of the prescreen session if possible). Participants were asked to refrain from consuming caffeine and alcohol within 24 hours of coming in for testing, and to eat a light meal at least two hours before testing (Nunan et al., 2009).

When participants arrived to the lab, they were greeted and completed a consent form. Measures of body temperature, blood pressure, height and weight, and HRV were then obtained. The participant was directed on how to properly place the Polar chest band and allowed to put it on in private. Then the corresponding Polar watch (800V) was started and reviewed to ensure that proper placement of the chest strap occurred. Participants were asked to relax and breathe normally for five minutes. Subsequently, they participated in a paced breathing exercise for five minutes. After the breathing exercise, participants rated on a scale of 1 to 10 how stressful the task was. Following the measurement of HRV, participants completed a series of psychosocial and health behavior questionnaires described below. The session took about 1 hour and 10 minutes.

2.4 Measures

2.5 Pre-screen

Participants were asked to self-report race, sex, lifetime history of medical issues (including cardiovascular related issues), lifetime mental health concerns, current

medication use, current tobacco use, current exposure to tobacco smoke, current alcohol use, marijuana and other illicit drug use (lifetime and days since last use).

2.6 Cardiovascular Measures

An automatic blood pressure monitor (Omron HBP-1300, Lake Forest, IL) was used to measure heart rate (in beats per minute) and blood pressure (in mmHg). Baseline HRV was measured via the Polar® V800 wristwatch and Wearlink H7 sensor and belt band (Polar ®,Bethpage, NY). The 1000 Hz sampling rate has been found to provide valid and reliable ECG data (Gamelin, Berthoin, & Bosquet, 2006; Nunan et al., 2009). HRV was collected during two 5-minute sessions. During the first session, the participants were instructed to breathe naturally and during the second session, the participants were asked to partake in a visual breathing exercise. Participants inhaled as the figure expanded and exhaled as it contracted. The interbeat intervals, low and high frequency bands, and the square root of mean successive differences (RMSSD) between R-Waves were calculated using KUBIOS HRV analysis software (Tarvainen, Niskanen, Lipponen, Ranta-aho, & Karjalainen, 2014).

2.7 Questionnaires

Perceived Discrimination: Perceived discrimination was measured using the Everyday Discrimination Scale (EDS; Williams, Yu, Jackson, & Anderson, 1997). The EDS is a 9-item self-report questionnaire that measures the extent to which one experiences discrimination daily. The EDS prompt reads: In your day-to-day life how often have any of the following things happened to you because of your race? Some versions of this measure do not include the “because of your race” aspect. However, the purpose of this study was to analyze perceived discrimination as a result of race,

therefore “because of race” was included in the prompt. The EDS uses a 6 point Likert scale from “1” almost every day to “6” never. Some items include “people act as if you are dishonest” and “called names.” This scale has good reliability (α = .87) and validity (Clark, Coleman, & Novak, 2004). This scale had good reliability for this sample (α = .91). The EDS was highly correlated with internalizing and externalizing symptoms (Clark et al., 2004).

Perceived Stress Reactivity: Perceived stress reactivity was measured using the perceived stress reactivity scale (PSRS; Schlotz et al., 2011a). The PSRS is 23-item self-report questionnaire that measures an individual’s perceived typical response across different potentially stressful experiences of everyday life (Schlotz et al., 2011a). Three answer choices are provided for each question. For example, “When I have conflicts with others that may not immediately be resolved: 0) I generally shrug it off; 1) It usually affects me a little; and 2) It usually affects me a lot.”` The PSRS has the following 5 subscales: Reactivity to Work Overload, Reactivity to Social Conflicts, Reactivity to Social Evaluation, Reactivity to Failure, and Prolonged Reactivity. An overall perceived stress reactivity score is computed by adding the scores from each subscale. This measure has been found to have good retest reliability over a 4 week period and good discriminant and convergent validity (Schlotz et al., 2011a). This scale had good reliability for this sample (α = .83).

2.8 Covariates

Several factors influence HRV, including sex, BMI, SES, stress, year in school, and exercise (Acharya et al., 2006). These data were collected and associations were examined with HRV. If any potential covariate was significantly related, it would be

included in the analyses to determine the unique contribution of perceived stress reactivity and perceived discrimination on HRV.

BMI: Participants' weight and height were measured, converted to kilograms and meters, and then calculated for BMI (kg/m^2).

Parent Income: Participants were asked the income of their household to determine SES. If they reside with and/or are dependent on their parents, they were instructed to provide their parents' annual income. Income was assessed on a scale of 1 ($0-$29,999) to 10 (More than $150,000). Further, participants were asked their job title if applicable, their year in school, and any previously obtained academic degree.

Stress of Breathing Task: Participants were asked to rate on a scale of 1 to 10 how stressful the breathing task was.

Physical Activity Questionnaire: Exercise regimen was measured using the international physical activity questionnaire (IPAQ; Craig et al., 2013). The IPAQ is 27-item self-report that measures physical activity within the past seven days. The questionnaire assesses the following: 1) job-related physical activity, 2) transportation physical activity, 3) housework, house maintenance, and caring for family, 4) recreation, sport, and leisure-time physical activity, and 5) time spent sitting. The questionnaire consists of questions such as "During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, heavy construction, or climbing up stairs as part of your work? Think about only those physical activities that you did for at least 10 minutes at a time." Questions such as these have follow-up questions such as "How much time did you usually spend on one of those days doing vigorous physical activities as part of your work?" Test-retest reliability for different countries had a

Spearman correlation of about 0.8 which indicates good repeatability (Craig et al., 2003). Criterion validity was fair to moderate (Craig et al., 2003).

2.9 Plan of Analysis

Data was analyzed using SPSS Version 23. Participants' race was reported as either AA or EA and coded (AA=1, EA=0). To determine any covariates a one-way ANOVA was conducted to determine whether there were racial differences in BMI, age, parent income, exercise, perceived stress reactivity, perceived discrimination, and perceived stress. A chi-square test was conducted to determine if race was independent by sex, year in school, and marijuana use in the past thirty days. Raw HF-HRV data were analyzed using $\log_{10}$ transformation. Further, a correlation was conducted to determine any significant associations between HRV and the time of day the HRV measurement was taken, in addition to the association between HRV and the stress of the breathing task. Zero order correlations were conducted to examine associations among primary variables of interest as well as potential covariates.

If significant relations were observed among perceived discrimination, perceived stress reactivity, and HRV, Hypothesis 1 would be examined by using PROCESS macro 4 (Hayes, 2013) to test whether perceived stress reactivity mediated the relationship between perceived discrimination and HRV, including statistically significant controls. This analysis would test the direct, indirect, and total effects of perceived discrimination and perceived stress reactivity on HRV. If Hypothesis 1 was supported, Hypothesis 2 would be tested by using PROCESS macro 1 to examine if race moderates the relationship between perceived discrimination and perceived stress reactivity. BMI, the time of day of the HRV measurement, and parent income would be entered as statistical

controls. If none of the proposed hypotheses are supported, post hoc tests would be conducted to determine if the data are consistent with existing literature.

Despite the screening, there were participants at the visit who endorsed some of the exclusion criteria listed below. Therefore, it was determined whether their inclusion impacted the relationship between HRV and race. Specifically, the data of participants who used tobacco products, (n=1), participants who used a stimulant or psychotropic medication (n=2), and participants with anxiety, depression, or attention deficit hyperactivity disorder (n=5) were removed from the sample to determine if inclusion influenced the relationship between race and HRV. Due to there being no significant changes in the results, these participants' data were included in the overall sample. BMI, the time of day of the HRV measurement, and parent income were entered as statistical controls.

CHAPTER 3: RESULTS

3.1 Participants

A total of 85 undergraduate students were recruited for the study; 42 African American and 43 European American. Overall, there were n=46 females and n=39 males. Participant characteristics and racial differences are presented in Table 1.

African Americans participants had a higher BMI than European American participants, $F(1, 84)=6.72$, $p<.05$. There was also a significant racial difference in parental income with African American parents having a lower income than European American parents, $F(1, 79)=21.21$, $p<.001$. Interestingly, as seen in tables 3 and 4, among African Americans there were significant correlations between sex and the following variables: parental income, perceived stress reactivity, and perceived discrimination. However, those associations were not significant for European Americans. As expected, African Americans reported experiencing more racial discrimination than European Americans, $F(1, 84)=15.66$, $p<.001$. Despite differing ratio of males to females by race, race and sex were independent of each other, χ^2 (1, N=85)=0.97, $p>.05$. As racial differences in BMI and parent income were detected, these variables were included in the multivariate analysis.

The correlations among the study variables for the entire sample are presented in Table 2. Of the variables included in this study, only race (i.e., being AA) and perceived discrimination were positively associated with higher HF-HRV. A significant association between HRV and the time of day the measure was collected was found (r=.28, $p<.01$), therefore measurement time was also entered as a covariate in subsequent analysis.

Correlations among study variables for African Americans and European American participants are presented in Table 3 and Table 4, respectively. The analyses revealed that none of the primary study variables (i.e., perceived discrimination or perceived stress reactivity) were associated with HRV within either group.

3.2 Hypothesis One

Given that perceived stress reactivity was not significantly associated with either perceived discrimination or HRV, mediational analyses were not conducted to test hypothesis 1.

3.3 Hypothesis Two

Given that perceived stress reactivity was not significantly associated with perceived discrimination and HRV, the moderating role of race in the relationship between perceived discrimination and perceived stress reactivity was not tested.

3.4 Post Hoc Analyses

Given being AA was related to higher HRV (see Table 1 and 2), the data display the expected unusual finding. In a fully adjusted regression model, race was significantly (p<.05) related to higher HRV above and beyond BMI, parental income, time of HRV measurement, and perceived discrimination. Given that racial differences were found in HRV, we examined if the data replicated the findings of studies that examine if discrimination acts as a mediator of the relationship between race and HRV.

Discrimination did not mediate the relationship between race and HRV. Results showed a direct effect of race on HRV (effect=.19, 95% CI [.02, .35], p =.02), but no indirect effect through perceived discrimination (effect=.01, 95% CI [-06, .09]).

CHAPTER 4: DISCUSSION

A few studies have found African Americans have lower HRV compared to European Americans (Choi et al., 2006; Lampert, Ickovics, Horwitz, & Lee, 2005). However, a recent meta-analysis found that overall African Americans had higher HRV compared to European Americans (Hill et al., 2015). These findings are surprising as AAs have greater morbidity and mortality than EAs, it would be expected that AAs would have lower HRV in comparison to EAs. The present study assessed whether these racial differences would be replicated in a sample of healthy, college students. Congruent with previous literature, there were significant racial differences in HF-HRV with African American participants having higher HF-HRV compared to European Americans. Therefore, this study contributes to the perplexing findings that African Americans have higher, healthier HRV despite being at a greater risk of suffering from poorer health outcomes compared to European Americans (Kahn & Fazio, 2005).

As expected, African Americans reported experiencing more racial discrimination than European Americans. These findings are congruent with other studies in the United States (Salomon & Jagusztyn, 2008; Williams & Mohammed, 2009). Surprisingly, discrimination exposure did not help explain the racial differences in HRV, which is inconsistent with a study by Kemp and colleagues (2016), who found that that perceived discrimination partially mediated the relationship between race and HRV. It is possible, that the small sample size limited our ability to detect those associations.

Although there was a significant racial difference in discrimination, European American participants still endorsed experiencing a significant amount of discrimination. Therefore, it would be valuable to conduct a more thorough assessment of the subtypes of

discrimination. Specifically, how do African Americans and European Americans differ in their reports of discrimination on the interpersonal, organizational, environmental, and social levels. Also, to what extent do they experience a sense of threat to their identity, culture, or actual threat against themselves or loved ones. This approach would allow for discernment of which aspects of discrimination are more relevant to each group and how these subtypes may impact HRV and health differently.

Within the entire sample, perceived discrimination was associated with higher levels of HRV. However, analyses examining associations within racial group showed that perceived discrimination did not have a significant association with HRV among African Americans or European Americans independently, which is most likely due to the small sample size of the current study as the association between HRV and perceived discrimination for African Americans appears to be underlying the overall findings. These findings are inconsistent with the findings reported by Hill and colleagues (2017), who found that higher reports of lifetime discrimination were associated with lower HRV in a sample of young, healthy, African American participants. Further, they assessed various subdomains of lifetime discrimination and found that threats and acts of aggression were associated with lower HRV (Hill et al., 2017).

These discrepant findings from the study by Hill and colleagues (2017) may be due to the different measures used for perceived discrimination in each study. Specifically, the current study used the Everyday Discrimination Scale (Williams et al., 1997), while Hill and colleagues (2017) assessed lifetime discrimination using the brief Perceived Ethnic Discrimination Questionnaire – Community Version (PEDQ-CV; Brondolo et al., 2005). The Everyday Discrimination Scale captures the everyday

frequency of experiences of discrimination whereas the brief PEDQ-CV captures lifetime experiences of discrimination at the interpersonal and social level. Further, the brief PEDQ-CV assesses for more specific experiences of threat/aggression compared to the Everyday Discrimination Scale. Being threatened or experiencing an act of aggression can be perceived as a threat to someone's survival, potentially activating the sympathetic nervous system. Persistent activation of the sympathetic system can result in decreased HF-HRV. Given the scales' differential estimates of perceived discrimination, the conflicting results suggest that further research into the type of discrimination may be critically important.

Given the paradoxical relationship between race and HRV, this study examined if perceived stress reactivity explained the association between exposure to discrimination and HRV. Contrary to expectations, perceived stress reactivity was not significantly associated with either perceived discrimination or HRV in the entire sample or within racial group. It was hypothesized that because AAs report experiencing more discrimination they would be less reactive to those experiences compared to EAs. In our society, expressions of anger by African Americans can lead to negative social consequences. Therefore, African Americans could be conditioned to not express anger (i.e. be less reactive) when experiencing discrimination which can in turn result in healthy cardiovascular recovery (Hokanson, Willers, & Koropsak, 1968). In other words, being less reactive could serve as a buffer to the development of poor physiological variability (lower HRV). Therefore, it was surprising to find that perceived stress reactivity was not associated with perceived discrimination or HRV.

In regards to group differences, for African Americans, there was a positive association between HRV and perceived stress reactivity although not significant, while the opposite was found for European Americans. HRV has been identified as an indicator of self-regulation, temperament, and the ability to shift attention (Segerstrom & Nes, 2007; Thayer & Lane, 2000). Specifically, those who are more vigilant and display lower self-regulatory effort are more likely to have lower HRV (Segerstrom & Nes, 2007; Thayer & Lane, 2000). Likewise, perceived stress reactivity reflects perceived individual differences in how one responds to stress and one's response to stress is thought to be relatively stable over time (Schlotz et al., 2011). Given this overlap, it was surprising to find no association between perceived stress reactivity and HRV. Overall, the findings of this study indicate that perceived stress reactivity does not help in explaining racial differences in HRV. It is possible that African Americans have learned to adapt to experiences of discrimination

Consistent with this hypothesis, one review of the literature suggested that higher HRV is associated with higher adaptability in stressful situations (Thayer, Hansen, Saus-Rose, & Johnsen, 2009). As discrimination is considered a chronic stressor for African Americans (Williams & Mohammed, 2009), it is likely that African Americans are less reactive to those experiences. Other constructs such as emotion regulation may provide a better explanation as to why African Americans have higher, healthier HRV.

Given chronic exposure to discrimination, African Americans could have developed adaptive emotion regulation strategies. A review by Kemp and Quintana (2013) suggests that HRV is a marker of mental and physical well-being and emotion regulation and emotion recognition is associated with HRV. African Americans could be

conditioned to not respond to experiences of racial discrimination because of the potential negative outcomes, thereby enhancing their emotion regulation skills. For example, when African Americans express anger, they have a slower physiological recovery compared to European Americans and a decrease in HRV possibly aligning with the avoidance learning theory (Dorr, Brosschot, Sollers, & Thayers, 2007; Hokanson et al., 1968).

According to this perspective, a relaxation state and cardiovascular recovery occurs when one engages in a behavior that will reduce negative social situations (Hokanson et al., 1968). In other words, because Africans Americans have learned that expressing anger will result in a negative social outcome, they have poorer cardiovascular recovery when expressing anger. Therefore, learning to navigate potentially confrontational social situations in order to decrease the likelihood of negative social outcomes could have a positive impact on African Americans' ability to regulate their emotions, thereby, resulting in higher heart rate variability.

There is a high degree of overlap between emotion regulation and coping (Appelhans & Luecken, 2006). Individuals who have better emotion regulation and adaptive coping have higher HRV (Appelhans & Luecken, 2006). For example, during an anger-inducing task, individuals who engaged in cognitive reappraisal had a significant increase in HRV when asked to reappraise the anger-inducing stimulus (Denson, Grisham, & Moulds, 2011). Furthermore, individuals who engaged in cognitive reappraisal reported less anger compared to those who did not use reappraisal (Denson et al., 2011). It could be that African Americans are more likely to employ cognitive reappraisal when facing discrimination, resulting in higher HRV despite chronic exposure to discrimination.

In regards to coping, culture-specific coping for African Americans has been identified as collective coping and spiritual coping (Utsey, Bolden, Lanier, & Williams 2007). Coping strategies that African Americans use when facing racism include racial identity development, social support, confrontation, suppression, and anger (Brondolo et al., 2009; Utsey, Ponterotto, Reynolds, & Cancelli, 2000). Contrary to Dorr and colleagues (2007), one study found that anger expression can have health benefits for African Americans (Park, Flores, Aschbacher, & Mendes, 2018). These health benefits were found in individuals who endorsed lower levels of discrimination, but not for African Americans who endorsed more frequent experiences of chronic discrimination (Park et al., 2018). Therefore, these discrepant findings could be due to the varying levels of exposure to discrimination.

Taken together, African Americans use a variety of methods to cope with racial discrimination. Given that adaptive coping (i.e., coping that reduces stress and can improve one's health) is associated with higher, healthier HRV, coping could be a factor that explains the intriguing relationship between race, discrimination, and HRV (Appelhans & Luecken, 2006). Assessing how African Americans regulate emotions and cope could provide further insight into the relationship between race and HRV.

Some have encouraged exploration of how emotion regulation influences brain activity and cerebral blood flow and how these mechanisms, in turn, effect racial differences in HRV (Hill et al., 2015). HF-HRV has been found to be negatively correlated with activation in the ventromedial prefrontal cortex (vmPFC) for African Americans, but a similar association was not found with European Americans (Allen, Jennings, Gianaros, Thayer, & Manuck, 2015). The vmPFC plays a critical role in linking

the integration of threat processing, emotion regulation, and HRV (Thayer et al., 2012). This indicates that there could be racial differences in how stressors such as discrimination are processed at the neural level. Further research on the relationships between these factors could explain how neural circuitry influences the relationship between HRV and race.

Genetics may also influence HRV. In twin studies, HRV is heritable and certain genes are associated with an increase in HRV (Busjahn et al., 1998). Further, the same genes influence HRV at rest and during exposure to a stressor (Wang et al., 2009). However, there was no difference in HRV heritability between African Americans and European Americans (Wang et al., 2009). In other words, although differences in HRV are present between African Americans and European Americans at an early age, there have been found to be no significant racial difference in heritability (Wang et al., 2005). Therefore, genetics may not assist in explaining racial differences in HRV.

4.1 Strengths and Limitations

A strength of this study was the recruitment of healthy individuals with minimal medication use. Individuals with health concerns are more likely to have lower HRV, therefore seeking healthy individuals helps to eliminate this confound.

Unfortunately, we did not account for social support as it could potentially buffer the negative impact of discrimination. Social support has been found to have a positive impact on psychological well-being and discrimination is related to poorer self-reported physical health only when social support was lacking (Finch & Vega, 2003; Jasinskaja-Lahti, Liebkind, Jaakkola, & Reuter, 2006). However, one study found that social support did not buffer the negative effects of perceived discrimination, as those who reported

higher perceived discrimination reported having poorer social support (Prelow, Mosher, & Bowman, 2006). Therefore, inclusion of social support in future research could potentially contribute to our understanding of the factors that help explain racial differences in HRV.

Additionally, this study was conducted at a predominately European American university; thus, these findings may not generalize to students who attend a predominately African American university as the subjective experience of racial discrimination may differ between these two environments. Specifically, African Americans attending a predominately African American university may be less exposed to experiences of racial discrimination, especially on a social level. They may also have more opportunities for coping given that they are in an environment with others who may experience similar discriminatory experiences. However, it could be that African American students on a predominately African American college campus still experience intra-racial discrimination such as colorism and face criticisms of not being "black enough" (Monk, 2015). Therefore, it would be beneficial to compare the relationship between perceived discrimination and HRV in African Americans who attend a predominately African American campus to those who attend a predominately European American campus.

Also, this study captured only a snapshot of a participant's HRV, as an individual's HRV can fluctuate and be influenced by a variety of factors (Acharya et al., 2006; Thayer et al., 2009). To minimize potential confounds, participants were asked to limit caffeine and alcohol intake 24 hours prior to testing. In addition, the relationships between HRV and factors known to affect it such as BMI, parent income, and exercise

regimen were examined. Future work might consider investigating HRV reactivity to experiencing a stressor in the moment.

Acute stressors, such as exposure to a subtle threatening stimulus or social evaluation during a stressful task, result in a reduction in HRV followed by recovery (e.g., Elliot, Payen, Brisswalter, Cury, & Thayer, 2011; Fagundes et al., 2011). In a sample of African American and European American women, experiencing more racial discrimination, regardless of race, was associated with lower HRV when experiencing a public speaking stressor (Wagner et al., 2015). Among a sample of youth and young adults, African Americans did not have a significantly different change in HRV when exposed to a stressor (i.e., video game task) compared to European Americans, meaning both groups reduced similarly, and this response remained stable over time (Li et al., 2009). Given these various physiological outcomes when exposed to a stressor, capturing HRV responses, in the moment a person experiences racial discrimination in a real world situation, such as ecological momentary assessment, could provide insight as to how the body actively adapts to stress outside the lab.

4.2 Future Directions

Future research should investigate how coping influences the relationship between perceived discrimination and resting HRV. A review by Appelhans and Luecken (2006) concluded that adaptive emotion regulation and healthy coping skills are associated with higher HRV. Racial identity development, social support, confrontation, suppression, and anger have been identified as coping strategies utilized by African Africans when facing racism (Brondolo et al., 2009; Utsey et al., 2000). Some coping strategies such as anger expression may have positive health effects for African

Americans who experience low levels of discrimination (Park et al., 2018). However, other forms of coping such as anger suppression and anger control have been related with negative health effects (Park et al., 2018). Given that there are numerous coping strategies and the literature on coping is expansive, future research should try to distinguish and continue to hone in on which specific coping strategies are utilized by African Americans, the context in which these strategies are used when coping with discrimination, and how the strategies might be influencing resting HRV.

Specifically, to answer this question, participants (African American and European American) could complete self-report questionnaires that assess how they cope with experiences of discrimination and another capturing various experiences of discrimination. For example, the Lifetime Discrimination Scale and the Perceived Ethnic Discrimination scale (Brondolo et al., 2005) measure factors such as overall lifetime discrimination, exclusion/rejection, stigmatization, avoidance factors, verbal rejection, discrimination against family members, discrimination in the media, etc. (Brondolo et al., 2005; Contrada et al., 2001). Data on various subtypes of discrimination can help distinguish whether specific forms of coping assist in alleviating overall experiences of discrimination or only certain subtypes. Therefore, assessing types of discrimination exposure and coping strategies used by African Americans to deal with discrimination exposure could add to the literature. These data could help explain why African Americans have higher HRV compared to European Americans, despite being at a higher risk of developing poor health outcomes. Finding that some forms of coping with discrimination contribute to higher, healthier HRV could provide methods or inform interventions designed to improve poor physiological variability.

4.3 Conclusion

Congruent with existing research, African Americans have higher resting HRV compared to European Americans, despite being at a higher risk of developing poor health outcomes. It was also found that within each group (African American and European American), perceived discrimination was not significantly related to resting HRV. Further, perceived stress reactivity was not associated with resting HRV for the entire sample or within each group. Race was the strongest predictor of HRV amongst all of the study variables. Given these findings, future research should explore what specifically about the experience of race contributes to racial differences in HRV. It could be that resting HRV is an indicator of copings skills and African Americans have adaptive coping skills when faced with discrimination. Further, discrimination scales that capture multiple factors related to the experience of discrimination should be used in future studies.

Table 1

Summary of sample characteristics (mean and standard deviation) and group differences.

	Overall (*n*=85)	African American (*n*=42)	European American (*n*=43)
Age (years)	20.58(1.66)	20.84(1.78)	20.34(1.52)
BMI (kg/m^2)	24.67(4.23)	25.84(4.46)*	23.53(3.70)
Parent income	6.71(2.89)	5.32(2.93)	7.98(2.21)**
HRV	11.50(8.30)	14.22(9.48)**	8.84(5.94)
Perceived Discrimination	19.86(8.67)	23.33(8.66)**	16.47(7.30)
Perceived Stress Reactivity	19.34(6.79)	18.48(7.33)	20.19(6.19)

Note. N=85. *$p < .05$, **$p < .01$. BMI = Body Mass Index. kg/m^2 = kilograms per meters squared. HRV = heart rate variability. Raw values provided to enhance interpretation, but analyses conducted with $\log_{10}$ transformation. Parent income was measured on a scale ranging from 1 ($0-$29,999) to 10 (More than $150,000) per year, 5 ($60,000-$69,999) and 8 ($90,000-$99,999). Perceived Discrimination was measured on a scale from 9 to 54. Perceived Stress Reactivity was measured on a scale from 0 to 46.

Table 2

Correlations among study variables for all participants

Variable	1	2	3	4	5	6	7	8
1. Race(AA)	--							
2. Age	.15	--						
3. Sex (female)	.10	-.01	--					
4. BMI	.27*	.09	.12	--				
5. Parent income	-.46**	-.16	-.34**	-.05	--			
6. PD	.39**	-.02	-.13	-.07	-.07	--		
7. PSR	-.12	.00	.26*	-.13	-.20	-.05	--	
8. HRV	.34**	.19	.08	.04	-.16	.21*	-.00	--

Note. N=85. *$p < .05$, **$p < .01$. BMI = Body Mass Index. PD = Perceived Discrimination. PSR= Perceived Stress Reactivity. HRV = Heart Rate Variability. AA is coded as 1 and EA as 0. Male is coded as 1 and female as 2.

Table 3

Correlations among African American participants

Variable	1	2	3	4	5	6	7
1. Age	--						
2. Sex (female)	-.07	--					
3. BMI	-.08	.23	--				
4. Parent income	.07	-.33*	.01	--			
5. PD	.08	-.32*	-.34*	.07	--		
6. PSR	-.06	.32*	-.14	-.41**	.07	--	
7. HRV	.28	-.01	-.09	.04	.16	.22	--

Note. N=42. *$p < .05$, **$p < .01$. BMI = Body Mass Index. PD = Perceived Discrimination. PSR= Perceived Stress Reactivity. HRV = Heart Rate Variability. Male is coded as 1 and female as 2.

Table 4

Correlations among European American participants

Variable	1	2	3	4	5	6	7
1. Age	--						
2. Sex (female)	.01	--					
3. BMI	.25	-.06	--				
4. Parent income	-.28	-.29	.23	--			
5. PD	-.32*	-.05	-.02	.19	--		
6. PSR	.14	.24	-.06	-.08	-.11	--	
7. HRV	-.00	.10	-.00	-.05	.00	-.18	--

Note. N=43. *$p < .05$, **$p < .01$. BMI = Body Mass Index. PD = Perceived Discrimination. PSR= Perceived Stress Reactivity. HRV = Heart Rate Variability. Male is coded as 1 and female as 2.

REFERENCES

Acharya, U. R., Joseph, K. P., Kannathal, N., Lim, C. M., & Suri, J. S. (2006). Heart rate variability: A review. *Medical and Biological Engineering and Computing, 44*(12), 1031-1051.

Allen, B., Jennings, J. R., Gianaros, P. J., Thayer, J. F., & Manuck, S. B. (2015). Resting high-frequency heart rate variability is related to resting brain perfusion. *Psychophysiology*, *52*(2), 277-287.

Antelmi, I., De Paula, R. S., Shinzato, A. R., Peres, C. A., Mansur, A. J., & Grupi, C. J. (2004). Influence of age, gender, body mass index, and functional capacity on heart rate variability in a cohort of subjects without heart disease. *The American Journal of Cardiology*, *93*(3), 381-385.

Appelhans, B. M., & Luecken, L. J. (2006). Heart rate variability as an index of regulated emotional responding. *Review of General Psychology, 10*(3), 229-240.

Bravi, A., Green, G., Longtin, A., & Seely, A. J. (2012). Monitoring and identification of sepsis development through a composite measure of heart rate variability. *PLoS One, 7*(9), 1-7.

Brondolo, E., Kelly, K. P., Coakley, V., Gordon, T., Thompson, S., Levy, E., Cassells, A., Tobin, J. N., Sweeney, M., & Contrada, R. J. (2005). The Perceived Ethnic Discrimination Questionnaire: Development and preliminary validation of a community version. *Journal of Applied Social Psychology*, *35*(2), 335-365.

Brondolo, E., Ver Halen, N. B., Pencille, M., Beatty, D., & Contrada, R. J. (2009). Coping with racism: A selective review of the literature and a theoretical and methodological critique. *Journal of Behavioral Medicine, 32*(1), 64-88.

Buijs, R. M. (2013). The autonomic nervous system: A balancing act. In R. M. Buijs & D. F. Swaab (Eds.), *Handbook of Clinical Neurology* (pp. 1-11). doi: 10.1016/B978-0-444-53491-0.00001-8.

Busjahn, A., Voss, A., Knoblauch, H., Knoblauch, M., Jeschke, E., Wessel, N., Bohlender, J., McCarron, J., Faulhaber, H. D., Schuster, H., Dietz, R., & Luft, F. C. (1998). Angiotensin-converting enzyme and angiotensinogen gene polymorphisms and heart rate variability in twins. *American Journal of Cardiology*, *81*(6), 755-760.

Choi, J. B., Hong, S., Nelesen, R., Bardwell, W. A., Natarajan, L., Schubert, C., & Dimsdale, J. E. (2006). Age and ethnicity differences in short-term heart-rate variability. *Psychosomatic Medicine*, *68*(3), 421-426.

Clark, R., Anderson, N. B., Clark, V. R., & Williams, D. R. (1999). Racism as a stressor for African Americans: A biopsychosocial model. *The American Psychologist, 54*(10), 805-816.

Clark, R., Coleman, A. P., & Novak, J. D. (2004). Brief report: Initial psychometric properties of the everyday discrimination scale in black adolescents. *Journal of Adolescence*, *27*(3), 363-368.

Contrada, R. J., Ashmore, R. D., Gary, M. L., Coups, E., Egeth, J. D., Sewell, A., Ewell, K., & Goyal, M. G. (2001). Measures of ethnicity-related stress: Psychometric properties, ethnic group differences, and associations with well-being. *Journal of Applied Social Psychology*, *31*(9), 1775-1820.

Craig, C. L., Marshall, A. L., Sjorstrom, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J. F., & Oja, P. (2003). International Physical Activity Questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise*, *35*(8), 1381-1395.

Crimmins, E. M., Kim, J. K., Alley, D. E., Karlamangla, A., & Seeman, T. (2007). Hispanic paradox and biological risk profiles. *American Journal of Public Health*, *97*(7), 1305-1310.

Denson, T. F., Grisham, J. R., & Moulds, M. L. (2011). Cognitive reappraisal increases heart rate variability in response to an anger provocation. *Motivation and Emotion*, *35*(1), 14-22.

Dorr, N., Brosschot, J. F., Sollers III, J. J., & Thayer, J. F. (2007). Damned if you do, damned if you don't: The differential effect of expression and inhibition of anger on cardiovascular recovery in Black and White males. *International Journal of Psychophysiology*, *66*(2), 125-134.

Elliot, A. J., Payen, V., Brisswalter, J., Cury, F., & Thayer, J. F. (2011). A subtle threat cue, heart rate variability, and cognitive performance. *Psychophysiology*, *48*(10), 1340-1345.

Fagundes, C. P., Murray, D. M., Hwang, B. S., Gouin, J. P., Thayer, J. F., Sollers III, J. J., Shapiro, C. L., Malarkey, W. B., & Kiecolt-Glaser, J. K. (2011). Sympathetic and parasympathetic activity in cancer-related fatigue: More evidence for a physiological substrate in cancer survivors. *Psychoneuroendocrinology*, *36*(8), 1137-1147.

Federenko, I. S., Schlotz, W., Kirschbaum, C., Bartels, M., Hellhammer, D. H., & Wüst, S. (2006). The heritability of perceived stress. *Psychological Medicine*, *36*(3), 375-385.

Finch, B. K., & Vega, W. A. (2003). Acculturation stress, social support, and self-rated health among Latinos in California. *Journal of Immigrant Health*, *5*(3), 109-117.

Flores, E., Tschann, J. M., Dimas, J. M., Bachen, E. A., Pasch, L. A., & de Groat, C. L. (2008). Perceived discrimination, perceived stress, and mental and physical health among Mexican-origin adults. *Hispanic Journal of Behavioral Sciences*, *30*(4), 401-424.

Folkman, S. (2013). Stress: Appraisal and coping. In *Encyclopedia of Behavioral Medicine* (pp. 1913-1915). New York, NY: Springer.

Gamelin, F. X., Berthoin, S., & Bosquet, L. (2006). Validity of the polar S810 heart rate monitor to measure R-R intervals at rest. *Medicine and Science in Sports and Exercise, 38*(5), 887–893.

Gee, G. C., Spencer, M. S., Chen, J., & Takeuchi, D. (2007). A nationwide study of discrimination and chronic health conditions among Asian Americans. *American Journal of Public Health*, *97*(7), 1275-1282.

Hayes, Andrew F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach.* New York, NY: The Guilford Press.

Hill, L. K., Hoggard, L. S., Richmond, A. S., Gray, D. L., Williams, D. P., & Thayer, J. F. (2017). Examining the association between perceived discrimination and heart rate variability in African Americans. *Cultural Diversity and Ethnic Minority Psychology*, *23*(1), 5-14.

Hill, L. K., Hu, D. D., Koenig, J., Sollers III, J. J., Kapuku, G., Wang, X., Snieder, H., & Thayer, J. F. (2015). Ethnic differences in resting heart rate variability: A systematic review and meta-analysis. *Psychosomatic Medicine*, *77*(1), 16-25.

Hokanson, J. E., Willers, K. R., & Koropsak, E. (1968). The modification of autonomic responses during aggressive interchange. *Journal of Personality*, *36*(3), 386-404.

Jasinskaja-Lahti, I., Liebkind, K., Jaakkola, M., & Reuter, A. (2006). Perceived discrimination, social support networks, and psychological well-being among three immigrant groups. *Journal of Cross-Cultural Psychology*, *37*(3), 293-311.

Jensen-Urstad, K., Storck, N., Bouvier, F., Ericson, M., Lindbland, L. E., & Jensen-Urstad, M. (1997). HRV in healthy subjects is related to age and gender. *Acta Physiologica Scandinavica*, *160*(3), 235-241.

Kahn, J. R., & Fazio, E. M. (2005). Economic status over the life course and racial disparities in health. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *60*(Special Issue 2), S76-S84.

Kemp, A. H., Koenig, J., Thayer, J. F., Bittencourt, M. S., Pereira, A. C., Santos, I. S., Dantas, E. M., Mill, J. G., Chor, D., Ribeiro, A. L. P., Benseñor, I. M., & Lotufo, P. A. (2016). Race and resting-state heart rate variability in Brazilian civil servants and the mediating effects of discrimination: An ELSA-Brasil cohort study. *Psychosomatic Medicine, 78*(8), 950-958.

Kemp, A. H., & Quintana, D. S. (2013). The relationship between mental and physical health: Insights from the study of heart rate variability. *International Journal of Psychophysiology*, *89*(3), 288-296.

Lampert, R., Ickovics, J., Horwitz, R., & Lee, F. (2005). Depressed autonomic nervous system function in African Americans and individuals of lower social class: A potential mechanism of race-and class-related disparities in health outcomes. *American Heart Journal*, *150*(1), 153-160.

Lazarus, R. S., & Folkman, S. (1984). Coping and adaptation. *The Handbook of Behavioral Medicine*, 282-325.

Li, Z., Snieder, H., Su, S., Ding, X., Thayer, J. F., Treiber, F. A., & Wang, X. (2009). A longitudinal study in youth of HRV at rest and in response to stress. *International Journal of Psychophysiology*, *73*(3), 212-217.

Limm, H., Angerer, P., Heinmueller, M., Marten-Mittag, B., Nater, U. M., & Guendel, H. (2010). Self-perceived stress reactivity is an indicator of psychosocial impairment at the workplace. *BMC Public Health*, *10*(1), 252-352.

McEwen, B. S. (2008). Central effects of stress hormones in health and disease: Understanding the protective and damaging effects of stress and stress mediators. *European Journal of Pharmacology*, *583*(2-3), 174-185.

McEwen, B. S. (1998). Protective and damaging effects of stress mediators. *New England Journal of Medicine, 338*(3), 171-179.

Monk Jr, E. P. (2015). The cost of color: Skin color, discrimination, and health among African-Americans. *American Journal of Sociology*, *121*(2), 396-444.

Nicolini, P., Ciulla, M. M., Asmundis, C. D., Magrini, F., & Brugada, P. (2012). The prognostic value of heart rate variability in the elderly, changing the perspective: From sympathovagal balance to chaos theory. *Pacing and Clinical Electrophysiology*, *35*(5), 621-637.

Nunan, D., Donovan, G. A. Y., Jakovljevic, D., Hodges, L., Sandercock, G., & Brodie, D. (2009). Validity and reliability of short-term heart-rate variability from the Polar S810. *Medicine & Science in Sports & Exercise*, *41*(1), 243-250.

Park, J., Flores, A. J., Aschbacher, K., & Mendes, W. B. (2018). When anger expression might be beneficial for African Americans: The moderating role of chronic discrimination. *Cultural Diversity and Ethnic Minority Psychology*, *24*(3), 303-318.

Pascoe, E. A., & Smart Richman, L. (2009). Perceived discrimination and health: A meta-analytic review. *Psychological Bulletin*, *135*(4), 531-554.

Porges, S. W. (1995). Cardiac vagal tone: A physiological index of stress. *Neuroscience & Biobehavioral Reviews*, *19*(2), 225-233.

Prelow, H. M., Mosher, C. E., & Bowman, M. A. (2006). Perceived racial discrimination, social support, and psychological adjustment among African American college students. *Journal of Black Psychology, 32*(4), 442-454.

Price, J. H., McKinney, M. A., & Braun, R. E. (2010). Social determinants of racial/ethnic health disparities in children and adolescents. *Health Educator*, *43*(1), 2-12.

Salomon, K., & Jagusztyn, N. E. (2008). Resting cardiovascular levels and reactivity to interpersonal incivility among Black, Latina/o, and White individuals: The moderating role of ethnic discrimination. *Health Psychology*, *27*(4), 473-481.

Schlotz, W. (2013). Stress reactivity. In *Encyclopedia of Behavioral Medicine* (pp. 1891-1894). New York, NY: Springer.

Schlotz, W., Hammerfald, K., Ehlert, U., & Gaab, J. (2011). Individual differences in the cortisol response to stress in young healthy men: Testing the roles of perceived stress reactivity and threat appraisal using multiphase latent growth curve modeling. *Biological Psychology*, *87*(2), 257-264.

Schlotz, W., Yim, I. S., Zoccola, P. M., Jansen, L., & Schulz, P. (2011a). The Perceived Stress Reactivity Scale: Measurement invariance, stability, and validity in three countries. *Psychological Assessment*, *23*(1), 80-94.

Segerstrom, S. C., & Nes, L. S. (2007). Heart rate variability reflects self-regulatory strength, effort, and fatigue. *Psychological Science*, *18*(3), 275-281.

Sellers, R. M., Caldwell, C. H., Schmeelk-Cone, K. H., & Zimmerman, M. A. (2003). Racial identity, racial discrimination, perceived stress, and psychological distress among African American young adults. *Journal of Health and Social Behavior*, *44*(3), 302-317.

Sturmberg, J. P., Bennett, J. M., Picard, M., & Seely, A. J. (2015). The trajectory of life. Decreasing physiological network complexity through changing fractal patterns. *Frontiers in Physiology*, *6*(169), 1-11.

Tarvainen, M. P., Niskanen, J. P., Lipponen, J. A., Ranta-Aho, P. O., & Karjalainen, P. A. (2014). Kubios HRV–heart rate variability analysis software. *Computer Methods and Programs in Biomedicine, 113*(1), 210-220.

Thayer, J. F., Åhs, F., Fredrikson, M., Sollers III, J. J., & Wager, T. D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: Implications for heart rate variability as a marker of stress and health. *Neuroscience & Biobehavioral Reviews, 36*(2), 747-756.

Thayer, J. F., Hansen, A. L., Saus-Rose, E., & Johnsen, B. H. (2009). Heart rate variability, prefrontal neural function, and cognitive performance: The neurovisceral integration perspective on self-regulation, adaptation, and health. *Annals of Behavioral Medicine, 37*(2), 141-153.

Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders, 61*(3), 201-216.

Thayer, J. F., & Sternberg, E. (2006). Beyond heart rate variability. *Annals of the New York Academy of Sciences, 1088*(1), 361-372.

Thayer, J. F., Yamamoto, S. S., & Brosschot, J. F. (2009). The relationship of autonomic imbalance, heart rate variability and cardiovascular disease risk factors. *International Journal of Cardiology, 141*(2), 122-131.

Umetani, K., Singer, D. H., McCraty, R., & Atkinson, M. (1998). Twenty-four hour time domain HRV and heart rate: Relations to age and gender over nine decades. *Journal of the American College of Cardiology, 31*(3), 593-601.

Utsey, S. O., Bolden, M. A., Lanier, Y., & Williams III, O. (2007). Examining the role of culture-specific coping as a predictor of resilient outcomes in African Americans from high-risk urban communities. *Journal of Black Psychology, 33*(1), 75-93.

Utsey, S. O., Ponterotto, J. G., Reynolds, A. L., & Cancelli, A. A. (2000). Racial discrimination, coping, life satisfaction, and self-esteem among African Americans. *Journal of Counseling & Development, 78*(1), 72-80.

Wagner, J., Lampert, R., Tennen, H., & Feinn, R. (2015). Exposure to discrimination and heart rate variability reactivity to acute stress among women with diabetes. *Stress and Health, 31*(3), 255-262.

Wang, X., Ding, X., Su, S., Li, Z., Riese, H., Thayer, J. F., Treiber, F., & Snieder, H. (2009). Genetic influences on heart rate variability at rest and during stress. *Psychophysiology, 46*(3), 458-465.

Wang, X., Thayer, J. F., Treiber, F., & Snieder, H. (2005). Ethnic differences and heritability of heart rate variability in African-and European American youth. *The American Journal of Cardiology, 96*(8), 1166-1172.

Williams, D. R., & Mohammed, S. A. (2009). Discrimination and racial disparities in health: Evidence and needed research. *Journal of Behavioral Medicine, 32*(1), 20-47.

Williams, D. R., Yu, Y., Jackson, J. S., & Anderson, N. B. (1997). Racial differences in physical and mental health: Socioeconomic status, stress, and discrimination. *Journal of Health Psychology, 2*(3), 335-351.

World Health Organization [WHO]. (2016). *Social Determinants of Health.* Retrieved from http://www.who.int/social_determinants/sdh_definition/en/.

Zhang, J. (2007). Effect of age and sex on HRV in healthy subjects. *Journal of Manipulative and Physiological Therapeutics, 30*(5), 374-379.

Ziegler, D., Laude, D., Akila, F., & Elghozi, J. L. (2001). Time-and frequency-domain estimation of early diabetic cardiovascular autonomic neuropathy. *Clinical Autonomic Research, 11*(6), 369-376.

APPENDIX A: PRESCREEN

Eligibility Questions & Data collection:

1. Are you biologically a male or female?
2. What is your race?
3. Definition of Racial Identity: An individual's sense of having their identity defined by belonging to a particular race. On a scale of 1 (least identified) to 10 (most identified), how strongly do you identify with your race?
4. Do you smoke/use tobacco?
5. Do you live in a household with a tobacco smoker?
6. Do you drink alcohol? If so, how often?
7. Have you drunk 5 or more drinks on the same occasion on each of 5 or more days in the past 30 days?
8. Do you use marijuana? If so, when was the last time you used it?
9. Do you use any other illicit drugs? If so, when was the last time you used it?

10. Please list any prescription and over-the-counter medications, supplements, you take on a regular basis. Record the medication name, dose taken, and how often it is taken.

Name of drug/supplement	***Taken daily (Y/N)?***
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

11.	
12.	

11. Are you currently being treated or have ever been treated for the any of the following:

Chronic Illness Category	***Endorsement (Y/N)***	***Diagnosis Date (mm/yyyy)***	***Currently Txt (Y/N)?***
1. Depression, anxiety, or ADHD			
2. Strokes or peripheral vascular disease			
3. Pace maker or life-threatening abnormal heart rhythms			
4. Seizures, epilepsy, convulsions			
5. Liver or kidney problems, recurrent urinary tract infections			
6. Digestive problems (heartburn, reflux, irritable bowel syndrome, ulcers)			
7. High blood pressure			
8. Cardiovascular problems			

Do you have any other physical or mental health concerns? If so, please list.

<u>Female potential participants only</u>

12. Are you currently pregnant or attempting to become pregnant?

YES, Skip to conclusion script

NO

13. Are you currently breastfeeding?

YES, Skip to conclusion script

NO

APPENDIX B: STRESS OF BREATHING TASK

How stressful was this task?

1 2 3 4 5 6 7 8 9 10

APPENDIX C: DEMOGRAPHIC QUESTIONNAIRE

Demographic Data Collection

1. What is your biological sex? Male Female
2. What is your birthday? _____/_____/_____ MM/DD/YY
3. How much do you weigh? _____ lbs
4. How tall are you? _____ (ft and inches)
5. Are you employed?
6. If you are employed, what is your job and responsibilities?
7. If you are employed, how many hours per week do you work?
8. On a scale of 1 (least stressful) to 10 (most stressful), how stressful is your job?
9. How much money do you earn a year?
10. How much money do(es) your parent(s) earn a year?
11. Do you reside with and/or are considered a dependent of your parents?
12. How many years of education have you received after high school/GED?
13. What year are you in school?
14. What is your race?
15. Definition of Racial Identity: An individual's sense of having their identity defined by belonging to a particular race. On a scale of 1 (least identified) to 10 (most identified), how strongly do you identify with your race?

Female potential participants only

1. What was the start date of your last period?
   ____/_____/_____
2. On average, how many days does your complete cycle last? 21 28 35 Other _____

APPENDIX D: EVERYDAY DISCRIMINATION SCALE

In your day-to-day life how often have any of the following things happened to you because of your race?

1 = never, 2 = less than once a year, 3 = a few times a year, 4 = a few times a month, 5 = at least once a week, 6 = almost every day

	Never	Less Than Once A Year	A Few Times A Year	A Few Times A Month	At Least Once A Week	Almost Every Day
You are treated with less courtesy than other people	1	2	3	4	5	6
You are treated with less respect than other people	1	2	3	4	5	6
You receive poorer service than other people at restaurants or stores	1	2	3	4	5	6
People act as if they think you are not smart	1	2	3	4	5	6
People act as if they are afraid of you	1	2	3	4	5	6
People act as if they think you are dishonest	1	2	3	4	5	6
People act as if they're better than you	1	2	3	4	5	6
You are called names or insulted	1	2	3	4	5	6
You are threatened or harassed	1	2	3	4	5	6

Williams, D. R., Yu, Y., Jackson, J. S., & Anderson, N. B. (1997). Racial differences in physical and mental health: Socioeconomic status, stress, and discrimination. *Journal of Health Psychology, 2*(3), 335-351.

APPENDIX E: PERCEIVED STRESS REACTIVITY SCALE

This questionnaire asks about your **reactions to situations which you may have experienced in the past**. Three answers are suggested. Please indicate the answer that most closely describes your own reaction in general. Please don't skip any item, even if it may be hard to find the best answer.

01	*When tasks and duties build up to the extent that they are hard to manage…*	○ I am generally untroubled ○ I usually feel a little uneasy ○ I normally get quite nervous
02	*When I want to relax after a hard day at work…*	○ This is usually quite difficult for me ○ I usually succeed ○ I generally have no problem at all
03	*When I have conflicts with others that may not be immediately resolved…*	○ I generally shrug it off ○ It usually affects me a little ○ It usually affects me a lot
04	*When I make a mistake…*	○ In general, I remain confident ○ I sometimes feel unsure about my abilities ○ I often have doubts about my abilities
05	*When I'm wrongly criticized by others…*	○ I am normally annoyed for a long time ○ I am annoyed for just a short time ○ In general, I am hardly annoyed at all
06	*When I argue with other people…*	○ I usually calm down quickly ○ I usually stay upset for some time

		○ It usually takes me a long time until I calm down
07	*When I have little time for a job to be done…*	○ I usually stay calm ○ I usually feel uneasy ○ I usually get quite agitated
08	*When I make a mistake…*	○ I am normally annoyed for a long time ○ I am normally annoyed for a while ○ I generally get over it easily
09	*When I am unsure what to do or say in a social situation…*	○ I generally stay cool ○ I often feel warm ○ I often begin to sweat
10	*When I have spare time after working hard…*	○ It often is difficult for me to unwind and relax ○ I usually need some time to unwind properly ○ I am usually able to unwind effectively and forget about the problems of the day
11	*When I am criticized by others…*	○ important arguments usually come to my mind when it is too late to still make my point ○ I often have difficulty finding a good reply ○ I usually think of a reply to defend myself
12	*When something does not go the way I expected…*	○ I usually stay calm ○ I often get uneasy

		○ I usually get very agitated
13	*When I do not attain a goal…*	○ I usually remain annoyed for a long time
		○ I am usually disappointed, but recover soon
		○ In general, I am hardly concerned at all
14	*When others criticize me…*	○ I generally don't lose confidence at all
		○ I generally lose a little confidence
		○ I generally feel very unconfident
15	*When I fail at something…*	○ I usually find it hard to accept
		○ I usually accept it to some degree
		○ In general, I hardly think about it
16	*When there are too many demands on me at the same time…*	○ I generally stay calm and do one thing after the other
		○ I usually get uneasy
		○ Usually, even minor interruptions irritate me
17	*When others say something incorrect about me…*	○ I usually get quite upset
		○ I normally get a little bit upset
		○ In general, I shrug it off
18	*When I fail at a task…*	○ I usually feel very uncomfortable
		○ I usually feel somewhat uncomfortable
		○ In general, I don't mind

19	*When I argue with others…*	○ I usually get very upset ○ I usually get a little bit upset ○ I usually don't get upset
20	*When I am under stress…*	○ I usually can't enjoy my leisure time at all ○ I usually have difficulty enjoying my leisure time ○ I usually enjoy my leisure time
21	*When tasks and duties accumulate to the extent that they are hard to cope with…*	○ My sleep is unaffected ○ My sleep is slightly disturbed ○ My sleep is very disturbed
22	*When I have to speak in front of other people…*	○ I often get very nervous ○ I often get somewhat nervous ○ In general, I stay calm
23	*When I have many tasks and duties to fulfil…*	○ In general, I stay calm ○ I usually get impatient ○ I often get irritable

Schlotz, W., Yim, I. S., Zoccola, P. M., Jansen, L., & Schulz, P. (2011a). The Perceived Stress Reactivity Scale: Measurement invariance, stability, and validity in three countries. *Psychological Assessment*, *23*(1), 80-94.

APPENDIX F: INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** and **moderate** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3.

1. Do you currently have a job or do any unpaid work outside your home?

☐ Yes

☐ No ***Skip to PART 2: TRANSPORTATION***

The next questions are about all the physical activity you did in the **last 7 days** as part of your paid or unpaid work. This does not include traveling to and from work.

2. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, heavy construction, or climbing up stairs **as part of your work**? Think about only those physical activities that you did for at least 10 minutes at a time.

_____ days per week

☐ No vigorous job-related physical activity → ***Skip to question 4***

3. How much time did you usually spend on one of those days doing **vigorous** physical activities as part of your work?

_____ hours per day
_____ minutes per day

4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads **as part of your work**? Please do not include walking.

_____ days per week

☐ No moderate job-related physical activity → ***Skip to question 6***

5. How much time did you usually spend on one of those days doing **moderate** physical activities as part of your work?

_____ hours per day
_____ minutes per day

6. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **as part of your work**? Please do not count any walking you did to travel to or from work.

_____ days per week

☐ No job-related walking → ***Skip to PART 2: TRANSPORTATION***

7. How much time did you usually spend on one of those days **walking** as part of your work?

_____ hours per day
_____ minutes per day

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

8. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a train, bus, car, or tram?

_____ days per week

☐ No traveling in a motor vehicle → ***Skip to question 10***

9. How much time did you usually spend on one of those days **traveling** in a train, bus, car, tram, or other kind of motor vehicle?

_____ **hours per day**
_____ **minutes per day**

Now think only about the **bicycling** and **walking** you might have done to travel to and from work, to do errands, or to go from place to place.

10. During the **last 7 days**, on how many days did you **bicycle** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No bicycling from place to place → ***Skip to question 12***

11. How much time did you usually spend on one of those days to **bicycle** from place to place?

_____ **hours per day**
_____ **minutes per day**

12. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No walking from place to place → ***Skip to PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY***

13. How much time did you usually spend on one of those days **walking** from place to place?

_____ **hours per day**
_____ **minutes per day**

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section is about some of the physical activities you might have done in the **last 7 days** in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

14. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous**

physical activities like heavy lifting, chopping wood, shoveling snow, or digging **in the garden or yard**?

_____ **days per week**

☐ No vigorous activity in garden or yard → ***Skip to question 16***

15. How much time did you usually spend on one of those days doing **vigorous** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, sweeping, washing windows, and raking **in the garden or yard**?

_____ **days per week**

☐ No moderate activity in garden or yard → ***Skip to question 18***

17. How much time did you usually spend on one of those days doing **moderate** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, washing windows, scrubbing floors and sweeping **inside your home**?

_____ **days per week**

☐ No moderate activity inside home → ***Skip to PART 4: RECREATION,***

SPORT AND LEISURE-TIME PHYSICAL ACTIVITY

19. How much time did you usually spend on one of those days doing **moderate** physical activities inside your home?

_____ **hours per day**

_____ **minutes per day**

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all the physical activities that you did in the **last 7 days** solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking you have already mentioned, during the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **in your leisure time**?

_____ **days per week**

☐ No walking in leisure time → ***Skip to question 22***

21. How much time did you usually spend on one of those days **walking** in your leisure time?

_____ **hours per day**
_____ **minutes per day**

22. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like aerobics, running, fast bicycling, or fast swimming **in your leisure time**?

_____ **days per week**

☐ No vigorous activity in leisure time → ***Skip to question 24***

23. How much time did you usually spend on one of those days doing **vigorous** physical activities in your leisure time?

_____ **hours per day**
_____ **minutes per day**

24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis **in your leisure time**?

_____ **days per week**

☐ No moderate activity in leisure time → ***Skip to PART 5: TIME SPENT SITTING***

25. How much time did you usually spend on one of those days doing **moderate** physical activities in your leisure time?
_____ hours per day
_____ minutes per day

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

26. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

_____ hours per day
_____ minutes per day

27. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekend day**?

_____ hours per day
_____ minutes per day

This is the end of the questionnaire, thank you for participating.

Craig, C. L., Marshall, A. L., Sjorstrom, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J. F., & Oja, P. (2003). International Physical Activity Questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise*, *35*(8), 1381-1395.