The CHAMPS Study: Cardiovascular Health: Associations with Mindfulness, Physical Exercise and Stress Appraisals

by

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Table of Contents

List of Tables

List of Figures

List of Appendices

Abstract

Cardiovascular functioning at baseline and during reactivity to acute stressors has been shown to be a significant predictor of future cardiovascular health. Research has indicated that cardiovascular functioning can be modulated through a variety of physical and psychological mechanisms, including exercise, mindfulness characteristics and practice, and stress management. While these three variables are associated with similar cardiovascular changes, exercise, mindfulness, and stress have not yet been considered in an integrative theory despite sharing comparable psychophysiological processes and outcomes. The present study sought to address this gap in the literature by examining associations among aerobic exercise, trait mindfulness, and cognitive stress appraisals and their relations to cardiovascular functioning at baseline and during reactivity to an acute psychological stressor. Fifty-four undergraduates, who were identified as either non-exercising subject pool students or student athletes, participated in the TSST, a stress protocol consisting of a speech task and a mental arithmetic task. Physiological measures for systolic and diastolic blood pressure, heart rate, and heart rate variability were assessed during the last five minutes of a 10-minute resting baseline period and during the two stress tasks. Self-report measures were collected on stress appraisals, perceived chronic stress, and trait mindfulness. Results indicated that athletes generally demonstrated healthier cardiovascular patterns than non-exercisers at baseline and no notable differences during reactivity. No group differences were found for mindfulness or stress appraisals. Mindfulness overall showed inverse associations with stress, and few physiological reactivity measures were accounted for by mindfulness. Psychological and physiological outcomes,

limitations, and future directions are discussed.

Keywords: exercise, mindfulness, stress, physiological reactivity

Chapter I

Introduction

Cardiovascular disease (CVD) is the leading cause of death for both men and women in industrialized countries. In the United States, one in four deaths in adulthood is attributed to a form of CVD, the most common being coronary heart disease (Murphy, Xu, & Kochanek, 2013). Diseases of the cardiovascular- and cerebro-vascular system, such as arrhythmias, atherosclerosis, and arteriosclerosis, often involve electrical or inflammatory malfunction. Atherosclerosis reduces blood circulation to cardiac tissue through pro-inflammatory mediated buildup of localized plaques in the arterial endothelium. These plaques are composed of lipids, fats, cholesterol, macrophages (or foam cells), and additional substances (Black & Garbutt, 2002). Arteriosclerosis involves the increasing rigidity of blood vessels through a calcification process that inhibits vessel dilation and cardiac flexibility (Sarafino & Smith, 2011). In addition, disruption of cardiac electrical activity may result from changes in autonomic nervous system activity, cardiac damage as a result of atherosclerosis, or a variety of other conditions (Black & Garbutt, 2002). These common cardiovascular illnesses, along with other disease processes, often result in myocardial infarction, angina, sudden cardiac arrest, cardiac arrhythmias, stroke, cardiomyopathy, peripheral arterial disease, and other medical conditions (Centers for Disease Control [CDC], 2015).

Mediating and moderating variables have been identified for the onset and maintenance of a variety of cardiovascular diseases. Unmodifiable risk factors include a genetic predisposition from a family history of CVD, being of male sex, and being of older age (Goff et al., 2014).

European-, African-, and Hispanic-American racial profiles are also associated with higher risk although the racial gap is narrowing (Heron, 2012). Modifiable factors point toward the presence of certain medical conditions and lifestyle behaviors. High-risk physical disorders include high blood pressure (Chobanian et al., 2003), high low density lipoprotein (LDL), high total cholesterol (Stamler et al., 2000; Terry et al., 2005), metabolic syndromes, diabetes, and obesity (Taylor et al., 2010; Vanuzzo, Pilotto, Mirolo, Pirelli, 2008).

Lifestyles that include smoking (Centers for Disease Control and Prevention, 2014), alcohol use (Quintana, McGregor, Guastella, Malhi, & Kemp, 2013), poor nutrition (Flock & Kris-Etherton, 2011), physical inactivity (Warburton, Nicol, & Bredin, 2006), and inadequate and excessive sleep (Cappuccio, Cooper, D'Elia, Strazzullo, & Miller, 2011) also promote CVD. Nontraditional, modifiable risk factors for CVD have received recent attention in the literature. These psychological and physiological contributors are the effects of stress (Rozanski, Blumenthal, & Kaplan, 1999), negative emotions (Musselman, Evans, & Nemeroff, 1998), low heart rate variability (Tsuji et al., 1996), elevated homocysteine levels (Nygård, Vollset, Refsum, Brattström, & Ueland, 1999), elevated C-reactive proteins (Ridker, Buring, Cook, & Rifai, 2003), and infectious agents (Sico et al., 2015). Roughly half of Americans are considered to be at a high risk in at least one area of smoking, high blood pressure, and high LDL cholesterol (Fryar, Chen, & Li, 2012). Additional epidemiological research will fully determine the widespread impact of understudied, nontraditional high-risk conditions.

Stress, in particular, is linked to increased risk of CVD in several meta-analyses and longitudinal studies. Occupational strain has been associated with a 1.23 increase in risk for CVD (Kivimäki et al., 2012), and long term unemployment with a 1.63 increase in risk of early death, often due to CVD (Roelfs, Shor, Davidson, & Schwartz, 2011). Cardiovascular disease has been linked to higher mortality rates of 0.54 for men and of 4.01 of women in chronically stressful marriages. Married men also carried a 2.7 increased risk of coronary heart disease if their wives experienced high job-related stress (Eaker, Sullivan, Kelly-Hayes, D'Agostino, & Benjamin, 2007). Another chronic stressor associated with CVD is physical and sexual abuse in childhood; one-fifth of 66,798 female participants who experienced severe maltreatment showed a 1.5 increase in risk of early onset CVD (Rich-Edwards et al., 2012).

Psychiatric illnesses also are linked to CVD, and depression, anxiety, and other psychosocial factors may mediate a portion of this association (Thayer & Sternberg, 2006). Patients with Bipolar Disorder are more likely to die prematurely of CVD or experience comorbid medical diseases than the general population, and the side effects of pharmacotherapy (e.g., weight gain, lipid and glucose dysregulation) do not fully account for these elevated risks (Swartz & Fagiolini, 2012). War veterans diagnosed with Posttraumatic Stress Disorder (PTSD) exhibit many risk CVD factors, including reduced heart rate variability, sympathetic hyperactivation, and elevated blood pressure and heart rate (Bedi & Arora, 2007). Significant events of myocardial infarction or unstable angina may trigger posttraumatic stress, perpetuating a jeopardized cardiovascular system. In one meta-analysis, at least 12% of individuals who had experienced these cardiac events suffered from PTSD symptoms related to the event with some studies calculating PTSD symptoms in over 30% in certain populations. Experiencing PTSD also was associated with an elevated risk of future cardiac events (Edmondson et al., 2012).

Despite the long list of threats to cardiovascular functioning, many of the risk factors lie on a continuum. In fact, engaging in healthful behaviors effectively mitigates some risky profiles (Rozanski, 2014). Behavioral examples include balanced and nutritious diets with limited alcohol consumption (Dietary Guidelines Advisory Committee, 2010), smoking abstinence

(Centers for Disease Control and Prevention, 2014), management of physical illness (Warburton et al., 2006), and exercise (Moya-Albiol et al., 200). Social interactions, positivity, optimism, and mindfulness are more recently identified psychosocial factors that may enhance cardiovascular health. (Carlson, Speca, Faris, & Patel, 2007; Endrighi, Hamer, & Steptoe, 2011; Ikeda et al., 2011). The focus of this paper is on the protective behaviors of physical exercise (Moya-Albiol et al., 2001; Rimmele et al., 2009; Warburton et al., 2006) and characteristics of mindfulness (Carlson et al., 2007; Garland, Gaylord, & Fredrickson, 2011; Nijjar et al., 2014), two factors robustly supported in cardiovascular health and stress management literature.

The relations among exercise, mindfulness, stress, and cardiovascular health reflect the biopsychosocial approach to wellness. While associations among these variables have been examined across many isolated studies, an analysis of all four variables in the context of an integrative theory has not been researched. The purpose of this study is to consider potential associations among these variables within the framework of psychological stress and cardiovascular stress responses.

Review of the Cardiovascular System

Given that CVD is the leading cause of death in United States (CDC, 2015), significant effort has been made to identify risk and preventive factors for disease processes. Ambulatory functioning and reactivity of the cardiovascular system to a variety of stressors have been shown to be significant in the outcome of a person's health status (Heponiemi et al., 2007; Moseley & Linden, 2006; Rozanski et al., 1999; Treiber et al., 2003). Relevant to the current study in terms of cardiovascular ambulatory and reactivity states are blood pressure, heart rate, and heart rate variability. Recovery from acute stressors, though also valuable for assessing cardiovascular health and risk (Thayer & Sternberg, 2006), will not be further discussed as it is beyond the scope of this manuscript.

Ambulatory functioning refers to the everyday allostatic conditions (which is described in greater detail below) of these variables. Reactivity denotes the acute physiological changes from an organism's relatively stable resting point in response to intrinsic or extrinsic stimuli (McEwen & Wingfield, 2003). Although these variables tend to be in constant flux, they maintain a reasonably narrow range during ambulatory states. In addition, alterations from ambulatory states should only fluctuate so much to preserve healthy functioning during reactivity events. Individuals often exhibit their CVD risk through allostatic inflexibility as shown by chronic physiological imbalances during ambulatory functioning and harmful physiological conditions during reactivity (Thayer & Sternberg, 2006).

Blood pressure. Blood pressure, the force exerted by blood on the arterial walls, maintains a dynamic ambulatory state that shifts between diastolic and systolic pressures. Diastolic blood pressure (DBP) signifies the arterial force between cardiac contractions and is the pressure of true cardiovascular rest. Systolic blood pressure (SBP) indicates the arterial force at the apex of ventricular contraction and reflects maximum pressure. Conditions of the peripheral vasculature determine DBP in relation to SBP, and contractile force of the heart from sympathetic innervation in the myocardium primarily modulates SBP although additional mechanisms are at play for both DBP and SBP (e.g., vascular flexibility). Contractile force impacts stroke volume (the amount of blood pumped from a single ventricle contraction) and the subsequent feedback from baroreceptors (stretch receptors) in the vasculature, both of which help to regulate blood pressure. In an adaptive cardiovascular system, ambulatory DBP and SBP fluctuate minimally, and reactivity occurs in low to moderate doses (Moseley & Linden, 2006; Sarafino & Smith, 2011).

Elevations in ambulatory blood pressure strongly predict morbidity and mortality. In a meta-analysis of 61 prospective observational studies, the Prospective Studies Collaboration (2002) examined cardiovascular events in 958,074 individuals, aged 40-70, with no preexisting vascular disease at baseline and found that any elevation across the blood pressure range (i.e., 115/75 – 185/115 mm Hg) was strongly and independently correlated with risk of death from CVD. Notably, no ambulatory blood pressure readings below 115/75 mm Hg indicated any significant reduction in disease risk. Across the above blood pressure range, each increment of 20 mm Hg of SBP (or 10 mm Hg of DBP) more than doubled the risk of death from stroke and at least doubled the risk of death from coronary heart disease and other CVD, including heart failure, hypertensive heart disease, atherosclerosis (Prospective Studies Collaboration, 2002).

Similarly, high blood pressure reactivity to a variety of acute stressors has been linked to the development of high-risk and diseased cardiovascular conditions (Chida & Hamer, 2008; Chobanian et al., 2003; Moseley & Linden, 2006; Rozanski et al., 1999; Treiber et al., 2003). A review by Treiber and colleagues (2003) found that elevated blood pressure reactivity to a cold pressor task in normotensive individuals strongly predicted future development of hypertension. Noted by the authors, this meaningful result was supported in three 20-year longitudinal studies; studies with less consistent outcomes operated under shorter time frames. The review further supported this finding with research using alternative stressors; including, but not limited to: mental mathematics, speech interviews, and video games; and with research using children, adolescents, young adults, and middle-aged adults. Blood pressure reactivity to acute stressors also was moderately associated with the development of carotid atherosclerosis and left ventricular hypertrophy (Treiber et al., 2003). Clinical CVD and high-risk cardiovascular conditions (e.g., hypertension) are often preceded by elevations in blood pressure at rest and during reactivity; however, other physiological mechanisms interact with blood pressure to establish a person's overall cardiovascular health status.

Heart rate. Heart rate, the number of ventricular beats per unit of time, significantly influences blood pressure since the rate of contractions, along with cardiac contractility, modulates the movement of blood throughout the body. Conditions for cardiac output, blood volume, peripheral resistance, vessel elasticity, viscosity, and the baroreflex are magnified through heart rate and its effect on blood pressure (Sarafino & Smith, 2011). Ambulatory heart rate is primarily controlled through electrochemical inputs through the autonomic nervous system at the sinoatrial node, although multiple factors interact to modulate heart rate, namely central command, respiration rate, cardiopulmonary reflexes, arterial baroreflexes, and the sympathovagal balance (Saul, 1990; Thayer & Sternberg, 2006). Of note to this paper, sympathovagal balance indicates the relative ratio of modulatory control between the efferent sympathetic activity and vagal parasympathetic activity (Saul, 1990; Sztajzel, 2004). Like blood pressure, heart rate reactivity in healthier cardiovascular profiles demonstrates some autonomic reactivity in response to acute stressors. However, when heart rate reactivity displays restricted autonomic flexibility or prolonged sympathetic activity, the predictive risk of CVD increases (Heponiemi et al., 2007; Rozanski et al., 1999).

Heart rate reliably indicates overall cardiac efficiency (Kannel, 2000; Palatini, 2007; Rozanski et al., 1999). As researched by Kannel (2000) from the Framingham Heart Study, high ambulatory heart rate served as a precursor of hypertension as well as congestive heart failure, which is an incurable, late-stage CVD stemming from hypertension and additional cardiovascular pathologies. Hypertension, when compared to myocardial infarction and valvular heart disease, accounted for the most variance in subsequent cases of congestive heart failure (Kannel, 2000). Elevated heart rate at rest (i.e., >80-85 bpm) also progresses atherosclerosis by increasing damage to the arterial endothelium and by promoting plaque development (Palatini, 2007). Elevated ambulatory heart rate promotes several high-risk and diseased cardiovascular processes.

Heart rate reactivity to acute stressors, as expressed by an increased frequency of heart beats, also accounts for a portion of future CVD. Heart rate reactivity turns maladaptive when the reactivity is blunted or prolonged, which often suggests the presence of an inflexible myocardium or electrical dysfunction (Heponiemi et al., 2007; Moseley & Linden, 2006; Rozanski et al., 1999). Heponiemi and researchers (2007) assessed 66 adults enrolled in the Cardiovascular Risk in Young Finns study on heart rate, respiratory sinus arrhythmia, and pre-ejection period during a speech task and a mental arithmetic task. Ultrasound data collected two years later indicated significantly higher levels of preclinical atherosclerosis in the carotid artery in participants who exhibited blunted reactivity of both autonomic branches during the stress tasks, even after adjusting for blood pressure, lipid count, and obesity (Heponiemi et al., 2007). Moseley and Linden (2006) measured SBP, DBP, and heart rate reactivity and recovery in 333 adults with normal blood pressure. Participants completed stress tasks with mental arithmetic, handgrip strength, and anger recall and were compared to their ambulatory and reactivity functioning at three- and 10-year follow-ups. Resting cardiovascular functioning unsurprisingly accounted for the most variance; nevertheless, reactivity and recovery patterns did significantly improve the predictive model. Heart rate reactivity accounted for another 4.3% of variance for the three-year outcomes in ambulatory functioning (Moseley & Linden, 2006).

Heart rate variability. Heart rate variability (HRV) is the measurement of variance of time between cardiac contractions as specified by the contiguous R peaks of the QRS complex on an electrocardiogram (ECG) (Task Force, 1996). While differential reactivity between the peripheral vasculature and cardiac system can be examined with impedance cardiography (Matthews, Salomon, Brady, & Allen, 2003), overall autonomic patterns in cardiovascular functioning can be estimated with an ECG (Sztajzel, 2004). Beat-to-beat time intervals during states of non-arousal and relaxation increase as parasympathetic activity increases control; as sympathetic activity gains dominance during reactivity to acute stressors (associated with flight-flight), the time intervals decrease. These general patterns reflect decreased and increased heart rate. In addition to parasympathetic withdrawal and sympathetic amplification during reactivity, the relative contributions of the autonomic branches shift regarding changes in variance of HRV, as shown, in part, by the sympathovagal balance (Saul, 1990; Sztajzel, 2004). Parasympathetic activity primarily influences the balance during ambulatory HRV, whereas sympathetic activity has a more significant part of the total contribution during HRV arousal.

Heart rate variability is a substantial indicator for cardiovascular health. With greater HRV, the heart adapts more flexibly to changes in energy needs (Murphy, Nevill, Murtagh, & Holder, 2007; Sandercock, Bromley, & Brodie, 2005; Tulppo et al., 2003). Reduced HRV during ambulatory functioning has been shown to be one of the most reliable markers for arrhythmic CVD, including sudden cardiac arrest, ventricular tachycardia, and mortality risk after myocardial infarction (Kleiger, Miller, Bigger, & Moss, 1987; Olshansky, Sabbah, Hauptman, & Colucci, 2008; Task Force, 1996). In a longitudinal study with 808 survivors of myocardial infarction, Kleiger et al. (1987) collected HRV data within two weeks of participants' cardiac event and at a 31-month follow-up. Individuals with low HRV (i.e., <50 ms) were at a 5.3 times greater risk of mortality than individuals with higher HRV (i.e., >100 ms). After the researchers adjusted for additional clinical and demographic variables, the strongest predictor of mortality was low HRV (Kleiger et al., 1987).

Two standard methods for HRV analysis are time domain measures and frequency domain spectral components measures. A third, less traditional method employs nonlinear analyses to assess degrees of complexity and entropy (Mansier et al., 1996). For time domain analyses, two measures are typically used. A global measure of the total variability within a sample of heart beats is obtained through the standard deviation of the heart beat time intervals (SDNN). A measure of rapidly-changing, relative parasympathetic activity can be obtained through the calculation of the root mean square of successive differences of the R-R intervals (RMSSD) in milliseconds (Task Force, 1996). Although these measures are useful for time interval variability, relatively little information is conveyed concerning the relative contributions of sympathetic and parasympathetic modulation of the sinoatrial node.

In order to garner greater information about these autonomic regulations, a frequency power density spectrum can be created from R-R interval data. Typically, either fast Fourier transformation or autoregressive techniques are used to generate the power spectrum. These methods partition the total variability into component sine waves of different frequencies and amplitudes. Specific frequency ranges represent different physiological activities with a strong representation of the autonomic nervous system. While variance from parasympathetic activity dominates the power spectrum and is a component of most frequency ranges, industry standard for frequency band interpretation attribute parasympathetic activity to high frequency (HF) power ranging from .15 to .40 Hz. Low frequency (LF) power, ranging from .04 to .15 Hz, is more controversial but is generally believed to be composed of variance from both sympathetic and parasympathetic activity with possible sympathetic dominance (Task Force, 1996). As an area currently not well understood, very low frequency (VLF) ranges from .00 to .04 Hz and is likely a mixture of autonomic, hormonal, and other sources of activity; VLF bands are inappropriate for short term readings (Berntson et al., 1997) and are, thus, not further discussed in this paper.

Effects of Aerobic Exercise

Definitions. Indisputably, regular physical activity and exercise reap cardiovascular benefits. Exercise not only establishes a healthier cardiovascular baseline but also is able to reverse the effects of damaged physical health (Fagard, 2001; Thompson et al., 2003). Exercise further enhances cardiovascular functioning by buffering against the negative, psychophysiological effects of stress and other mental health conditions (Blumenthal et al., 2005). Physical activity and exercise fall into a broad category of full-body movement; both activities expend energy (or calories) and engage the skeletal muscles. Physical activity ranges from cleaning a house to participating in an organized sport.

Intention discriminates exercise from physical activity. Exercise is planned, structured, and repetitive with the goal to improve or maintain physical fitness. Physical fitness is characterized by a person's ability to engage in activity and exercise which is developed through aerobic (or cardiorespiratory) exercise, strength training, flexibility, and body composition (Caspersen, Powell, & Christenson, 1985; Thompson et al., 2003). The magnitudes of physical fitness, psychological health benefits, and cardiovascular outcomes depend on the intensity and frequency of exercise (Dvorak et al., 2000; Physical Activity Guidelines Advisory Committee [PAGAC], 2008).

Although physical fitness requires many areas of training, aerobic exercise is particularly emphasized for the prevention of CVD (Mitchell, Haskell, Snell, & Van Camp, 2005). Classification of aerobic exercise begins with an understanding of metabolisms associated with physiological arousal, that is, anaerobic and aerobic metabolisms. Both anaerobic and aerobic metabolisms produce heat, but only aerobic energy expenditure leads to oxygen uptake (as understood by processes associated with ATP turnover) (Scott, 2005). Steady-state (or endurance) aerobic exercise engages oxygen-dependent metabolism that burns fat sources for energy in the mitochondria of cells and remains below the lactate threshold. Lactate (or lactic acid) accumulates in the muscles and blood stream when oxygen levels are insufficient to maintain aerobic metabolism. Surpassing the lactate threshold instigates anaerobic metabolism in the cytoplasm of cells by switching to glucose energy sources as observed in high-intensity physical activity that reach a person's maximum oxygen intake (VO_{2MAX}) or short, intense bursts of exercise (e.g., sprints, weightlifting, wrestling) (Mitchell et al., 2005; Scott, 2005).

Heart rate maintains optimal aerobic metabolism which is modulated in large part by exercise intensity and VO_{2MAX} (Mitchel et al., 2005). Absolute intensity refers to the amount of general effort needed for a given activity but does not consider an individual's level of fitness. Relative energy intensity takes into account an individual's fitness in regards to VO_{2MAX}, heart rate reserve, and aerobic capacity reserve for the ideal aerobic heart rate range (Mitchel et al., 2005; PAGAS, 2008). Thus, light, moderate, and vigorous relative intensities may or may not reflect the same heart rate ranges as in absolute intensities. Although intensity and VO_{2MAX} satisfactorily address aerobic heart rate, meaningful calculation of energy expenditure includes additional measurements for distance (e.g., miles or kilometers per day or week) and/or time (e.g., minutes or hours per day or week). For example, absolute intensity for energy expenditure is typically measured in kilocalories per day or week, kilocalories per kilograms of body weight per day or week, or MET (multiples of resting energy expenditure) minutes or hours per day or week (PAGAC, 2008).

The Physical Activity Guidelines Advisory Committee (2008), commissioned by the U.S. Department of Health and Human Services, provide both time and intensity amounts for an adult's weekly energy expenditure. In accordance to the recommendation, a person's exercise should meet the following criteria at minimum: 150 minutes per week of moderate intensity, 75 minutes per week of vigorous intensity, or a combination of the two previous options. Exercise duration must be sustained at least 10 minutes (PAGAC, 2008), although some sources suggest at least 20 minutes of continuous activity to qualify as endurance exercise (Carter, Banister, & Blaber, 2003). Adults who adhere to this regime notably gain health (e.g., mitigated risk for premature death) but only reach the minimum of their potential benefits. Physically fit adults and athletes can easily surpass the minimum, weekly recommendation with more frequent and intense bouts of energy expenditure. Greater amounts of exercise, within the reasonable limits of human functioning, augment an individual's health benefits (e.g., significantly lowered chance for breast cancer) (PAGAC, 2008).

However, these guidelines do not clearly quantify the terms *moderate* and *vigorous* intensities since they are provided at the group level. The PAGAC (2008) does offer a couple examples for the average American: Moderate intensity exercise is estimated to brisk walking at 3.0 miles per hour; vigorous intensity exercise is roughly equivalent to running at 6.0 miles per hour. Moderate intensity is associated with 40 – 59% of an individual's VO_{2MAX}, and vigorous intensity with 60 – 84% (Mitchell et al., 2005; PAGAC, 2008). In the following review, the discussion of physiological changes focuses on steady-state aerobic exercise, which will be synonymously referred to as exercise unless otherwise specified.

Exercise and the cardiovascular system. Exercise directly impacts cardiovascular health through a variety of mechanisms, including the manipulation of blood pressure, heart rate, and HRV. Exercise-induced changes in these three variables are controlled directly by a dynamic interplay between the branches of the autonomic nervous system and indirectly by additional cardiovascular adaptations (e.g., ventricular remodeling). At the start of exercise, autonomic changes prompt increased cardiac output which is immediately followed by metabolic and additional autonomic changes. Hormonal activity concomitantly becomes engaged at a slower rate. Central command in the cortex, medulla, and hypothalamus communicate to the body and receive feedback from mechanoreceptors (muscle mechanical activity) and chemoreceptors (tissue chemical activity). This feedback signals further autonomic adjustments to the aroused heart and vasculature (Klabunde, 2011).

After blood is shunted toward the heart to support greater cardiac output by several functions (i.e., skeletal muscle pump, Frank-Starling mechanism, vasodilation in active muscles), the hypothalamus signals the medulla for parasympathetic withdraw and sympathetic dominance (Klabunde, 2011; Olshansky et al., 2008). Sympathetic, efferent fibers innervating the sinoatrial node, atrioventricular node, and myocardium stimulate β-adrenergic receptors with norepinephrine. (Gielen, Sheler, & Adams, 2010; Maron & Pelliccia, 2006; Porges, 1995; Williamson, 2010). Norepinephrine, epinephrine, and other mechanisms elevate heart rate and respiration, increase contractile force, and contribute to greater cardiac output. These cardiorespiratory changes support increased oxygen uptake for the intensified demands placed on the heart, lungs, and large skeletal muscles, including the cardiac muscle tissue itself (Carter et al., 2003; Klabunde, 2011). These effects move the body toward use of aerobic metabolism.

Additionally, as sympathetic innervation manages the increased venous return, cardiac preload is supplied adequate blood for appropriate cardiac output and contractile force. The sympathetic nervous system counteracts a plummet in blood pressure from vasodilation in large muscle groups. Sympathetic innervation increases vascular resistance by constricting blood vessels in the gastrointestinal tract, kidneys, and non-active muscles. Norepinephrine and epinephrine, components of sympathetic activity, continue to stimulate the heart and appropriate vasoconstriction through neuronal reuptake as well as through catecholamine spillover into the blood stream (Klabunde, 2011; Olshansky et al., 2008). (Of note, epinephrine can have differential effects on vasodilation and vasoconstriction depending on its concentration, which could be sensitive to stress responses. Epinephrine in lower concentrations preferentially binds to β-2 receptors, dropping systemic vascular resistance; in higher amounts, it also binds to α receptors, resulting in increased systemic vascular resistance [Klabunde, 2011]).

As blood pressure rises, sympathetic activity reset the arterial baroreflex to a higher pressure point (although the baroreflex maintains its original sensitivity for ambulatory blood pressure adjustments [Raven, Fadel, & Ogoh, 2006]) (Carter et al., 2003). Arterial baroreceptors also fire more frequently to adjust to the escalating pressure. This increased firing stimulates efferent, parasympathetic fibers and inhibits vasoconstrictor receptors via acetylcholine at muscarinic receptors located in the atria, ventricles, endocardium, epicardium, cardiomyocytes, coronary arteries, endothelial cells of capillaries, and cells at the sinoatrial and atrioventricular nodes (Olshansky et al., 2008). Consequently, the widespread parasympathetic activity subverts the risk of overstimulation of β-adrenergic receptors, which would lead to cardiomyocyte apoptosis if left unchecked. Thus, the parasympathetic nervous system increases in dominance, reining in maladaptive cardiac and blood pressure arousal while supporting appropriate exercise-induced arousal (Carter et al., 2003; Olshansky et al., 2008).

This fluctuation in autonomic balance (or sympathovagal balance) is heavily influenced by regular exercise. Left to the devices of the electrical signals at the sinoatrial node, intrinsic heart rate beats around 100 to 110 bmp; however, parasympathetic tone maintains ambulatory heart rate between 60 and 100 bmp (Klabunde, 2011). Initial arousal from exercise, up to the intrinsic heart rate mark (i.e., ~100 bmp), stems from parasympathetic withdrawal. Past this threshold, the sympathetic branch gains control of arousal through persistent β-adrenergic stimulation (Banister, & Blaber, 2003; Olshansky et al., 2008). As the cardiovascular system experiences the complementary effects of the sympathetic and parasympathetic nervous systems during exercise, over time from regular exercise, the sympathovagal balance shifts, which is expressed through healthier cardiovascular ambulatory and reactivity states.

Endurance aerobic exercise reduces ambulatory sympathetic activity and concomitantly strengthens ambulatory parasympathetic tone as shown by lowered heart rate, lowered blood pressure, and increased HRV during ambulatory functioning in both professional runners (Raczak et al., 2006) and normative healthy individuals (Shi, Stevens, Foresman, Stern, & Raven, 1995; Tulppo et al., 2003). Participants randomized into high volume (60 minutes) or moderate volume (30 minutes) exercise groups exhibited significant heart rate and HRV changes after completion of an eight-week exercise program (running at 70-80% VO_{2MAX}) (Tulppo et al., 2003). Ambulatory functioning in both groups, collected over a 24-hour, non-exercising period, demonstrated an increased dominance of parasympathetic activity and decreased control of sympathetic activity as evidenced by reduced heart rate, increased HF power normalized units (nu), decreased LF power nu, and lower sympathovagal balance (Tulppo et al., 2003).

Aerobic training also alters the cardiovascular system during reactivity to physical exercise and other stress tasks. Young adult males who completed an eight-month, exercise program (running at 80% VO_{2MAX}) demonstrated significant cardiovascular changes as shown by lower resting heart rate, increased parasympathetic tone, and decreased sympathetic activity during ambulatory functioning and while running at a submaximal intensity (Shi et al., 1995). After completion of a 10-week exercise program with a combination of running, cycling, and stair-stepping, healthy, middle-aged adults showed a significant attenuation in blood pressure and heart rate during ambulatory functioning and reactivity (Cornelissen, Verheyden, Aubert, & Fagard, 2010). Participants in the low and high intensity conditions (exercising at 33% or 66% VO_{2MAX}) exhibited lower SBP when resting and when exercising at maximum intensity. Heart rate was significantly lowered at rest and during maximum exercise in only the high intensity condition (Cornelissen et al., 2010). Pre-hypertensive and mildly hypertensive, middle-aged men completed a 16-week exercise regime (cycling at 60-80% VO_{2MAX}) and demonstrated significantly lowered SBP, DBP, and heart rate at rest and during multiple stages of exercised-induced reactivity (Pitsavos et al., 2011). Furthermore, these changes during reactivity can be observed when comparing fit individuals to a control group. Exercise-trained individuals exhibited less sympathetic activity as well as more parasympathetic activity while exercising relative to sedentary individuals who were exercising at the same intensity (Gregoire, Tuck, Hughson, & Yamamoto, 1996). As parasympathetic tone strengthens from regular exercise, resting and reactivity of heart rate, blood pressure, HRV, and the sympathovagal balance are engaged more effectively by autonomic innervation.

Cross-stressor adaptation hypothesis. As an acute stressor, physical exercise stimulates activity in several physiological systems, including the sympatho-adreno-medullary (SAM) axis and hypothalamic-pituitary-adrenocortical (HPA) axis (which are delineated below), and temporarily depresses the parasympathetic nervous system. Exercise adjusts the relative strength of these systems over time, leading to sustained lower baseline heart rate and blood pressure and increased parasympathetic activity for greater HRV. The cross-stressor adaptation hypothesis extends the cardiovascular benefits of exercise to non-exercise situations (Klaperski, von Dawans, Heinrichs, & Fuchs, 2014). The sustainable changes from habitual exercise may lead to improved cardiovascular reactivity for both acute exercise and acute psychological stress (Sothmann, 2006). These psychophysiological gains indicate healthier connections among the brain, heart, and periphery (Forcier et al., 2006; Spalding, Lyon, Steel, & Hatfield, 2004). In support for this hypothesis, researchers conducted a mental arithmetic stress task with healthy young adults after completion of a six-week exercise program which included tailored activities for aerobic training, strength training, and no training groups (Spalding et al., 2004). Systolic blood pressure at rest and during reactivity were significantly lower in both aerobic and strength training conditions, and aerobically-trained participants demonstrated a significant attenuation in heart rate when at rest and during reactivity to the mental arithmetic stressor (Spalding et al., 2004). In addition, physically fit individuals maintain these healthier autonomic reactivity patterns during other stress tasks, such as a cold pressor task (Dishman, Jackson, & Nakamura, 2002; Jackson & Dishman, 2002).

While research is mixed for the cross-stressor adaptation hypothesis, standardization is marginal in the literature for psychological stressors and exercise (Forcier et al., 2006). Because of the heterogeneous research, decreased reactivity, faster recovery, and even baseline measurements are not consistently demonstrated across studies (Alex et al., 2013; Jackson & Dishman, 2006; Sloan et al., 2011). Research that disconfirms the psychophysiological benefits from exercise during acute psychological stressors also comment on the variation in studies (Huang, Webb, Zourdos, & Acevedo, 2013). Nevertheless, the literature generally indicates healthier cardiovascular reactivity and recovery in fit individuals when confronted with a psychological stressor (Forcier et al., 2006; Hagberg, Park, & Brown, 2000; Huang et al., 2013; Spalding, Jeffers, Porges, & Hatfield, 2000).

As an example of the mixed evidence, in one study researchers found that physically fit individuals exhibited greater cardiovascular reactivity to acute psychological stress although still showed faster recovery (Jackson & Dishman, 2006). Rimmele and colleagues (2009) noted that the differences in the above findings may have emerged from variations in participant activity level, participant athleticism, types of psychological stressors, age, sex, and other methodological deviations. In support for the bulk of literature that shows lesser reactivity and faster recovery, training regime appears to moderate a significant amount of physiological changes. Comparisons among elite runners, recreational runners, and inactive men indicated that as exercise intensity increased among the groups, heart rate reactivity showed significantly greater restraint and heart rate recovery returned more quickly to baseline when confronted with stress tasks consisting of an evaluated speech, mental arithmetic, and a Stroop Task (Moya-Albiol et al., 2001; Rimmele et al., 2009). Professional athletes also reported overall less state anxiety during psychological stress tasks than recreational exercisers and inactive individuals, which likely contributed to their cardiovascular responses (Rimmele et al., 2009).

Effects of Psychophysiological Stress

Definition and mechanisms. Aerobic exercise as a form of physical stress develops a robust cardiovascular system. Psychological stress, however, is linked to CVD. While many models exist to conceptualize stress (which are explained below), the theory of interest in this manuscript is the Transactional Model of Stress (Lazarus & Folkman, 1984) in addition to an understanding of the physiological stress experience (Andreassi, 2013). According to Lazarus and Folkman (1984), psychological stress is a state of physiological and emotional arousal which occurs in response to an experience perceived as disruptive to an individual's status. Environmental demands elicit cognitive appraisals, and these dynamic evaluations are central to the magnitude of the stress state and to the subsequent actions. (Asztalos et al., 2012).

While stress emerges from perception, an explanation of mind-body connectivity is important to understand the stress experience. A complex interaction among cortical and subcortical neurological pathways lead to accompanying physiological stimulation, which is partially activated through a chain of sympathetic mechanisms as part of the SAM axis (Andreassi, 2013). Once the brain receives input of a stressor, the reticular formation in the brain stem initiates a cascade of sympathetic and hormonal activity. The SAM axis releases norepinephrine at sympathetic terminal nerve endings as well as chatecholamines from the adrenal medulla. Traveling through the blood stream, systemic norepinephrine and epinephrine stimulate sympathetic nerve fibers in a variety of muscles, glands, and organs to mobilize energy.

In a separate pathway, the reticular formation also engages the limbic system, cortex, and thalamus to further the psychophysiological stress response. The thalamus communicates to the hypothalamus within the HPA axis to release corticotrophin releasing hormone (CRH) into the anterior pituitary gland. The anterior pituitary gland then releases adrenocorticotrophic hormone

(ACTH) to stimulate the adrenal cortex to secrete more cortisol and other glucocorticoids into the blood. Cortisol then raises blood glucose levels, inhibits peripheral uptake of glucose, and stimulates the breakdown of proteins into amino acids. Through a negative feedback loop, cortisol targets the hippocampus to slow neuroendocrine secretion within the HPA axis. In a well-functioning system, this cortisol response to stress calms, promoting healing and reducing inflammation (Chida & Hamer, 2008; Straub, 2012).

Models of stress. Historical models of stress have sought to specify this physiological stress response as well as the individual differences for stress. Walter Cannon postulated an early model examining homeostasis and the fight-or-flight response (Cannon, 1929a, 1929b, 1939). Cannon termed homeostasis as the preference of a living body to remain in a stable state. Associated mechanisms are equipped to maintain homeostasis and to reduce instability. When the body is subjected to the unstable state of stress, the fight-or-flight response pours out neurohormones as a necessary defense, upsetting the physiological system further. Defense is followed by self-preservation and physical restoration. Cannon's model views stress as primarily biological (although he did acknowledge psychological threats to the system) with a nonspecific SAM reaction to all stressors.

In a later model, Hans Selye expanded on Cannon's work with the General Adaptation Syndrome (Selye, 1956, 1974). Selye's model divides the stress response into three phases: alarm, resistance, and exhaustion. Alarm initiates fight-or-flight and the HPA axis. Resistance begins as the body adapts to the stress, and successful adjustment to stress creates a new, stable state (Selye, 1956). Exhaustion occurs when internal, physical resources are depleted; pathology and death are the ultimate end points in chronic stress. Like Cannon, Selye approached the stress response as generally nonspecific, a viewpoint that was not challenged for years (Goldstein & Kopin, 2007).

Newer theories of stress integrate physiological processes with variations among stressors. McEwen and Wingfield (2003) adopted the theory of allostasis as a model for stress. Whereas homeostasis works toward stability, allostasis is based conceptually on stability through change. Homeostasis is maintained for crucial, core body functions, but the rest is subject to change. Allostasis alters physiological set points in response to stress to keep the body functioning optimally (Sterling & Eyer, 1988). Stress responses are not nonspecific as Cannon and Selye proposed; instead, stressors engage different systems. However, if the set points are overly taxed from change, allostatic overload occurs. Here, pathology develops from cumulative, adverse changes (McEwen & Stellar, 1993; McEwen & Wingfield, 2003). Though conceptually sound, allostasis proves difficult to measure since there are multiple, complex physiological reactions to manage different forms of stress (Goldstein & Kopin, 2007). Another conceptual limitation to allostasis as a stress model is that it does not emphasize the role of cognition as in the Transactional Model of Stress (Lazarus & Folkman, 1984).

A modern view of stress is Lazarus and Folkman’s (1984) Transactional Model of Stress. Whereas early models conceptualized stress as hardwired biology (Selye, 1974), the Transactional Model of Stress incorporates cognition to account for individual differences. The magnitude of the SAM and HPA axes in the stress response is determined, in part, by an individual’s cognitive appraisals in the situation. Primary appraisals label an experience as positive, neural, or stressful; stressful appraisals include harm-loss, threat, challenge, or a combination of these. Challenge appraisals are unique in that they are applied when a stressful situation is discerned to bring about personal growth, whereas harm-loss and threat are associated with perceived negative outcomes. Secondary appraisals are implemented to assess relevant coping skills to engage the stressor. Thus, the interaction of primary and secondary appraisals determines the extent of a physiological stress response. Tertiary appraisals are delayed in order to reassess if the chosen coping techniques are effective. According to the model, stressors and stress require personal change. Depending on an individual's psychological state, this stipulation can either be seen as opportunistic or threatening (Asztalos et al., 2012). Events are not inherently stressful, and appraisals are subject to change.

Coping is defined as the strategic methods to manage what an individual is experiencing physiologically and psychologically (Lazarus & Folkman, 1984). Types of coping are emotion-focused coping, problem-focused coping, and, to some extent, positive reappraisal. The first seeks to avoid one's emotions; the second works to resolve a problem. Reappraisal occurs as a secondary appraisal: An experience is deemed stressful and beyond one's coping, but when selecting a coping mechanism, a person chooses to reappraise the scenario in a positive light. Instead of problem solving, a person actively decides not to become stressed (Lazarus & Folkman, 1984).

Because stressors arise unflaggingly, individuals learn to reuse their appraisals and coping skills from prior stressful experiences. This innate, cognitive process allows efficient and protective responses as long as the coping mechanisms are relevant (Lazarus & Folkman, 1984). However, past situations are not replications of a present experience, and often people become attached to old patterns of cognitions and behaviors. The misconstrued overlap creates a dearth of appropriate or flexible appraisals and subsequent coping. The attachment further contributes to cognitive reactivity seen in various mental illnesses, such as recurrence of maladaptive thoughts in depression. Termed as mindless appraisals, this habit limits present-moment success and ultimately does not inhibit stress (Brown, Ryan, & Creswell, 2007; Hayden, 2012).

Stress and the cardiovascular system. Stress can be acute in which an individual may be able to benefit from the physiological response, or stress can be chronic which leads an individual to experience strain, the wear-and-tear on the body and mind from sustained physiological reactivity. In regards to acute stress, a physiological response occurs whether one evaluates the situation as threatening or challenging (Mendes, Reis, Seery, & Blascovich, 2003). Autonomic arousal related to challenge appraisals supports the cardiovascular system. However, the stress response associated with threat appraisals does not necessarily benefit cardiovascular functioning and, in fact, can facilitate pathology (Blascovich & Tomaka, 1996). Exposure to chronic stress can negatively alter cardiovascular ambulatory functioning and reactivity, adding another pathological layer to threat appraisals (Juster, McEwen, & Lupien, 2010).

When an individual experiences acute psychological stress, heart rate, contractile force, and cardiac output increase due to SAM axis activation. Challenge appraisals during demanding events tend to demonstrate a pattern of elevated epinephrine in concentrations leading to vasodilation and a decrease in total peripheral resistance. Reactivity transitions into recovery quickly, as well, which supports a stronger and more adaptable organism (Blascovich & Tomaka, 1996). Threat appraisals are correlated with greater HPA axis stimulation in addition to sympathetic activity. This different response increases vasoconstriction, total peripheral resistance, and cortisol. Recovery is also delayed from the transient stress response, increasing the likelihood of immediate damage and strain (Lucini, De Fede, Parati, & Pagani, 2005). Although not all research supports these differences (Wright & Kirby, 2003), literature has examined these reactivity patterns both in theory and in empirical work (Mendes et al., 2003).

When an individual is exposed to chronic stress, the SAM and HPA axes lose the ability to adjust their stress-activated signals to restorative ambulatory states (Treiber et al., 2003). Within the SAM axis, sympathetic activity over-stimulates the cardiovascular system, and the baroreflex loses its response flexibility to the parasympathetic branch (Lucini et al., 2005). Additionally, the SAM and HPA axes can become insensitive to present-moment stress and become unable to engage in any reactivity, indicating a rigid allostatic system (Het et al., 2015; Lovallo, Farag, Sorocco, Cohoon, & Vincent, 2012; Voellmin et al., 2015). Thus, psychological stress has been implicated in short and long term cardiovascular dysfunction and disease (Juster et al., 2010; Rozanski, 2014).

Of interest to this manuscript, repeated or exaggerated blood pressure reactivity to acute psychological stressors is strongly predictive of CVD (Treiber et al., 2003; Rozanski et al., 1999). Blunted or prolonged cardiac reactivity to acute psychological stressors as well as reduced heart rate variability are indicative of CVD, also (Heponiemi et al., 2007; Het et al., 2015; Rozanski et al., 1999). Other pathological changes from SAM and HPA hyperactivity include, but are not limited to, ulcerations (Salim, 1987), immunological suppression (Kiecolt-Glaser, McGuire, Robles, & Glaser, 2002), and sleep disturbances (Seib et al., 2014). Recent research has also indicated maladaptive stress leads to neural atrophy, organ hypertrophy, telomere decay, and weight fluctuations (Epel et al., 2000).

A non-traditional CVD risk factor, psychophysiological stress impacts health from brief and extended periods of stress as well as from the natures of the stressors. Chronic stress during childhood can lead to blunted heart rate and HPA reactivity to acute psychological stressors as young adults (Lovallo et al., 2012; Voellmin et al., 2015). As detailed in a meta-analysis by Chida and Hamer (2008), experiencing multiple life stressors, depression, and anxiety contribute to blunted cardiovascular reactivity to acute stressors, whereas hostile and Type-A personality profiles demonstrate increased reactivity to acute stressors (Chida & Hamer, 2008).

Complementary to these chronic stressors and in line with the Transactional Model of Stress, the perception of being stressed influences health. Keller and researchers (2012) examined 28,753 individuals on self-reported stress levels, their beliefs that stress affects health, and health and mortality rates. Both high levels of reported stress and strong beliefs regarding the harmful effects of stress independently contributed to significant outcomes of long term mental and physical disease. Furthermore, appraising stress as harmful significantly interacted with high stress, leading to a 43% elevated risk of early death (Keller et al., 2012). Correspondingly, Jamieson, Nock, and Mendes (2012) demonstrated that reappraising one's physiological arousal as benign, instead of threatening, while encountering a stressor significantly reduces cardiovascular reactivity. As shown by the above research, psychological variables, notably acute and chronic stress, strongly impact cardiovascular functioning and disease, and cognitive stress appraisals and associated beliefs enhance and mitigate cardiovascular reactivity.

Stress and mental health. Stress management is essential for acute and lifelong healthy cardiovascular functioning. Maladaptive responses to acute and chronic stressors negatively impact the cardiovascular system, and when combined with sustained negative emotions, the risk for CVD augments. These emotions principally include depression (Musselman et al., 1998), anxiety (Kubzansky & Kawachi, 2000), anger, pessimism, and the dispositional trait of hostility (Chida & Steptoe, 2009; Grossardt, Bower, Geda, Colligan, & Rocca, 2009). In order to address the cognitive and emotional factors related to stress, a variety of stress and emotion management techniques as well as specific protective variables have been researched. Stress literature examines direct contributors to the development of pathology and buffers that deter engagement in health-damaging behaviors (Rozanski, 2014; Straub, 2012).

Exercise and stress management. Significant to this paper, stress and other negative psychological factors can be mitigated through physical exercise (Baghurst & Kelley, 2014; Blumenthal et al., 2005; Salmon, 2001). Individuals who exercise regularly report overall higher levels of self-efficacy and self-esteem (Craft, 2005), and in the period immediately following exercise, individuals frequently report an uplifted mood and attitude of well-being (Motl et al., 2005). Also in the time period following exercise, individuals demonstrate more accurate and faster cognitive performance and show a stronger capacity for learning information (Alderman & Olson, 2014; Erickson et al., 2009; Lambourne & Tomporowski, 2010). One theory for these acute gains focuses on the correlation between exercise and neurohormones. During exercise, the molecular building blocks for catecholamines and serotonin increase in availability. Physiological arousal in the SAM and HPA axes requires these neurohormones, particularly norepinephrine and epinephrine, to function; therefore, a variety of mechanisms support an increased production of neurohormones to maintain the arousal and feedback loops. Additionally, several of these neurotransmitters enhance mood and concentration. As such, this theory recognizes the concomitant, beneficial changes to physical and cognitive functioning (McMorris, 2009).

Regarding long term effects of physical activity on mental health, exercise effectively alleviates depression in clinical and subclinical populations; its mood-boosting effects have been shown to supersede a number of antidepressants (Babyak et al., 2000; Blumenthal et al., 2007). Clinical and subclinical populations also report significant reductions in anxiety (Wipfli, Rethorst, & Landers, 2008). Regular exercise shows to be an effective tool in stress management for individuals with CVD (Blumenthal et al., 2005) as well as healthy young adults (Baghurst & Kelley, 2014). Furthermore, young adults who maintained exercise habits from adolescence into adulthood report significantly better mental health and more life satisfaction than individuals who maintained an inactive lifestyle or delayed engagement in exercise behaviors until adulthood (Rangul, Bauman, Holmen, & Midthjell, 2012). Enjoyment of the exercise, regardless of the form of activity, is also important for mental health (Asztalos et al., 2012). In the short and long term, exercise improves mental health and buffers psychological stress (Ströhle, 2009) in addition to its extensive support of the cardiovascular system.

Athletes and stress appraisals. The subpopulation of athletes, both students and professionals who are trained in physical exercise, are noteworthy in the stress literature and relevant to this paper. Much research for athletes has been directed at self-efficacy and stressors as applied to circumstances related to their sport or exercise (Blascovich, Seery, Mugridge, Norris, & Weisbuch, 2004; Hanton, Neil, & Mellalieu, 2008), and not all findings are consistent (Meijen, Jones, Sheffield, & McCarthy, 2014). Using the Transactional Model of Stress, research generally shows that athletes tend to choose challenge stress appraisals when engaging with their sport (Blascovich & Mendes, 2000). Stress research, however, largely does not study athletes in non-fitness situations.

Nicholls, Perry, and Calmeiro (2014) studied achievement goals, stress appraisals, emotions, and coping strategies of athletes and their sport-specific competitive goals. Athletes who selected challenge appraisals experienced more positive emotions and, subsequently, chose effective coping strategies. Athletes who selected threat appraisals experienced more negative emotions and engaged in avoidance in order to cope with stressors. In line with the Transactional

Model of Stress, these findings indicate that certain cognitive appraisals precede emotional states and specific coping strategies (Lazarus & Folkman, 1984; Nicholls et al., 2014).

Sellers and Peterson (1993) researched cognitive appraisals and problem- and emotion-focused coping in college football players and their athletic and academic stressors. Football players who reported challenge appraisals held greater beliefs that they could control stressors, and they selected more problem-focused coping to manage their stress. This research suggests that challenge appraisals and perceived controllability can lead to more productive coping (Sellers & Peterson, 1993). Athletes who engage in adaptable cognitive appraisals show better stress management techniques and emotion regulation, which is supported through a variety of dimensions related to their profession as well as the benefits from the exercise itself.

Additional sources for stress management. Likewise, alternative psychological and social factors that do not involve physical activity may protect against CVD and stress. Healthier cardiovascular profiles have been linked to positive emotions, optimism, having a sense of purpose, social connectivity, and meditation (Endrighi et al., 2011; Ikeda et al., 2011). The practice of traditional and contemporary meditation has gained traction in recent research as a protective, psychological factor (Gotink et al., 2015; Grossman, Niemann, Schmidt, & Walach, 2004). In addition, mindfulness, an intentional mode of being, has been studied as an important feature to cognitive appraisals and coping strategies (Asztalos et al., 2012; Epel, Daubenmier, Moskowitz, Folkman, & Blackburn, 2009; Folkman, 2006; Folkman, 2008).

Effects of Mindfulness

Definition. Mindfulness is the metacognitive mode that opens an individual to a state of present-moment, nonjudgmental, intentional awareness (Kabat-Zinn, 1994). When a person engages in mindfulness, thoughts, emotions, and sensations are not labeled as inherently good nor bad. Additionally, no effort is made to alter the momentary experience (Brown et al., 2007; Kabat-Zinn, 1994). Various subcomponents within the mindfulness process have also been examined. For example, trait mindfulness refers to an individual's cognitive tendency to view intra- and interpersonal events through a mindful lens, whereas state mindfulness is the transient, active engagement of mindfulness. Another subcomponent, reperceiving shifts an individual's attention to connect intimately with one's physiological experience but without identifying the specific sensations. The purpose is not to detach from the experience although non-attachment may follow suit (Segal, Williams, & Teasdale, 2012; Shapiro, Carlson, Astin, & Freedman, 2006). Reperceiving provides an opportunity for a person to recognize psychophysiological activity and still act in accordance with what best suits the situation. Regarding stress, mindfulness frees an individual from automatic, conditioned reactivity to stressors. Thus, one objectively views the stress response and selects novel ways to respond to the stressful experience.

Mindfulness and its relationship to cognitive appraisals. Although true mindfulness does not focus on a goal-specific outcome, regular practice of mindfulness does lead to greater cognitive flexibility. Cognitive flexibility provides ground for an individual to "self-regulate; assess values; evaluate emotive, cognitive, and behavioral options; and experience exposure to alternatives" (Shapiro et al., 2006). After cognitive flexibility is employed, the next step is a selection of cognitive appraisals, including appraisals of neutrality, threat, and challenge as well as positive reappraisal. Reappraisal requires returning to the state of cognitive flexibility, choosing a more advantageous mindset, and then reengaging the stressor (Garland, Gaylord, & Park, 2009).

Mindfulness is not equivalent to appraisal; the former is non-evaluative, whereas the latter assigns emotions. Mindfulness is then a necessary component to adaptive appraisals, but it not sufficient for these appraisals without cognitive flexibility. Initially, the use of mindfulness when confronting a stressor requires effortful disengagement from an emotionally-laden, reflexive response. Over time with practice, a person is able to move fluidly into the mindfulness mode. This ability coupled with increased cognitive flexibility allows an initial appraisal of a stressor to be more plastic and adaptable, particularly greater cognitive appraisals of challenge and lesser threat appraisals (Folkman & Moskowitz, 2000; Garland et al., 2009; Shapiro et al., 2006).

Because mindfulness opens a person to choose a response route objectively, hypothetically, negative appraisals could be selected. In line with traditional Buddhist theory, the purpose of mindfulness is to foster a virtuous, strong, and flexible mind (Mipham & Rinpoche, 2004). Mindful meditation supports this outcome through practiced self-control, transient release from negative emotive-cognitive patterns, and insight (Garland et al., 2009; Thrangu, 1993). Therefore, traditional mindfulness is an expected step toward upright values and actions, which is mediated by cognitive flexibility for positive, profitable appraisals and, in turn, produces positive affect and decreased stress (Folkman & Moskowitz, 2000). Ultimately, cognitive flexibility becomes a sustained approach to stressors to result in a more positive, meaningful experience.

Research indicates that programs using mindfulness-based stress reduction (MBSR) and mindfulness-based cognitive therapy (MBCT) lead to significantly increased mental health. In a meta-analysis of MBSR interventions, Grossman and researchers (2004) found that an effect size of .5 remained steady across a broad range of groups with chronic physical and mental health conditions. The consistency in outcomes related to mindfulness likely reflect changes in daily coping skills to address emotions and increase cognitive flexibility as well as greater adaptability to illness-specific problems (Grossman et al., 2004). Gotink and colleagues (2015) in a meta-analysis of MBSR and MBCT randomized controlled trials concluded that mindfulness is an effective component in preventive interventions and rehabilitation for depression, anxiety, cancer, CVD, and chronic pain. Adults and children benefitted from mindfulness through increased quality of life and physical functioning and decreased stress, anxiety, and depression (Gotink et al., 2015).

In another meta-analysis comparing outcomes of generally healthy people and MBSR programs, Chiesa and Serretti (2009) found similar results for use of mindfulness for greater mental health. These beneficial outcomes include reductions in perceived stress, rumination, and trait anxiety as well as gains in empathy, self-compassion, and clarified spiritual values. These cognitive and emotive associations and changes are supported through individual studies highlighting perceived stress, cognitive appraisals, and mindfulness (Garland et al., 2011; Schmertz, Masuda, & Anderson, 2012). Regular practice of mindfulness has been shown to increase the ability to select more adaptive appraisals and, consequently, decrease perceived stress, increase coping strategies, and improve positive affect (Garland et al., 2011). High threat appraisals and low trait mindfulness are also strongly correlated to greater levels of psychopathology, such as social anxiety and phobias (Roemer et al., 2009; Schmertz et al., 2012; Smalley et al., 2009; Wupperman, Neumann, Whitman, & Axelrod, 2009). The characteristics of mindfulness may free an individual from conditioned threat appraisals associated with pathology and foster the ability for cognitive flexibility, leading to increased adaptive appraisals and positive affect (Brown & Ryan, 2003).

Mindfulness and the cardiovascular system. Research has well-established that mindfulness improves mental health as well as physical functioning, often by teaching mindfulness to individuals who are naïve to meditation. Regarding cardiovascular health, mindfulness meditation has supported significant short and long term autonomic improvements (Carlson et al., 2007). Mindfulness meditation lowers blood pressure (Nyklíček, Mommersteeg, Van Beugen, Ramakers, & Van Boxtel, 2013) and blood pressure reactivity to acute psychological stress (Steffen & Larson, 2014). Mindfulness also lowers resting heart rate (Zeidan, Johnson, Gordon, & Goolkasian, 2010), increases parasympathetic control, and decreased sympathetic activity immediately after a meditation (Nijjar et al., 2014).

Using a three-day MBSR training, Zeidan et al. (2010) examined mood, heart rate, and blood pressure in 82 undergraduate students. Data was collected before and after each intervention session on the first and third days. To account for demand characteristics, the study included a mindfulness group, a sham group, and a control group. After each 20-minute session, the sham group participants all verbally agreed that they believe that were practicing mindfulness, though they received no guided instructions. With an effect size of .52 for both variables, heart rate and negative mood significantly decreased in the mindfulness group relative to the other conditions. Systolic and diastolic blood pressure significantly decreased although no specific group interaction was found. Suggested by the researchers, longer sessions may have exhibited clearer results for the mindfulness group. Additionally, the presence of a stressor may also have shown more of a distinction among groups for blood pressure changes (Zeidan et al., 2010).

In a traditional, eight-week MBSR intervention, Nyklíček and researchers (2013) investigated blood pressure, heart rate, and cortisol in 85 adults who self-reported regularly experiencing high stress and negative emotions. Data was collected during a non-evaluative mental mathematics and speech task pre- and post-intervention. Compared to waist list controls, systolic and diastolic blood pressure significantly decreased in the experimental group with global lower blood pressure levels as well less blood pressure reactivity during the post-intervention stressors. Unfortunately, mechanical malfunctions and cardiac complications undermined the heart rate and HRV data. Similar to the commentary from Zeidan et al. (2010), the researchers speculated that cortisol and blood pressure would show stronger reactions with a more intense stressor, such as a social evaluative situation (Nyklíček et al., 2013).

Steffen and Larson (2014) trained 62 undergraduate students for less than one hour in mindfulness meditation and then measured blood pressure and heart rate reactivity to a complex mathematics task. Relative to controls, from baseline to the end of the stress task, systolic and diastolic blood pressure reactivity significantly attenuated in the mindfulness group. Furthermore, participants in the mindfulness group showed a tapering of their blood pressure from the start to the finish of the task, whereas blood pressure in the control group continued to escalate throughout the entire task. Cardiovascular recovery rates for the groups did not differ significantly although the mindfulness group showed a nonsignificant trend for lowered systolic blood pressure in early recovery. As shown, a short bout of mindfulness training can reduce stress-induced cardiovascular reactivity. Heart rate did not reach significance across the measurements; however, as posited by the researchers, a different stress task may be better suited to evoke heart rate reactivity (Steffen & Larson, 2014).

Implementing an eight-week MBSR program with a small adult sample size, Nijjar and researchers (2014) evaluated HRV and psychological stress among three experimental conditions: spontaneous breathing, controlled respiration, and mindful meditation. Participants had physiological data collected in a pre/post design and in each condition. Compared to controlled respiration, participants engaging in mindful meditation showed significant reductions in LF(nu) and LF power and significant dominance of HF(nu). Participants' change in lowered sympathetic activity and greater parasympathetic activity trended toward significance when comparing the meditation condition to before and after the intervention. Additionally, self-reported stress significantly mitigated after the mindfulness intervention. The positive outcomes for parasympathetic control had been demonstrated in other research with other meditation forms (Peng et al., 2004; Peng et al., 1999). Mindfulness meditation significantly improved acute HRV spectral components over controlled respiration alone. As postulated by the researchers, more sustainable changes may be possible with longer duration of mindfulness practicing (Nijjar et al., 2014).

Carlson and colleagues (2007) implemented an eight-week MBSR intervention in cancer outpatients with early-stage breast or prostate cancer. At pre-intervention, post-MBSR, and six- and 12-month follow-ups, participants were measured on quality of life, stress, mood, proinflammatory cytokines, cortisol, blood pressure, and heart rate. All measured variables improved acutely and/or over time, independent of how much the participants practiced meditation and yoga at home. Blood pressure significantly decreased and remained at lower levels at follow-ups, even with the normotensive participants. Some research indicates that individuals who have high blood pressure will benefit more from MBSR than those with normal blood pressure (Campbell, Labelle, Bacon, Faris, & Carlson, 2012); however, these findings demonstrate that postulation is not always the case (Carlson et al., 2007). Participants who did not have as strong of a blood pressure reduction were individuals of older age, which is a natural occurrence with aging, or who had been cancerous for longer periods of time (Carlson et al., 2007; van Boxtel, Gaillard, van Es, Jolles, & de Leeuw, 1996). Resting heart rate significantly lowered post-intervention and at follow-ups with changes seen most strongly directly after meditation. Furthermore, heart rate closely correlated with reported stress levels. The researchers suggest that high heart rate may be a physiological expression of the psychological stress, so as stress mitigated, so did resting heart rate. Individuals who had lived with the cancer for longer periods of time did not exhibit these reciprocal improvements (Carlson et al., 2007).

Mindfulness and aerobic exercise. As demonstrated, the characteristics of mindfulness improve ambulatory functioning and reactivity states of the cardiovascular system as well as proves to be an effective stress management tool for a wide range of populations. Bridging mindfulness and physical activity, yoga is implicated in enhancing mindfulness (Carmody & Baer, 2008), considering that the theory behind traditional yoga is to be a moving meditation (Kabat-Zinn, 1990; Kabat-Zinn, 1994). The association between mindfulness and exercise is relatively new in research (Mothes, Klaperski, Seelig, Schmidt, & Fuchs, 2014) although mindfulness interventions are already being delivered to athletes to improve performance (Goodman, Kashdan, Mallard, & Schumann, 2014). Moreover, the relationship between aerobic exercise and mindfulness is not well-studied despite both activities exerting similar effects on the cardiovascular system and autonomic system, particularly concerning heart rate, heart rate variability, and blood pressure (Madanmohan, Udupa, Bhavanani, Shatapathy, & Sahai, 2004; Straub, 2012).

As postulated by Demarzo and colleagues (2014), because of these psychophysiological similarities, mindfulness may act as a mediating and moderating variable to some of the healthful cardiovascular changes from exercise. Aerobic exercise, such as swimming or running, involve rhythmic, controlled breathing along with repetitive movements. These behaviors foster self-awareness and the ability to observe objectively one's moment-to-moment state (Asztalos et al., 2012; Berger & Owen, 1988). Endurance running, in particular, increases one's capability for self-regulatory attention (Salmon, Hanneman, & Harwood, 2010). Although exercise does not use guided meditations, it does carry the qualities of mindfulness: intentional and present-moment awareness (Kee & Wang, 2008; Netz & Lidor, 2003).

In a cross-sectional, retrospective study on exercise maintenance, Ulmer, Stetson, and Salmon (2010) assessed 226 YMCA gym attendees on trait and state mindfulness, acceptance, and suppression. Concerning behaviors over the past year, individuals' measured scores were significantly tied to how many weeks they had missed of their exercise regime. The researches hypothesized that this correlation may be explained through the Transactional Model of Stress and mindfulness (Kabat-Zinn, 1990; Lazarus & Folkman, 1984). Individuals who scored high in mindfulness sustained their exercise behaviors, perhaps through their abilities for non-judgment, active intention, and cognitive flexibility. In accordance to the natural outcome of mindfulness, exercise maintainers may have increased their use of adaptive appraisals (i.e., challenge, benign, and positive reappraisal) regarding the importance of exercise despite the potential stressors of physical discomfort and scheduling demands. Mindfulness may have also prevented relapse from exercise maintenance as setbacks would not be viewed as detrimental. These hypotheses suggest possible ways that regular exercisers are able to sustain their healthful behavior (Ulmer et al., 2010).

In a complementary study, Loucks, Britton, Howe, Eaton, and Buka (2014) examined trait mindfulness and healthy behaviors in 400 participants. Using the criteria from the American Heart Association, the researchers examined seven maintaining health factors and behaviors for optimum cardiovascular health (Go et al., 2014). Although environmental, genetic, and personality variables may influence which specific factors and behaviors an individual manages through mindfulness, individuals who were high in trait mindfulness were 1.56 times more likely to engage in physical activity than low-scoring participants. Physical activity, among only a few other behaviors, significantly correlated with trait mindfulness (Loucks et al., 2014).

The first of its kind, in a 12-week randomized control trial, Mothes and colleagues (2014) divided 159 adult men into an aerobics training group, a relaxation training group, or a wait list control group. Participants held sedentary jobs and maintained little to no exercise and relaxation behaviors. The exercise group (running at 60-80% VO_{2MAX}) and relaxation group received their designated intervention for 60 minutes two times per week; mindfulness was deliberately and cautiously not incorporated into any condition. In a pre/post design, trait mindfulness significantly increased in the aerobic exercisers and did not increase in either the relaxation or control groups. Mindfulness for the aerobic exercisers correlated significantly with improved emotional functioning and trended toward significance in improved social functioning, as well (Mothes et al., 2014).

The Present Study: Integration of Exercise, Stress, and Mindfulness

Taking these studies together, the cardiovascular and cognitive-emotive changes from aerobic exercise may be, in part, accounted for by the increase in trait mindfulness that has been shown to accompany regular exercise (Loucks et al., 2014; Mothes et al., 2014; Ulmer et al., 2010). Regarding this manuscript, exercise impacts ambulatory functioning and reactivity of blood pressure, heart rate, and HRV through the innervation of the autonomic nervous system (Carter et al., 2003; Klabunde, 2011). Support for the cross-stressor adaptation hypothesis indicates that healthy reactivity during exercise also propels adaptive stress responses to psychological stressors (Sothmann, 2006). Mindfulness during acute psychological stressors and meditation are also strongly associated with these sympathetic and parasympathetic adaptations. General, healthful patterns include lowered blood pressure, lowered heart rate, decreased sympathetic dominance, increased parasympathetic control, and overall greater HRV during ambulatory functioning (Carlson et al., 2007; Nijjar et al., 2014; Nyklíček et al., 2013; Zeidan et al., 2010). Cardiovascular reactivity patterns reflect allostatic flexibility with moderate blood pressure elevations, increased but not prolonged heart rate, and greater vagal activity (Nijjar et al., 2014; Steffen & Larson, 2014).

Furthermore, exercise and mindfulness both mitigate perceived stress and enhance positive affect (Baghurst & Kelley, 2014; Blumenthal et al., 2007; Chiesa & Serretti, 2009; Gotink et al., 2015). These cognitive-emotive gains may occur through the similarities of exercise and mindfulness: increased body awareness, repetitive and controlled breathing and movement, present-moment focus, and intentional cognitions and behavior (Demarzo et al., 2014). Like mindfulness, a nonjudgmental mindset may also take place with exercise as the moment-to-moment psychophysiological experience is attended to and accepted (Demarzo et al., 2014). The mental health benefits associated with these characteristics augment cognitive flexibility and, subsequently, engagements with stressors in a variety of situations (Folkman & Moskowitz, 2000; Garland et al., 2009; Shapiro et al., 2006). In line the sustainable changes from mindfulness coupled with the Transactional Model of Stress, regular exercisers and athletes in particular are anticipated to have more adaptive appraisals during psychological stress (Nicholls et al., 2014; Sellers & Peterson, 1993). Because athletes' cognitive appraisals in non-sport situations are understudied, established theories of exercise, mindfulness, and stress drive the hypotheses predicted in this manuscript regarding cognitive appraisals. The relations among these variables are depicted in Figure 1; components of the integrative theory are stated in the hypotheses and tested in the stress protocol.

Therefore, the present study examined the following hypotheses:

1. High exercisers are expected to have healthier cardiovascular profiles relative to non-exercisers at baseline as demonstrated by lower values for SBP, DBP, heart rate, LF power, and LF/HF and by higher values for HF power, SDNN, and RMSSD.

2. High exercisers are predicted to report higher levels of trait mindfulness compared to non-exercisers.

3. High exercisers are anticipated to report fewer cognitive stress appraisals of threat and, instead, to report more appraisals of challenge than non-exercisers before the acute stress tasks.

4. Mindfulness is hypothesized to be positively associated with challenge appraisals and negatively associated with threat appraisals.

5. During both acute stress tasks, high exercisers are hypothesized to show less cardiovascular reactivity relative to non-exercisers with a lesser decrease in SDNN, RMSSD, and HF power and a lesser increase in SBP, DBP, heart rate, LF power, and LF/HF.

6. In addition, mindfulness is predicted to be associated with cardiovascular reactivity to both acute stress tasks as exhibited by a lesser decrease in SDNN, RMSSD, and HF power and a lesser increase in SBP, DBP, heart rate, LF power, and LF/HF

Chapter II

Methods

Study Design

The study design examined both between groups and within groups analytic techniques.

Participants

Male and female participants, aged 18-28 (M = 19.5, SD = 2.3), were recruited from the undergraduate student population at the University of Michigan Dearborn. The present study contained two arms for recruitment and compensation. Students involved in varsity and club sports comprised the first arm, labeled as high exercisers (n = 18, male = 14). Students enrolled in Introductory Psychology courses comprised the second arm, labeled as non-exercisers (n = 36, male = 18). High exercisers were recruited through flyers distributed by the research team and coaches to the cross-country, soccer, lacrosse, ice hockey, and basketball teams (see Appendix A). Posters targeting student athletes were displayed throughout the athletic department, as well (see Appendix B). The flyers indicated that only individuals who had maintained an aerobic exercise regime that was consistent with the guidelines, as detailed above from the Office of Disease Prevention and Health Promotion (2008), should register. Criteria required high exercisers to have adhered their regime for 46 weeks of the year with no more than two back-to-back weeks missed. The high exercisers sample averaged 450 minutes spent exercising within the past week (minimum = 60, maximum = 1080) and averaged 19.39 days spent exercising within the past month. For primary exercise type, 67% endorsed running, 22% soccer, and 11% basketball.

Non-exercisers were recruited through SONA, an online research participation program for undergraduate psychology students at U-M Dearborn. Before the start of the semester, students completed a prescreening questionnaire through SONA. Only students who self-reported that they exercised less than four weeks per year and that they considered themselves to be generally healthy were able to register. The SONA webpage further detailed that students should have abstained from exercise within eight weeks of study enrollment.

Additional constraints required both high and non-exercisers to be individuals who did not practice meditation (i.e., seated or moving meditation, religious/spiritual meditation). Participants were instructed to abstain from alcohol and caffeine 12 hours and tobacco three hours prior to the study. Furthermore, participants needed to endorse having taken no medications that influence cardiovascular functioning (e.g., stimulants, steroids, antidepressants, anti-inflammatory medications) and having no diagnosis of certain medical and psychiatric conditions that could affect cardiovascular functioning (e.g., high blood pressure, diabetes, chest pain, depression). Participants also needed to endorse no use of over-the-counter allergy, cold, flu, or pain medications within 24 hours of the study. Lastly, participants were excluded if pregnant, breast-feeding, or under the age of 18.

Regarding compensation, high exercisers were provided a selection of one of two options for participation. High exercisers chose either entrance into a raffle to win a $25.00 Visa gift card which was awarded to one out of every ten participants or an award of research credit through SONA. The option for raffle entrance accommodated student athletes who were not enrolled in undergraduate psychology classes. All non-exercisers were awarded research credit through SONA for participation. Study duration lasted approximately 80 minutes.

Measures

Physiological measures. This study measured both ECG and blood pressure data. Electrocardiograms were collected with a Biopac MP150 System which ran continuously from the start of baseline to the completion of the final stress task. Blood pressure was collected with a Critikon 8100 System; this noninvasive equipment measures diastolic and systolic blood pressure, mean arterial pressure, and pulse rate. Four blood pressure readings were taken during baseline, the last two of which were averaged and used in the data analysis. Additional readings were taken and averaged during subsequent protocol stages—three readings during preparation and three readings each for the two stress tasks. The readings during the stress tasks were used in data analysis; preparation data was not included.

Demographics and exercise screening questionnaire. Participant age, gender, religion, smoking habits, exercise behaviors, and meditation practices were collected via self-report. Height and weight were collected by the researchers via a wall-mounted ruler and a professional medical scale. For potential exclusion, religion was included to compare with any endorsement of meditation practices. Height and weight for BMI calculations as well as smoking habits were included as items that would likely further differentiate non- and high exercisers. Screening questionnaire is displayed in Appendix C.

Stress appraisal measure (SAM). Cognitive appraisals were measured using the 20-item Stress Appraisal Measure using the subscales for *threat*, *challenge*, *stressfulness*, *centrality*, and *control of self* (Peacock & Wong, 1990). Each subscale consists of four items using a 5-point response scale ranging from 1 (*not at all*) to 5 (*extremely*). *Threat* is designed to measure the perceived threat in a situation, whereas *challenge* is designed to measure one's perceived potential growth or gain in a situation. *Stressfulness* is created to measure the degree of perceived acute stress, *centrality* is designed measure the perceived relevancy of the stressor, and *control of* *self* is created to measure the perceived ability to use coping skills. Validation studies indicate that these subscales tap relatively distinct dimensions of appraisals related to the overall stress experience (Peacock & Wong, 1990). The SAM for the speech task is displayed in Appendix D and for the mental arithmetic in Appendix E.

Mindful attention awareness scale (MAAS). The Mindful Attention Awareness Scale is designed to evaluate trait mindfulness in adult populations with 15 items, scored on a 6-point scale from 1 (*very frequently*) to 6 (*almost never*) (Brown & Ryan, 2003). Items are worded toward having an absence of mindfulness in order to identify with individuals who may be unfamiliar with terminology related to mindfulness. The MAAS loads onto a single factor of mindfulness with an emphasis on self-awareness. The test indicates good test-retest reliability, Pearson's $r = .81$, $p < .001$, high internal validity, $\alpha = .87$, and good convergent and discriminant validity (Brown & Ryan, 2003). The MAAS is displayed in Appendix F.

Freiburg mindfulness inventory (FMI). The Freiburg Mindfulness Inventory (FMI) is designed to assess trait mindfulness in adult populations (Walach, Buchheld, Buttenmüller, Kleinknecht, & Schmidt, 2006). The 14 items are rated from 1 (*rarely*) to 4 (*almost always*); a modifiable date range is provided, and 30 days has been chosen for consistency with the date range on additional scales in this study. The FMI shows high internal validity, $\alpha = .86$, and good convergence with relevant constructs (Walach et al., 2006). The FMI is displayed in Appendix G.

Five facet mindfulness questionnaire-short form (FFMQ-SF). The Five Facet Mindfulness Questionnaire-Short Form is designed to measure five dimensions of the mindfulness experience and ranges from 1 (*never/very rarely true*) to 5 (*very often/always true*) (Bohlmeijer, ten Klooster, Fledderus, Veehof, & Baer, 2011). The FFMQ-SF is comprised of 24 preexisting items from various mindfulness scales and, from these items, does not create a single scale but instead measures five distinct subscales: *observing*, *describing*, *acting with awareness*, *nonjudging*, and *nonreacting*. The MAAS already accounted for some of the items, so these select items were excluded from the 19-item draft of the FFMQ-SF for this study. *Observing* measures the ability to pay attention to external stimuli through one's senses. *Describing* assesses the ability to identify and to verbally express one's thoughts, feelings, and sensations. *Nonjudging* measures acceptance and permission of one's thoughts and feelings, although the items are worded to emphasize judgment, disapproval, and rejection. *Nonreacting* measures the ability to maintain nonattachment and to feel calm in the presence of distressing thoughts and feelings. Items on the FFMQ-SF indicate high content validity and moderate to strong convergent validity, and the short form creates an equivalent five-factor structure to its full scale. Internal consistency of the short form subscales ranges from $\alpha = .86$ for *nonreacting* to $\alpha = .91$ for *describing* (Bohlmeijer et al., 2011). The FFMQ-SF is displayed in Appendix H.

Perceived stress scale (PSS). The Perceived Stress Scale is a 10-item measure which assesses the degree to which individuals perceive themselves as having a sense of control over and an ability to cope with, nonspecific life events during the past 30 days (Cohen, Kamarck, & Mermelstein,1983). Items are scored from 0 (*never*) to 4 (*very often*). The PSS has good internal consistency, $\alpha = .84$-.86, and has demonstrated construct validity (Cohen et al., 1983). The PSS is displayed in Appendix I.

Procedure

Participants were first provided with the demographics and exercise screening questionnaire. Individuals who did not meet the health, substances, meditation, and exercise qualifications were excluded, compensated based on their responses to the exercise questions, and dismissed. For individuals who met the participant profile, they then provided written informed consent. Next, the researchers measured participants' height and weight and explained how to self-apply electrodes with a hands-on demonstration. A plastic mannequin was presented for a visual demonstration of a lead two configuration, as well, with one electrode placed on the upper right chest, one placed on the upper left chest, and one placed on the lower left side beneath the ribcage. To protect the equipment and to increase the perceived formality of the situation, participants were asked to redress in a medical gown for the protocol. Participants were left in privacy for electrode application, and once complete, the researchers fitted a blood pressure cuff to the participants' non-dominant, upper arm.

With the participants quietly seated, blood pressure and ECG data began collection at the 10-minute baseline with the last five minutes being used in data analysis. The researchers then explained the first task: a free-speech presentation in which the participant needed to convince the management of a company that he/she was the best candidate for his/her dream job in a five-minute personal interview. Participants were informed that the speech would also be video recorded and analyzed at a later date, which was novel, unexpected information to them. This deception was incorporated in order to reduce perceived controllability and maximize the stress response (Rimmele et al., 2009).

Participants were given a 3X5 notecard to prepare the speech for five minutes. After the five minutes, the researchers confiscated the notecard, moved a video camera mounted on a full-sized tripod into the participants' line of sight, and simulated a start to the video camera. The researchers then provided the Stress Appraisal Measure (SAM) to evaluate participants' cognitive stress appraisals about the upcoming speech task. Once the SAM was complete, participants were instructed to begin their speech, and during this time the researchers provided neutral and negative nonverbal feedback. For example, the researchers sighed audibly, glanced at the video camera, and disengaged their gaze from the participants' eye contact. At two minutes into the speech, the researchers whispered to one another to imitate private discussion of the participant.

After the speech task, the researchers stopped participants and moved into the explanation of the second task: five minutes of mental arithmetic in which participants were instructed to count backward by serial sevens and to work quickly and accurately. Participants were told that if the performance was slow or included mistakes, the researchers would give them a new starting number until they successfully completed the task. The researchers provided the SAM for a second time, now to evaluate participants' cognitive stress appraisals about the upcoming arithmetic task. Once the SAM was complete, participants engaged in five minutes of mental arithmetic. During this period, the researchers provided nonverbal and verbal feedback and harassment. For example, the researchers told participants to work faster and to indicate that others had gotten farther in the task. Participants were interrupted at times when they made real errors and even at times when they were accurate. The researchers also tapped pens noisily as a distraction.

After the mental arithmetic, the continuous ECG and intermittent blood pressure readings were discontinued, and participants were informed that all physiological data was complete. Participants were then allowed to remove the electrodes in privacy before returning to complete the MAAS, FMI, FFMQ-SF, and PSS. Lastly, the researchers debriefed participants about the ruse of the video camera and provided a debriefing form, as well (see Appendix J). Participants received appropriate compensation and were then dismissed.

Data Analytic Techniques

Hypothesis 1 was analyzed by independent samples *t*-tests for cardiovascular baseline data. Hypothesis 2 was analyzed by independent samples *t*-tests for the six mindfulness scores: MAAS total scale score, FMI total scale score, the FFMQ-SF *observing* subscale score, the FFMQ-SF *describing* subscale score, the FFMQ-SF *nonjudging* subscale score, and the FFMQ-SF *nonreacting* subscale score. Hypothesis 3 was analyzed by independent samples *t*-tests for the four SAM subscale scores with tests conducted independently for the speech task and for the mental arithmetic. Hypothesis 4 was analyzed by bivariate correlations regarding the six mindfulness scores, the challenge appraisal score for both tasks, and the threat appraisal score for both tasks. Hypothesis 5 was analyzed by independent samples *t*-tests with change scores for cardiovascular reactivity data during the speech task and mental arithmetic. Hypothesis 6 was analyzed by hierarchical linear regressions with each mindfulness variable in regards to speech task cardiovascular reactivity and for mental arithmetic cardiovascular reactivity.

Chapter III

Results

Manipulation Check

An analysis of skewness indicated that data for HF(ms^2) and LF/HF had a skewness statistic above three. A natural logarithm (ln) transformation was applied to these variables to account for this skewness, and statistical tests for the hypotheses analyzed both the raw and transformed data. Before evaluating the hypotheses, a manipulation check was conducted to ensure that the stress protocol produced the anticipated physiological responses. The repeated measures ANOVA showed significant findings for all cardiovascular variables from baseline to speech task reactivity: SBP, $F(1,52) = 5688.021$, $p < .000$, DBP, $F(1,52) = 8882.281$, $p < .000$, heart rate, $F(1,46) = 1729.440$, $p < .000$, SDNN, $F(1,46) = 471.389$, $p < .000$, RMSSD, $F(1,46) = 204.970$, $p < .000$, HF(ms^2), $F(1,46) = 57.627$, $p < .000$, ln HF(ms^2), $F(1,46) = 1653.658$, $p < .000$, HF(nu), $F(1,46) = 366.078$, $p < .000$, LF(ms^2), $F(1,46) = 111.941$, $p < .000$, LF(nu), $F(1,46) = 1751.513$, $p < .000$, LF/HF, $F(1,46) = 127.833$, $p < .000$, and ln LF/HF, $F(1,46) = 119.236$, $p < .000$. Before going through each hypothesis, a noteworthy consideration is that the study was stopped before reaching the a priori sample size due to time constraints to complete the Master's thesis. The groups are imbalanced in size and gender for a similar reason.

Main Analyses

Cardiovascular functioning at baseline. Hypothesis 1 predicted that high exercisers would have lower SBP, DBP, heart rate, LF power, and LF/HF and higher SDNN, RMSSD, and HF power relative to non-exercisers. Results for Hypothesis 1 independent *t*-tests are displayed in Table 1. As expected, high exercisers demonstrated significantly lower heart rate, significantly greater SDNN and RMSSD, and marginally greater HF(ms^2) and ln HF(ms^2). High exercisers also exhibited significantly greater LF(ms^2), which was in the unexpected direction. No marginal or significant outcomes were found for SBP, DBP, HF(nu), LF(nu), LF/HF, and ln LF/HF.

Trait mindfulness. Hypothesis 2 predicted that high exercisers would report greater levels of trait mindfulness than non-exercisers. Results for Hypothesis 2 independent *t*-tests are displayed in Table 2. Due to the later addition of the FFMQ-SF in the protocol, the entire sample completed the MAAS and FMI while only a portion of high exercisers and non-exercisers completed the FFMQ-SF. All outcomes for this hypothesis were non-significant.

Stress appraisals. Hypothesis 3 predicted that high exercisers would report fewer threat appraisals and more challenge appraisals before both acute stress tasks relative to non-exercisers. Results for Hypothesis 3 independent *t*-tests are displayed in Table 3. All outcomes for this hypothesis were non-significant.

Mindfulness and stress appraisals. Hypothesis 4 predicted that trait mindfulness would be positively associated with challenge appraisals and negatively associated with threat appraisals. Results for Hypothesis 4 correlations are displayed in Table 4. The MAAS was significantly, negatively associated with *threat* for the speech task and was marginally, negatively associated with *threat* for the mental arithmetic. The FFMQ-SF *describing* subscale was significantly, positively associated with *challenge* for the speech task and significantly, negatively associated with *threat* for the mental arithmetic. The FFMQ-SF *describing* subscale was also marginally, positively associated with *challenge* for the mental arithmetic. No associations were found among stress appraisals, the FMI, and the FFMQ-SF subscales *observing*, *nonjudging*, and *nonreacting*.

Cardiovascular reactivity. Hypothesis 5 predicted that high exercisers would show a lesser decrease in SDNN, RMSSD, HF power and a lesser increase in SBP, DBP, heart rate, LF power, and LF/HF during both acute stress tasks compared to non-exercisers. The independent *t*-tests of delta scores showed that, during the speech task, the change in DBP was marginally greater for high exercisers than non-exercisers in the unexpected direction, $t(51) = 1.923$, $p < .1$, $r = .19$ (see Table 5). During the mental arithmetic, SDNN reactivity was significant with high exercisers demonstrating a decrease and non-exercisers demonstrating an increase in SDNN, which was unexpected, $t(45) = -2.220$, $p < .05$, $r = .21$ (see Table 6). All of the other physiological variables for both stress tasks were non-significant.

Mindfulness and cardiovascular reactivity. Hypothesis 6 predicted that mindfulness would be positively associated with cardiovascular reactivity to both acute stress tasks as exhibited by a lesser decrease in SDNN, RMSSD, and HF power and a lesser increase in SBP, DBP, heart rate, LF power, and LF/HF. The hierarchical linear regressions showed that, during the speech task, the MAAS significantly accounted for 7.7% of the variance of ln LF/HF reactivity (see Table 7). The MAAS accounted for marginal change of DBP, ln HF(ms^2), HF(nu), LF(nu), and LF/HF speech task reactivity. No associations were found for the MAAS and mental arithmetic reactivity (see Table 8). During the speech task, the FMI accounted for marginal change of SBP reactivity (see Table 9); no associations were found for the FMI and mental arithmetic reactivity (see Table 10).

During the speech task, the FFMQ-SF *observing* subscale significantly accounted for 8.0% of the variance of SBP reactivity (see Table 11). During the mental arithmetic, the FFMQ-SF *observing* subscale significantly accounted for 9.4% of the variance of RMSSD reactivity, for 15.2% of the variance of HF(ms^2) reactivity, and for 12.1% of the variance of LF(ms^2) reactivity (see Table 12). The FFMQ-SF *observing* subscale accounted for marginal change of SDNN mental arithmetic reactivity. During the speech task, the FFMQ-SF *describing* subscale significantly accounted for 15.7% of the variance of HF(nu) reactivity, for 18.8% of the variance of LF/HF reactivity, and for 18.4% of the variance of ln LF/HF reactivity (see Table 13). During the mental arithmetic, the FFMQ-SF *describing* subscale significantly accounted for 6.1% of the variance of SBP reactivity, for 15.0% of the variance of HF(nu) reactivity, for 15.4% of the variance of LF(nu) reactivity, for 20.3% of the variance of LF/HF reactivity, and for 19.2% of the variance of ln LF/HF reactivity (see Table 14). The FFMQ-SF *nonjudging* subscale showed no associations during the speech task (see Table 15) and accounted for marginal change of LF/HF mental arithmetic reactivity (see Table 16). No associations were found for the FFMQ-SF *nonreacting* subscale and speech task reactivity (see Table 17) nor mental arithmetic reactivity (see Table 16).

Ancillary Analyses

The following results for ancillary analyses are based on data collected during the protocol but are not included in the original hypotheses. Independent samples *t*-tests for group differences on *stressfulness*, *centrality*, and *control of self* on the SAM for both stress tasks were conducted. Groups were not expected to differ on appraisals of stressfulness and centrality; high exercisers were anticipated to report fewer appraisals of control of self than non-exercisers. All results for group differences were non-significant. Independent samples *t*-tests for group differences in perceived chronic stress were conducted with the expectation that high exercisers would report lower scores on the PSS than non-exercisers. Results did indicate that high exercisers ($M = 15.83$, $SD = 7.31$) reported experiencing significantly less stress over the last 30 days than non-exercisers ($M = 20.78$, $SD = 6.11$), $t(52) = -2.625$, $p < .05$, $r = .21$. Bivariate correlations were conducted on relations of mindfulness to perceived chronic stress. As expected, the majority of mindfulness measures was significantly, negatively associated with the PSS. Results for the ancillary correlations for mindfulness and the PSS are included in Table 4 along with the outcomes for Hypothesis 4.

Chapter IV

Discussion

The purpose of this study is to examine components of the integrative theory regarding aerobic exercise, cognitive stress appraisals, and mindfulness and how they relate to blood pressure, heart rate, and heart rate variability functioning at baseline and during reactivity to an acute psychological stressor. The presented theory of these relations is based on the cross-stressor adaptation hypothesis regarding psychophysiological changes from exercise, the Transactional Model of Stress, and constituents of trait mindfulness. The study seeks to address gaps in the literature by considering these variables as being expressed in a network due to their shared psychological and cardiovascular outcomes. Using a stress protocol consisting of a speech task and a mental arithmetic task, this research and its results are applied to a sample of healthy, undergraduate students. Participants were divided into two groups with student athletes in the high exercisers arm and with subject pool students in the non-exercisers arm.

A manipulation check confirmed that the stress protocol elicited significant cardiovascular reactivity for the whole sample in the expected direction. As stated above, data collection was prematurely terminated before reaching the a priori sample size due to time constraints to complete the Master's thesis, which, in part, led to a smaller sample of participants and imbalanced groups. The findings for each hypothesis are addressed below and are followed by a discussion of the related, post-hoc analyses.

Cardiovascular Functioning at Baseline

High exercises were anticipated to demonstrate lower SBP, DBP, heart rate, sympathetic power, and LF/HF and higher parasympathetic power and total variability at baseline than non-exercisers. High exercisers exhibited significantly lower heart rate, which is likely due to the strengthening of parasympathetic innervation of the myocardium associated with regular exercise. High exercisers exhibited significantly greater SDNN and RMSSD. Results for these time domain measures suggest that high exercisers have both greater total variability and greater relative parasympathetic activity, which also may be attributed to an overall increase in autonomic activation from exercise (Carter et al., 2003; Raczak et al., 2006; Shi, Stevens, Foresman, Stern, & Raven, 1995).

For spectral components, high exercisers also demonstrated marginally greater HF(ms^2) and ln HF(ms^2), with both measures interpreted as parasympathetic activity. High exercisers also exhibited significantly greater LF(ms^2), a measure composed of variance from both branches with possible sympathetic dominance. Although contrary to the hypothesis, the stronger LF power in high exercisers indicates that the student athletes had greater, global activation than non-exercisers, which is supported by results for SDNN, RMSSD, and HF power.

Outcomes for spectral components of HF(nu), LF(nu), LF/HF, and ln LF/HF were not supported. While high exercisers demonstrated greater total variability by a larger area under the curve of the power spectrum, as evidenced by findings for autonomic power in milliseconds squared and SDNN, the relative ratio of HF(nu) and LF(nu) powers and the LF/HF is not different between groups. While the high exercisers were predicted to demonstrate a greater sympathovagal balance, the non-significant difference may be due to using a young, healthy population. Initial screening also failed to control for participants' extended history of physical activity. Although cardiovascular deconditioning begins to occur within a couple weeks of cessation of physical activity (Hughson & Shoemaker, 2015), information was not collected on participants' physical demands in certain vocations, frequency of walking throughout the university campus, and recency of potential injuries of athletes. Outcomes for SBP and DBP were also not supported. Again, results may be due to the nature of the young, healthy groups who may not exhibit notable CVD risk factors at this time. Indeed, in young, healthy participants, altered cardiovascular reactivity has been found to be a risk factor for future development of carotid atherosclerosis, increased ventricular mass, and ambulatory hypertension (Heponiemi et al., 2007; Treiber et al., 2003). History of physical activity may also have influence the outcomes for blood pressure.

Trait Mindfulness

High exercisers were anticipated to report greater levels of trait mindfulness than non-exercisers, yet all outcomes were non-significant. A potential reason for the lack of group differences is the variation of sports represented in the high exercisers. Certain sports may share more similarities with components of mindfulness than other sports. Research that has examined these parallel processes focuses on repetitive physical movement and rhythmic breathing, such as swimming and running (Asztalos et al., 2012; Berger & Owen, 1988; Demarzo et al., 2014; Mothes et al., 2014; Salmon, Hanneman, & Harwood, 2010). The high exercisers in this study are a heterogeneous sample from cross-country, soccer, basketball, and lacrosse teams. While 67% of individuals identified running as their primary form of aerobic exercise, this portion does not reflect with which sport these individuals associated. For example, an athlete on the cross-country team experiences a very different run than an athlete running down a basketball court with other players and an opposing team. Mindfulness does not demand stillness, but it does require intention to maintain a single, nonjudgmental focus (Kee & Wang, 2008; Netz & Lidor, 2003), which may be jeopardized by certain sports.

Furthermore, the sample has notable gender imbalance with a 7:2 ratio of male to female high exercisers and with a 16:11 ratio of males to females in the whole sample. Prior literature has demonstrated a significant gender by mindfulness interaction for performance with females expressing higher trait mindfulness with stronger academic performance and with males expressing lower trait mindfulness with stronger academic performance (Shao & Skarlicki, 2009). Although the current study did not examine constituents and outcomes of performance, the protocol did require performance for both stress tasks. Thus, these non-significant findings may be related to an underrepresentation of females in the high exercisers group.

Another factor that may have affected mindfulness, and consequently stress appraisals and reactivity, in the sample as a whole is sleep. Limited and inconsistent sleep is prevalent among college students. Emotional and academic stress in undergraduates have been shown to be significant predictors of poor sleep patterns, which are further linked to increased physical and psychological problems (Lund, Reider, Whiting, & Prichard, 2010). High levels of stress have been associated with low levels of trait mindfulness (Soysa & Wilcomb, 2015). Complementarily, mindfulness characteristics and practice have significantly predicted and improved overall well-being, sleep quality, stress, and mood (Caldwell, Harrison, Adams, Quin, & Greeson, 2010; Howell, Digdon, Buro, & Sheptycki, 2008; Klatt, Norre, Reader, Yodice, & White, 2016). In the present study, mood states and sleep behaviors were not assessed; however, these two variables may have affected this population and negatively affected mindfulness.

Additionally, exercise behaviors and mindfulness are significantly impacted by motivational sources. Research based on the self-determination theory has indicated that mindfulness acts as a moderator between intrinsic motivation (behavior change for pleasure or enjoyment) and regular exercise with college-aged and young adult groups. External motivation (behavior change based on rewards and punishments) is not a strong predictor of engaging in exercise habitually nor is associated with trait mindfulness (Gardner & Lally, 2013; McCarthy, 2011; Ruffault, Bernier, Juge, & Fournier, 2016). Although student athletes may use intrinsic motivation for their exercise behaviors, they also are influenced by rewards, punishments, training expectations, and performance comparisons by the competitive climate of collegiate athletics. While mindfulness has been shown to be fostered through exercise, preexisting mindfulness also affects the expression and experience of exercise behaviors as well as cardiovascular functioning. Motivational sources for student athletes may differentially impact their approach to both mindfulness and exercise than an adult population who exercises outside of this climate.

Stress Appraisals

High exercisers were predicted to report fewer threat appraisals and more challenge appraisals before both acute stress tasks relative to non-exercisers. Results were all non-significant. Given that the groups did not differ on mindfulness, these outcomes were not surprising. Conceptually, mindfulness was anticipated to affect cognitive appraisals to stressful situations. Mindfulness increases cognitive flexibility which, in turn, allows a person to select a variety of adaptive appraisals (Shapiro et al., 2006; Garland, et al., 2009). Based on the theory, high exercisers and non-exercisers would necessarily show differences in mindfulness—which they did not—before this hypothesis would be statistically supported.

Mindfulness and Stress Appraisals

Trait mindfulness was hypothesized to be positively associated with challenge appraisals and to be negatively associated with threat appraisals. The MAAS showed a couple of notable findings in the expected direction. The MAAS was significantly, negatively associated with threat appraisals for the speech task and was marginally, negatively associated with threat appraisals for the mental arithmetic. The MAAS was not associated with challenge appraisals for either task. Given the findings below for the FFMQ-SF, self-awareness, which is heavily represented by the MAAS, may not be the most salient component of mindfulness to be related to perceived growth (challenge appraisals) to these stressors.

The FFMQ-SF *describing* subscale; which measures the ability to identify and to verbally express thoughts, feelings, and sensations; demonstrated meaningful results in the expected direction for most variables. *Describing* was significantly, positively associated with challenge appraisals for the speech task. For the mental arithmetic, *describing* was significantly, negatively associated with threat appraisals and was marginally, positively associated with challenge appraisals. Taken together, these expected results follow the nature of the acute stressors and the related psychological processes.

No associations were found among stress appraisals, the FMI, and the FFMQ-SF subscales *observing*, *nonjudging*, and *nonreacting*. Similar to self-awareness in the MAAS, *observing*, the subscale measuring one's ability to pay attention to external stimuli through the senses, may not be the most relevant component of mindfulness for these stressors. *Nonjudging* and *nonreacting* may not have shown significant findings as college-aged individuals may be more sensitive to peer evaluations and, therefore, interpreted their experience in a more negative way. Supported by research on social-evaluative threats and cardiovascular reactivity in a similarly-designed TSST, this phenomenon may have detracted from participants' ability to remain nonjudgmental and nonreactive to the stressors (Smith & Jordan, 2015).

Cardiovascular Reactivity

High exercisers were predicted to show a lesser decrease in SDNN, RMSSD, HF power and a lesser increase in SBP, DBP, heart rate, LF power, and LF/HF during both acute stress tasks compared to non-exercisers. In general, the groups did not show differential cardiovascular reactivity to the stress tasks. Given that high exercisers and non-exercisers did not differ on mindfulness and, consequently, stress appraisals, the Transactional Model of Stress indicates that the groups would express a lack of significant physiological reactivity.

If these non-significant outcomes were to be considered as coming from exercise-induced, physiological changes only, and not to be considered from psychological processes, these findings are unexpected. Many mechanisms were discussed in the introduction about the effects of exercise on cardiovascular reactivity (Carter et al., 2003; Klabunde, 2011; Mitchell et al., 2005; Scott, 2005). No clear theoretical explanation accounts for the lack of differences in reactivity, but there may be methodological factors. These possible influences include use of a young, healthy population and lack of screening for the participants' comprehensive history of physical activity.

In addition, research has showed that physically fit individuals show changes in reactivity to physiological stressors, such as acute exercise (Cornelissen et al., 2010; Gregoire et al., 1996; Pitsavos et al., 2011; Shi et al., 1995). Literature is heavily mixed, however, on differential reactivity to psychological stressors (Alex et al., 2013; Forcier et al., 2006; Jackson & Dishman, 2006; Moya-Albiol et al., 2001; Sloan et al., 2011; Spalding et al., 2004). This phenomenon is shown, in part, by the significant differences at baseline but not during reactivity to the stress tasks. As previously stated, the cross-stressor adaptation hypothesis has not been consistently supported in studies due to methodological variance, including a dose-dependent relationship of exercise and mood changes, participant age and sex, and additional factors (Dvorak et al., 2000; Rimmele et al., 2009). Indeed, high exercisers may show greater improvements in psychological functioning concerning everyday decisions, interactions, and hassles due to the effects of exercise but may not demonstrate such notable benefits during acute psychological stressors and psychophysiological reactivity.

Mindfulness and Cardiovascular Reactivity

Mindfulness was predicted to be positively associated with cardiovascular reactivity to both acute stress tasks as exhibited by a lesser decrease in SDNN, RMSSD, and HF power and a lesser increase in SBP, DBP, heart rate, LF power, and LF/HF. In general, neither mindfulness nor its constituents predicted cardiovascular reactivity to the speech task nor the mental arithmetic. Findings were somewhat surprising, given that mindfulness was generally, inversely associated with threat appraisals. Based on the model of Lazarus and Folkman (1984), threat appraisals would be expected to be associated with greater cardiovascular reactivity, although the literature on this association is mixed (Gump & Matthews, 1999).

Regarding the limited number of significant findings, *describing*, one of the measured components of mindfulness, makes up approximately two-thirds of the significant results. Within the context of the limitations of this study, for this population (college students) and the specific stress tasks utilized, the ability to identify and verbally express one's thoughts, feelings, and sensations may be the most relevant aspect of mindfulness. Indeed, the results are consistent with Hypothesis 4 in that *observing*, *nonjudging*, and *nonreacting* did not predict threat appraisals. In the absence of associations with threat appraisals, the Transactional Model of Stress would suggest that physiological reactivity would be minimal.

Ancillary Analyses

In order to better understand the above global findings, post-hoc analyses were conducted for appraisals of stressfulness, centrality, and control of self and for perceived chronic stress. High exercisers and non-exercisers did not differ on appraisals of stressfulness, centrality, and control of self for either stress task, which is consistent with the above results. As expected, high exercisers reported experiencing significantly less stress over the last 30 days than non-exercisers, which is likely due to a variety of sources, including the mood-boosting effects of exercise and support from coaches (Baghurst & Kelley, 2014; Lu et al., 2016; McMorris, 2009; Rangul et al., 2012). Regarding associations of mindfulness to perceived chronic stress, the MAAS, FMI, and the FFMQ-SF subscales *describing*, *nonjudging*, and *nonreacting* were significantly, inversely correlated with the PSS. Association of the FFMQ-SF subscale *observing* and the PSS was non-significant. These patterns support prior research which has shown that individuals who report higher levels of stress tend to exhibit less trait mindfulness, to struggle to remain in the present moment, to have more judgmental cognitions about situations, and to be more reactive to stimuli (Soysa & Wilcomb, 2015).

Summary

While the majority of the hypotheses were not supported, the theory behind this study hinged on individuals with a high volume of aerobic exercise reporting greater levels of mindfulness compared to sedentary individuals. Differential mindfulness was expected to lead to differential cognitive stress appraisals which would lead to differential cardiovascular responses. For the cross-stressor adaptation hypothesis, a portion of the literature has indicated that high exercisers demonstrate healthier cardiovascular reactivity to acute psychological stressors. Research has also implicated cognitive flexibility as the mediating variable between mindfulness and adaptive cognitive appraisals. Lastly, the role of mindfulness has been recently postulated to act as both a mediating and moderating variable to exercise and its effect on cardiovascular functioning. Since this premise was not supported, the lack of differences between high exercisers and non-exercisers in Hypothesis 2 may be a fundamental driving factor in the non-significant findings in the study as a whole.

Limitations

This study contained a number of limitations. As previously mentioned, data collection was discontinued early due to time constraints, and the a priori sample size was not obtained. The smaller sample size meant that some of the statistical assumptions of the employed analytic techniques were violated, particularly for the hierarchical regressions. No statistical corrections were applied for any of the hypotheses; thus, all results must be interpreted with caution. A larger sample may yield a clearer understanding of potential associations.

Additionally, inequalities existed between and within groups. The non-exercisers group was twice as large as the high exercisers. Although the 16:11 male to female ratio of the whole sample was not unmanageable, there was a significant gender imbalance between the groups. For the non-exercisers, the male to female ratio was 1:1. For the high exercisers, the male to female ratio was 7:2, resulting in only four female athletes in the group. The research team recruited male, female, and gender-mixed sports teams, but the reasons why female athletes did not participate was unclear. Lastly, a heterogeneous representation of sports comprised the high exercisers. Despite the athletes all maintaining a high volume of aerobic activity, they likely differed on their accompanying experiences of mindfulness in meaningful ways. Results should be interpreted with caution due to the small sample size and group imbalances.

Another limitation was the predominately female research team. Only females recruited male sports teams, and recruitment of female and gender-mixed sports teams was split between the female team and one male researcher to diminish a potential researcher effect on athlete interest. However, only females ran participants through the protocol. As prior literature has shown regarding gender differences in perceived stress, some of the non-significant findings may be related to a greater proportion of men in the sample paired to female researchers (Duchesne, Tessera, Dedovic, Engert, & Pruessner, 2012).

Future Directions

To this author's knowledge, this study was the first in the literature to evaluate exercise, acute stress, and mindfulness and their associations with blood pressure, heart rate, and heart rate variability at baseline and during reactivity to an acute psychological stressor. The hypotheses, protocol, and sample size allowed an examination of components of these variables operating in a theoretical network. Future research should expand on the role of and mechanisms behind mindfulness and its components on stress and cardiovascular functioning. Relevant physiological responses should include ambulatory, reactivity, as well as recovery processes. Cognitive flexibility, the mediator variable between mindfulness and cognitive appraisals, should also be measured to understand the full psychological process leading to reactivity. A larger study could implement structural equation modeling to investigate all aspects of the theory, as detailed in the introduction and depicted in Figure 1.

Future studies should homogenize the sports represented by high exercisers for increased reliability in the results and should also examine trends in mindfulness based on diversity in forms of physical exercise or sports. Gender differences in mindfulness in athletes could also be explored. Studies could assess potential effects on history of physical activity, whether related to athletics or vocational demands, on mindfulness as well as cardiovascular functioning.

Future research should also be conducted on athletes in non-fitness situations. In most studies that have extended athletes' stressors beyond sports, the research has emphasized academic and athletic variables, which were stressors already present in the athletes' lives (Nicholls et al., 2014; Sellers & Peterson, 1993). The stress protocol in this study was a novel situation for the high exercisers. Additional studies that present novel, psychological stressors that are unrelated to sports may provide further clarification for the cross-stressor adaptation hypothesis.

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Tables

Table 1

Independent T-Tests Comparing High- and Non-Exercisers on Cardiovascular Baseline Functioning

			High Exercisers (*n = 16)*		Non-Exercisers (*n = 31)*		
Variable	***t***	***df***	***M***	***SD***	***M***	***SD***	***r***
SBP	1.161	52	113.083	11.683	109.500	10.169	.15
DBP	-.449	52	65.000	5.605	65.667	4.906	.09
HR	-2.705**	45	75.875	13.750	85.507	10.301	.23
SDNN	3.005**	45	68.344	20.885	49.948	19.367	.24
RMSSD	2.278*	45	47.450	22.838	32.652	20.184	.21
HF(ms^2)	1.719+	45	1224.813	1145.294	696.581	915.526	.19
ln HF(ms^2)	1.918+	45	6.608	1.155	5.942	1.116	.20
HF(nu)	-.064	45	32.888	16.803	33.187	14.260	.04
LF(ms^2)	2.539*	45	2078.313	1317.388	1143.645	1130.547	.22
LF(nu)	.300	45	67.044	16.795	65.574	15.449	.08
LF/HF	.722	45	3.395	3.785	2.778	2.103	.13
ln LF/HF	.209	45	.827	.889	.778	.706	.07

Note. SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD = Root Mean Square of Successive Difference, HF = High frequency spectral power, LF = Low frequency spectral power, ms^2 =

milliseconds squared, nu = normalized units, ln = natural logarithm, LF/HF = Ratio of Low frequency to High frequency spectral powers.
$^{+}p < .1.$ $^{*}p < .05.$ $^{**}p < .01.$

Table 2

Independent T-Tests Comparing High- and Non-Exercisers on Trait Mindfulness

			High Exercisers			Non-Exercisers		
Variable	***t***	***df***	***M***	***SD***	***n***	***M***	***SD***	***n***
MAAS	.485	52	59.833	10.623	18	57.583	12.789	36
FMI	1.034	52	38.722	7.339	18	36.722	6.363	36
FFMQ-SF Observe	.933	29	14.625	4.534	8	13.217	3.357	23
FFMQ-SF Describe	1.297	29	17.000	5.182	8	14.870	3.546	23
FFMQ-SF Nonjudge	1.289	29	16.250	3.694	8	14.435	3.342	23
FFMQ-SF Nonreact	.454	29	15.250	5.258	8	14.478	3.716	23

Note. MAAS = Mindful Attention Awareness Scale, FMI = Freiburg Mindfulness Inventory, FFMQ-SF = Five Factor Mindfulness Questionnaire—Short Form.
All non-significant.

Table 3

Independent T-Tests Comparing High- and Non-Exercisers on Cognitive Stress Appraisals

			High Exercisers (*n = 18)*		Non-Exercisers (*n = 36)*	
Variable	***t***	***df***	***M***	***SD***	***M***	***SD***
Speech Task						
SAM-Threat	.418	52	11.000	1.910	10.764	1.980
SAM-Challenge	.514	52	11.778	4.152	11.222	3.530
Mental Arithmetic						
SAM-Threat	-.344	52	9.833	2.121	10.028	1.874
SAM-Challenge	.296	52	8.667	3.581	8.361	3.579

Note. SAM = Stress Appraisal Measure.
All non-significant.

Table 4

Bivariate Correlations Comparing Trait Mindfulness and Components of Stress

	Speech Task		Mental Arithmetic		
	SAM-Threat	**SAM-Challenge**	**SAM-Threat**	**SAM-Challenge**	**PSS**
MAAS	-.393**	.077	-.262+	.114	-.509**
FMI	-.121	.152	-.045	.003	-.617**
FFMQ-SF Observe	.037	.012	.174	-.117	-.153
FFMQ-SF Describe	-.267	.356*	-.462**	.323+	-.377*
FFMQ-SF Nonjudge	.070	-.038	.024	-.039	-.586**
FFMQ-SF Nonreact	-.224	-.222	-.184	-.029	-.643**

Note. SAM = Stress Appraisal Measure, MAAS = Mindful Attention Awareness Scale, FMI = Freiburg Mindfulness Inventory, FFMQ-SF = Five Factor Mindfulness Questionnaire—Short Form.
$^{+}p < .1$. $^{*}p < .05$. $^{**}p < .01$.

Table 5

Independent T-Tests Comparing Change Scores for Speech Task Cardiovascular Reactivity

	High Exercisers (n = 16)		Non-Exercisers (n = 31)		
Variable	Δ*M*	Δ*SD*	Δ*M*	Δ*SD*	*Cohen's d*
SBP	22.462	11.300	22.546	10.043	-.008
DBP	16.441	4.938	12.277	8.229	.614^{+}
HR	13.597	9.885	14.741	15.328	.247
SDNN	7.631	19.135	12.487	23.760	-.225
RMSSD	-8.763	19.945	-5.087	16.226	-.202
HF(ms^2)	-199.063	1354.749	-179.194	814.688	-.018
ln HF(ms^2)	-.183	1.093	-.115	1.036	-.064
HF(nu)	-4.269	18.845	-4.061	14.285	-.012
LF(ms^2)	-66.875	1170.141	62.807	1033.656	-.117
LF(nu)	4.319	18.865	3.571	18.128	.040
LF/HF	.110	3.989	.286	2.706	-.052
ln LF/HF	.184	.987	.176	.741	.009

Note. SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD = Root Mean Square of Successive Difference, HF = High frequency spectral power, LF = Low frequency spectral power, ms^2 = milliseconds squared, nu = normalized units, ln = natural logarithm, LF/HF = Ratio of Low frequency to High frequency spectral powers.
$^{+}p < .1$.

Table 6

Independent T-Tests Comparing Change Scores for Mental Arithmetic Cardiovascular Reactivity

	High Exercisers (n = 16)		Non-Exercisers (n = 31)		
Variable	**Δ*M***	**Δ*SD***	**Δ*M***	**Δ*SD***	***Cohen's d***
SBP	22.787	12.171	19.889	8.570	.275
DBP	13.446	5.163	12.889	5.302	.106
HR	13.452	10.706	13.119	13.610	.027
SDNN	-7.100	15.727	3.442	15.272	-.068*
RMSSD	-10.913	18.039	-2.665	16.046	-.483
HF(ms^2)	-446.250	992.623	-25.032	756.336	-.477
ln HF(ms^2)	-.263	1.011	.028	.926	-.300
HF(nu)	-3.719	16.895	-2.265	14.040	-.094
LF(ms^2)	-384.125	1110.480	135.161	1242.721	-.441
LF(nu)	2.450	14.889	3.455	15.500	-.066
LF/HF	-.370	3.156	.293	2.913	-.218
ln LF/HF	.123	.844	.107	.738	.020

Note. SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD = Root Mean Square of Successive Difference, HF = High frequency spectral power, LF = Low frequency spectral power, ms^2 = milliseconds squared, nu = normalized units, ln = natural logarithm, LF/HF = Ratio of Low frequency to High frequency spectral powers.
$^{*}p < .05$.

Table 7

Hierarchical Linear Regressions of Mindful Attention Awareness Scale (MAAS) and Speech Task Cardiovascular Reactivity

Variable	R	R^2	ΔR^2	B	t	β
Systolic BP						
Step 1: BL SBP	.731	.534	--	--	--	--
Step 2: MAAS	.738	.545	.011	-.132	-1.100	-.105
Diastolic BP						
Step 1: BL DBP	.441	.194	--	--	--	--
Step 2: MAAS	.489	.239	$.045^{+}$	-.146	-1.722	-.213
HR						
Step 1: BL HR	.676	.457	--	--	--	--
Step 2: MAAS	.694	.481	.024	-.239	-1.437	-.156
SDNN						
Step 1: BL SDNN	.560	.314	--	--	--	--
Step 2: MAAS	.565	.319	.005	.149	.572	.071
RMSSD						
Step 1: BL RMSSD	.624	.389	--	--	--	--
Step 2: MAAS	.629	.396	.007	.114	.707	.083
HF(ms^2)						
Step 1: BL HF(ms^2)	.399	.159	--	--	--	--
Step 2: MAAS	.414	.172	.013	7.575	.820	.114
ln HF(ms^2)						

Step 1: BL ln HF(ms^2)	.586	.343	--	--	--	--
Step 2: MAAS	.620	.385	.042$^+$	.019	1.730	.205
HF(nu)						
Step 1: BL HF(nu)	.337	.113	--	--	--	--
Step 2: MAAS	.431	.186	.072$^+$	.270	1.979	.269
LF(ms^2)						
Step 1: BL LF(ms^2)	.586	.344	--	--	--	--
Step 2: MAAS	.597	.356	.012	-9.762	-.914	-.112
LF(nu)						
Step 1: BL LF(nu)	.224	.050	--	--	--	--
Step 2: MAAS	.350	.122	.072$^+$	-.296	-1.902	-.269
LF/HF						
Step 1: BL LF.HF	.210	.044	--	--	--	--
Step 2: MAAS	.329	.108	.064$^+$	-.046	-1.778	-.253
ln LF/HF						
Step 1: BL ln LF/HF	.318	.101	--	--	--	--
Step 2: MAAS	.422	.178	.077*	-.015	-2.032	-.278

Note. BP = Blood pressure, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD=Root Mean Square of Successive Difference, HF=High frequency spectral power, LF=Low frequency spectral power, ms^2=milliseconds squared, nu=normalized units, ln = natural logarithm, LF/HF=Ratio of Low frequency to High frequency spectral powers.
$^+p < .1$. $^*p < .05$.

Table 8

Hierarchical Linear Regressions of Mindful Attention Awareness Scale (MAAS) and Mental Arithmetic Cardiovascular Reactivity

Variable	*R*	R^2	ΔR^2	*B*	*t*	β
Systolic BP						
Step 1: BL SBP	.726	.527	--	--	--	--
Step 2: MAAS	.738	.544	.017	.156	1.384	.131
Diastolic BP						
Step 1: BL DBP	.734	.538	--	--	--	--
Step 2: MAAS	.735	.541	.002	-.030	-.492	-.047
HR						
Step 1: BL HR	.711	.506	--	--	--	--
Step 2: MAAS	.713	.509	.002	-.073	-.467	-.049
SDNN						
Step 1: BL SDNN	.680	.462	--	--	--	--
Step 2: MAAS	.681	.464	.002	-.057	-.356	-.039
RMSSD						
Step 1: BL RMSSD	.643	.413	--	--	--	--
Step 2: MAAS	.643	.414	.001	-.033	-.213	-.025
HF(ms^2)						
Step 1: BL HF(ms^2)	.547	.299	--	--	--	--
Step 2: MAAS	.548	.300	.001	-1.575	-.232	-.029
ln HF(ms^2)						

Step 1: BL ln HF(ms^2)	.659	.434	--	--	--	--
Step 2: MAAS	.663	.440	.006	.007	.690	.078
HF(nu)						
Step 1: BL HF(nu)	.445	.198	--	--	--	--
Step 2: MAAS	.458	.210	.012	.119	.812	.109
LF(ms^2)						
Step 1: BL LF(ms^2)	.445	.198	--	--	--	--
Step 2: MAAS	.452	.204	.006	-6.716	-.599	-.081
LF(nu)						
Step 1: BL LF(nu)	.478	.228	--	--	--	--
Step 2: MAAS	.485	.235	.007	-.097	-.649	-.086
LF/HF						
Step 1: BL LF.HF	.298	.089	--	--	--	--
Step 2: MAAS	.344	.119	.030	-.032	-1.223	-.173
ln LF/HF						
Step 1: BL ln LF/HF	.427	.182	--	--	--	--
Step 2: MAAS	.447	.200	.017	-.007	-.978	-.132

Note. BP = Blood pressure, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD=Root Mean Square of Successive Difference, HF=High frequency spectral power, LF=Low frequency spectral power, ms^2=milliseconds squared, nu=normalized units, ln = natural logarithm, LF/HF=Ratio of Low frequency to High frequency spectral powers.
All non-significant.

Table 9

Hierarchical Linear Regressions of Freiburg Mindfulness Inventory (FMI) and Speech Task Cardiovascular Reactivity

Variable	*R*	R^2	ΔR^2	*B*	*t*	*β*
Systolic BP						
Step 1: BL SBP	.731	.534	--	--	--	--
Step 2: FMI	.748	.560	$.026^{+}$	-.367	-1.726	-.162
Diastolic BP						
Step 1: BL DBP	.441	.194	--	--	--	--
Step 2: FMI	.448	.201	.007	-.100	-.645	-.082
HR						
Step 1: BL HR	.676	.457	--	--	--	--
Step 2: FMI	.676	.457	.000	-.051	-.167	-.019
SDNN						
Step 1: BL SDNN	.560	.314	--	--	--	--
Step 2: FMI	.562	.316	.002	-.183	-.389	-.049
RMSSD						
Step 1: BL RMSSD	.624	.389	--	--	--	--
Step 2: FMI	.624	.390	.001	.082	.283	.033
HF(ms^2)						
Step 1: BL HF(ms^2)	.399	.159	--	--	--	--
Step 2: FMI	.402	.161	.002	-5.547	-.333	-.046
ln HF(ms^2)						

Step 1: BL ln HF(ms^2)	.586	.343	--	--	--	--
Step 2: FMI	.592	.350	.007	.014	.688	.084
HF(nu)						
Step 1: BL HF(nu)	.337	.113	--	--	--	--
Step 2: FMI	.338	.114	.001	.054	.210	.030
LF(ms^2)						
Step 1: BL LF(ms^2)	.586	.344	--	--	--	--
Step 2: FMI	.587	.344	.000	-1.927	-.100	-.012
LF(nu)						
Step 1: BL LF(nu)	.224	.050	--	--	--	--
Step 2: FMI	.252	.063	.013	.230	.792	.116
LF/HF						
Step 1: BL LF.HF	.210	.044	--	--	--	--
Step 2: FMI	.236	.056	.012	-.036	-.738	-.109
ln LF/HF						
Step 1: BL ln LF/HF	.318	.101	--	--	--	--
Step 2: FMI	.324	.105	.004	-.006	-.422	-.061

Note. BP = Blood pressure, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD=Root Mean Square of Successive Difference, HF=High frequency spectral power, LF=Low frequency spectral power, ms^2=milliseconds squared, nu=normalized units, ln = natural logarithm, LF/HF=Ratio of Low frequency to High frequency spectral powers.
$^+p < .1$.

Table 10

Hierarchical Linear Regressions of Freiburg Mindfulness Inventory (FMI) and Mental Arithmetic Cardiovascular Reactivity

Variable	*R*	R^2	ΔR^2	*B*	*t*	*β*
Systolic BP						
Step 1: BL SBP	.726	.527	--	--	--	--
Step 2: FMI	.730	.533	.006	-.164	-.798	-.077
Diastolic BP						
Step 1: BL DBP	.734	.538	--	--	--	--
Step 2: FMI	.744	.553	.015	-.139	-1.302	-.122
HR						
Step 1: BL HR	.711	.506	--	--	--	--
Step 2: FMI	.712	.508	.001	-.100	-.353	-.038
SDNN						
Step 1: BL SDNN	.680	.462	--	--	--	--
Step 2: FMI	.680	.463	.001	.072	.250	.028
RMSSD						
Step 1: BL RMSSD	.643	.413	--	--	--	--
Step 2: FMI	.644	.415	.002	.096	.344	.040
HF(ms^2)						
Step 1: BL HF(ms^2)	.547	.299	--	--	--	--
Step 2: FMI	.547	.299	.000	-.654	-.054	-.007
ln HF(ms^2)						

Step 1: BL ln HF(ms^2)	.659	.434	--	--	--	--
Step 2: FMI	.662	.438	.004	.011	.542	.061
HF(nu)						
Step 1: BL HF(nu)	.445	.198	--	--	--	--
Step 2: FMI	.445	.198	.000	.002	.009	.001
LF(ms^2)						
Step 1: BL LF(ms^2)	.445	.198	--	--	--	--
Step 2: FMI	.447	.200	.002	7.125	.355	.048
LF(nu)						
Step 1: BL LF(nu)	.478	.228	--	--	--	--
Step 2: FMI	.478	.229	.001	.053	.196	.026
LF/HF						
Step 1: BL LF.HF	.298	.089	--	--	--	--
Step 2: FMI	.308	.095	.006	-.027	-.561	-.082
ln LF/HF						
Step 1: BL ln LF/HF	.427	.182	--	--	--	--
Step 2: FMI	.428	.183	.001	-.003	-.222	-.030

Note. BP = Blood pressure, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD=Root Mean Square of Successive Difference, HF=High frequency spectral power, LF=Low frequency spectral power, ms^2=milliseconds squared, nu=normalized units, ln = natural logarithm, LF/HF=Ratio of Low frequency to High frequency spectral powers.
All non-significant.

Table 11

Hierarchical Linear Regressions of Five Factor Mindfulness Questionnaire—Short Form (FFMQ-SF) Observing Subscale and Speech Task Cardiovascular Reactivity

Variable	R	R^2	ΔR^2	B	t	β
Systolic BP						
Step 1: BL SBP	.731	.534	--	--	--	--
Step 2: FFMQ-SF Observe	.784	.614	.080*	-1.171	-2.412	-.283
Diastolic BP						
Step 1: BL DBP	.441	.194	--	--	--	--
Step 2: FFMQ-SF Observe	.444	.197	.003	-.115	-.303	-.051
HR						
Step 1: BL HR	.676	.457	--	--	--	--
Step 2: FFMQ-SF Observe	.682	.465	.007	.437	.579	.087
SDNN						
Step 1: BL SDNN	.560	.314	--	--	--	--
Step 2: FFMQ-SF Observe	.569	.324	.010	-.686	-.593	-.100
RMSSD						
Step 1: BL RMSSD	.624	.389	--	--	--	--
Step 2: FFMQ-SF Observe	.661	.436	.048	-.980	-1.423	-.218
HF(ms^2)						
Step 1: BL HF(ms^2)	.339	.159	--	--	--	--
Step 2: FFMQ-SF Observe	.436	.190	.031	-38.880	-.959	-.177
ln HF(ms^2)						

Step 1: BL ln HF(ms^2)	.586	.343	--	--	--	--
Step 2: FFMQ-SF Observe	.595	.354	.011	-.032	-.630	-.104
HF(nu)						
Step 1: BL HF(nu)	.337	.113	--	--	--	--
Step 2: FFMQ-SF Observe	.338	.114	.000	-.076	-.114	-.023
LF(ms^2)						
Step 1: BL LF(ms^2)	.586	.344	--	--	--	--
Step 2: FFMQ-SF Observe	.607	.368	.024	-44.738	-.957	-.156
LF(nu)						
Step 1: BL LF(nu)	.224	.050	--	--	--	--
Step 2: FFMQ-SF Observe	.224	.050	.000	-.055	-.074	-.015
LF/HF						
Step 1: BL LF.HF	.210	.044	--	--	--	--
Step 2: FFMQ-SF Observe	.238	.056	.012	-.072	-.563	-.120
ln LF/HF						
Step 1: BL ln LF/HF	.318	.101	--	--	--	--
Step 2: FFMQ-SF Observe	.319	.102	.000	-.003	-.080	-.017

Note. BP = Blood pressure, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD=Root Mean Square of Successive Difference, HF=High frequency spectral power, LF=Low frequency spectral power, ms^2=milliseconds squared, nu=normalized units, ln = natural logarithm, LF/HF=Ratio of Low frequency to High frequency spectral powers.
$^*p < .05$.

Table 12

Hierarchical Linear Regressions of Five Factor Mindfulness Questionnaire—Short Form (FFMQ-SF) Observing Subscale and Mental Arithmetic Cardiovascular Reactivity

Variable	R	R^2	ΔR^2	B	t	β
Systolic BP						
Step 1: BL SBP	.726	.527	--	--	--	--
Step 2: FFMQ-SF Observe	.726	.527	.000	-.035	-.068	-.009
Diastolic BP						
Step 1: BL DBP	.734	.538	--	--	--	--
Step 2: FFMQ-SF Observe	.735	.541	.002	.099	.370	.047
HR						
Step 1: BL HR	.711	.506	--	--	--	--
Step 2: FFMQ-SF Observe	.729	.531	.025	.775	1.132	.159
SDNN						
Step 1: BL SDNN	.680	.462	--	--	--	--
Step 2: FFMQ-SF Observe	.734	.538	$.076^{+}$	-1.322	-1.990	-.276
RMSSD						
Step 1: BL RMSSD	.643	.413	--	--	--	--
Step 2: FFMQ-SF Observe	.712	.507	$.094^{*}$	-1.360	-2.139	-.307
HF(ms^2)						
Step 1: BL HF(ms^2)	.547	.299	--	--	--	--
Step 2: FFMQ-SF Observe	.672	.451	$.152^{*}$	-68.878	-2.578	-3.92
ln HF(ms^2)						

Step 1: BL ln HF(ms^2)	.659	.434	--	--	--	--
Step 2: FFMQ-SF Observe	.697	.485	.051	-.071	-1.546	-.228
HF(nu)						
Step 1: BL HF(nu)	.445	.198	--	--	--	--
Step 2: FFMQ-SF Observe	.473	.224	.026	-.604	-.896	-.168
LF(ms^2)						
Step 1: BL LF(ms^2)	.445	.189	--	--	--	--
Step 2: FFMQ-SF Observe	.564	.319	.121*	-94.592	-2.064	-.349
LF(nu)						
Step 1: BL LF(nu)	.478	.228	--	--	--	--
Step 2: FFMQ-SF Observe	.507	.257	.029	.660	.963	.177
LF/HF						
Step 1: BL LF.HF	.298	.089	--	--	--	--
Step 2: FFMQ-SF Observe	.299	.090	.001	.020	.159	.033
ln LF/HF						
Step 1: BL ln LF/HF	.427	.182	--	--	--	--
Step 2: FFMQ-SF Observe	.450	.202	.020	.027	.772	.149

Note. BP = Blood pressure, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD=Root Mean Square of Successive Difference, HF=High frequency spectral power, LF=Low frequency spectral power, ms^2=milliseconds squared, nu=normalized units, ln = natural logarithm, LF/HF=Ratio of Low frequency to High frequency spectral powers.
$^+p < .1$. $^*p < .05$.

Table 13

Hierarchical Linear Regressions of Five Factor Mindfulness Questionnaire—Short Form (FFMQ-SF) Describing Subscale and Speech Task Cardiovascular Reactivity

Variable	*R*	R^2	ΔR^2	*B*	*t*	*β*
Systolic BP						
Step 1: BL SBP	.731	.534	--	--	--	--
Step 2: FFMQ-SF Describe	.750	.563	.029	.658	1.367	.176
Diastolic BP						
Step 1: BL DBP	.441	.194	--	--	--	--
Step 2: FFMQ-SF Describe	.451	.203	.009	-.201	-.557	-.099
HR						
Step 1: BL HR	.676	.457	--	--	--	--
Step 2: FFMQ-SF Describe	.677	.458	.001	-.159	-.215	-.035
SDNN						
Step 1: BL SDNN	.560	.314	--	--	--	--
Step 2: FFMQ-SF Describe	.561	.314	.000	.153	.139	.025
RMSSD						
Step 1: BL RMSSD	.624	.389	--	--	--	--
Step 2: FFMQ-SF Describe	.638	.407	.018	.566	.853	.139
HF(ms^2)						
Step 1: BL HF(ms^2)	.399	.159	--	--	--	--
Step 2: FFMQ-SF Describe	.436	.190	.031	36.223	.959	.182
ln HF(ms^2)						

Step 1: BL ln HF(ms^2)	.586	.343	--	--	--	--
Step 2: FFMQ-SF Describe	.609	.370	.027	.047	1.018	.168
HF(nu)						
Step 1: BL HF(nu)	.337	.113	--	--	--	--
Step 2: FFMQ-SF Describe	.521	.271	.157*	1.194	2.277	.399
LF(ms^2)						
Step 1: BL LF(ms^2)	.586	.344	--	--	--	--
Step 2: FFMQ-SF Describe	.623	.388	.044	-58.356	-1.319	-.224
LF(nu)						
Step 1: BL LF(nu)	.224	.050	--	--	--	--
Step 2: FFMQ-SF Describe	.372	.138	.088	-.980	-1.568	-.299
LF/HF						
Step 1: BL LF.HF	.210	.044	--	--	--	--
Step 2: FFMQ-SF Describe	.481	.232	.188*	-.241	-2.422	-.441
ln LF/HF						
Step 1: BL ln LF/HF	.318	.101	--	--	--	--
Step 2: FFMQ-SF Describe	.534	.286	.184*	-.068	-2.489	-.434

Note. BP = Blood pressure, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD=Root Mean Square of Successive Difference, HF=High frequency spectral power, LF=Low frequency spectral power, ms^2=milliseconds squared, nu=normalized units, ln = natural logarithm, LF/HF=Ratio of Low frequency to High frequency spectral powers.
$^*p < .05$.

Table 14

Hierarchical Linear Regressions of Five Factor Mindfulness Questionnaire—Short Form (FFMQ-SF) Describing Subscale and Mental Arithmetic Cardiovascular Reactivity

Variable	*R*	R^2	ΔR^2	*B*	*t*	β
Systolic BP						
Step 1: BL SBP	.726	.527	--	--	--	--
Step 2: FFMQ-SF Describe	.767	.589	.061*	.906	2.044	.255
Diastolic BP						
Step 1: BL DBP	.734	.538	--	--	--	--
Step 2: FFMQ-SF Describe	.737	.543	.004	-.129	-.510	-.068
HR						
Step 1: BL HR	.711	.506	--	--	--	--
Step 2: FFMQ-SF Describe	.718	.515	.009	-.458	-.675	-.104
SDNN						
Step 1: BL SDNN	.680	.462	--	--	--	--
Step 2: FFMQ-SF Describe	.680	.462	.000	-.077	-.113	-.018
RMSSD						
Step 1: BL RMSSD	.643	.413	--	--	--	--
Step 2: FFMQ-SF Describe	.654	.428	.014	.501	.779	.125
HF(ms^2)						
Step 1: BL HF(ms^2)	.547	.299	--	--	--	--
Step 2: FFMQ-SF Describe	.555	.308	.008	15.009	.536	.094
ln HF(ms^2)						

Step 1: BL ln HF(ms^2)	.659	.434	--	--	--	--
Step 2: FFMQ-SF Describe	.700	.490	.056	.068	1.623	.240
HF(nu)						
Step 1: BL HF(nu)	.445	.198	--	--	--	--
Step 2: FFMQ-SF Describe	.590	.348	.150*	1.267	2.353	.390
LF(ms^2)						
Step 1: BL LF(ms^2)	.445	.198	--	--	--	--
Step 2: FFMQ-SF Describe	.459	.210	.013	-29.359	-.618	-.119
LF(nu)						
Step 1: BL LF(nu)	.478	.228	--	--	--	--
Step 2: FFMQ-SF Describe	.618	.382	.154*	-1.332	-2.442	-.394
LF/HF						
Step 1: BL LF.HF	.298	.089	--	--	--	--
Step 2: FFMQ-SF Describe	.540	.291	.203*	-.250	-2.618	-.458
ln LF/HF						
Step 1: BL ln LF/HF	.427	.182	--	--	--	--
Step 2: FFMQ-SF Describe	.612	.374	.192*	-.072	-2.713	-.443

Note. BP = Blood pressure, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD=Root Mean Square of Successive Difference, HF=High frequency spectral power, LF=Low frequency spectral power, ms^2=milliseconds squared, nu=normalized units, ln = natural logarithm, LF/HF=Ratio of Low frequency to High frequency spectral powers.
$^*p < .05$.

Table 15

Hierarchical Linear Regressions of Five Factor Mindfulness Questionnaire—Short Form (FFMQ-SF) Nonjudging Subscale and Speech Task Cardiovascular Reactivity

Variable	*R*	R^2	ΔR^2	*B*	*t*	*β*
Systolic BP						
Step 1: BL SBP	.731	.534	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.731	.534	.000	-.050	-.088	-.011
Diastolic BP						
Step 1: BL DBP	.441	.194	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.508	.258	.064	.612	1.556	.258
HR						
Step 1: BL HR	.676	.457	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.684	.468	.011	.561	.704	.105
SDNN						
Step 1: BL SDNN	.560	.314	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.571	.326	.013	-.828	-.674	-.114
RMSSD						
Step 1: BL RMSSD	.624	.389	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.624	.389	.000	.035	.046	.007
HF(ms^2)						
Step 1: BL HF(ms^2)	.399	.159	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.401	.161	.002	-10.433	-.240	-.045
ln HF(ms^2)						

Step 1: BL ln HF(ms^2)	.462	.213	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.470	.220	.007	17.036	.469	.087
HF(nu)						
Step 1: BL HF(nu)	.337	.113	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.376	.141	.028	-.584	-.882	-.167
LF(ms^2)						
Step 1: BL LF(ms^2)	.586	.344	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.588	.346	.002	14.006	.275	.046
LF(nu)						
Step 1: BL LF(nu)	.224	.050	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.225	.051	.001	.096	.126	.025
LF/HF						
Step 1: BL LF.HF	.210	.044	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.297	.088	.044	.134	1.075	.210
ln LF/HF						
Step 1: BL ln LF/HF	.318	.101	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.354	.125	.024	-.024	-.808	-.155

Note. BP = Blood pressure, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD=Root Mean Square of Successive Difference, HF=High frequency spectral power, LF=Low frequency spectral power, ms^2=milliseconds squared, nu=normalized units, ln = natural logarithm, LF/HF=Ratio of Low frequency to High frequency spectral powers.
All non-significant.

Table 16

Hierarchical Linear Regressions of Five Factor Mindfulness Questionnaire—Short Form (FFMQ-SF) Nonjudging Subscale and Mental Arithmetic Cardiovascular Reactivity

Variable	*R*	R^2	ΔR^2	*B*	*t*	*β*
Systolic BP						
Step 1: BL SBP	.726	.527	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.728	.529	.002	-.190	-.353	-.046
Diastolic BP						
Step 1: BL DBP	.734	.538	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.734	.538	.000	-.003	-.011	-.001
HR						
Step 1: BL HR	.711	.506	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.733	.537	.031	.911	1.264	.177
SDNN						
Step 1: BL SDNN	.680	.462	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.696	.485	.023	-.768	-1.028	-.152
RMSSD						
Step 1: BL RMSSD	.643	.413	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.652	.426	.013	-.531	-.726	-.113
HF(ms^2)						
Step 1: BL HF(ms^2)	.547	.299	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.565	.320	.020	-26.531	-.845	-.143
ln HF(ms^2)						

Step 1: BL ln HF(ms^2)	.659	.434	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.660	.435	.001	-.011	-.245	-.038
HF(nu)						
Step 1: BL HF(nu)	.445	.198	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.498	.248	.050	-.854	-1.268	-.225
LF(ms^2)						
Step 1: BL LF(ms^2)	.445	.198	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.449	.201	.004	17.343	.327	.060
LF(nu)						
Step 1: BL LF(nu)	.478	.228	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.526	.277	.049	.874	1.273	.222
LF/HF						
Step 1: BL LF.HF	.298	.089	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.462	.213	.125$^+$	.225	1.952	.354
ln LF/HF						
Step 1: BL ln LF/HF	.427	.182	--	--	--	--
Step 2: FFMQ-SF Nonjudge	.432	.187	.004	-.011	-.364	-.067

Note. BP = Blood pressure, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD=Root Mean Square of Successive Difference, HF=High frequency spectral power, LF=Low frequency spectral power, ms^2=milliseconds squared, nu=normalized units, ln = natural logarithm, LF/HF=Ratio of Low frequency to High frequency spectral powers.
$^+p < .1$.

Table 17

Hierarchical Linear Regressions of Five Factor Mindfulness Questionnaire—Short Form (FFMQ-SF) Nonreacting Subscale and Speech Task Cardiovascular Reactivity

Variable	*R*	R^2	ΔR^2	*B*	*t*	β
Systolic BP						
Step 1: BL SBP	.731	.534	--	--	--	--
Step 2: FFMQ-SF Nonreact	.740	.548	.014	-.447	-.933	-.120
Diastolic BP						
Step 1: BL DBP	.441	.194	--	--	--	--
Step 2: FFMQ-SF Nonreact	.442	.196	.001	-.078	-.227	-.039
HR						
Step 1: BL HR	.676	.457	--	--	--	--
Step 2: FFMQ-SF Nonreact	.702	.493	.036	.876	1.310	.194
SDNN						
Step 1: BL SDNN	.560	.314	--	--	--	--
Step 2: FFMQ-SF Nonreact	.561	.315	.001	-.225	-.207	-.036
RMSSD						
Step 1: BL RMSSD	.624	.389	--	--	--	--
Step 2: FFMQ-SF Nonreact	.624	.389	.000	-.058	-.088	-.014
HF(ms^2)						
Step 1: BL HF(ms^2)	.399	.159	--	--	--	--
Step 2: FFMQ-SF Nonreact	.403	.163	.003	12.020	.310	.061
ln HF(ms^2)						

Step 1: BL ln HF(ms^2)	.586	.343	--	--	--	--
Step 2: FFMQ-SF Nonreact	.589	.346	.003	-.016	-.344	-.058
HF(nu)						
Step 1: BL HF(nu)	.337	.113	--	--	--	--
Step 2: FFMQ-SF Nonreact	.355	.126	.013	.337	.591	.114
LF(ms^2)						
Step 1: BL LF(ms^2)	.586	.344	--	--	--	--
Step 2: FFMQ-SF Nonreact	.589	.347	.003	-15.066	-.347	-.058
LF(nu)						
Step 1: BL LF(nu)	.224	.050	--	--	--	--
Step 2: FFMQ-SF Nonreact	.299	.089	.039	.650	1.017	.200
LF/HF						
Step 1: BL LF.HF	.210	.044	--	--	--	--
Step 2: FFMQ-SF Nonreact	.293	.086	.042	-.111	-1.046	-.204
ln LF/HF						
Step 1: BL ln LF/HF	.318	.101	--	--	--	--
Step 2: FFMQ-SF Nonreact	.354	.125	.024	-.024	-.808	-.155

Note. BP = Blood pressure, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD=Root Mean Square of Successive Difference, HF=High frequency spectral power, LF=Low frequency spectral power, ms^2=milliseconds squared, nu=normalized units, ln = natural logarithm, LF/HF=Ratio of Low frequency to High frequency spectral powers.
All non-significant.

Table 18

Hierarchical Linear Regressions of Five Factor Mindfulness Questionnaire—Short Form (FFMQ-SF) Nonreacting Subscale and Mental Arithmetic Cardiovascular Reactivity

Variable	R	R^2	ΔR^2	B	t	β
Systolic BP						
Step 1: BL SBP	.726	.527	--	--	--	--
Step 2: FFMQ-SF Nonreact	.726	.527	.000	.014	.031	.004
Diastolic BP						
Step 1: BL DBP	.734	.538	--	--	--	--
Step 2: FFMQ-SF Nonreact	.735	.541	.002	-.090	-.375	-.048
HR						
Step 1: BL HR	.711	.506	--	--	--	--
Step 2: FFMQ-SF Nonreact	.729	.531	.025	.708	1.136	.162
SDNN						
Step 1: BL SDNN	.680	.462	--	--	--	--
Step 2: FFMQ-SF Nonreact	.681	.463	.001	-.153	-.230	-.036
RMSSD						
Step 1: BL RMSSD	.643	.413	--	--	--	--
Step 2: FFMQ-SF Nonreact	.643	.414	.001	-.110	-.174	-.028
HF(ms^2)						
Step 1: BL HF(ms^2)	.547	.299	--	--	--	--
Step 2: FFMQ-SF Nonreact	.549	.302	.003	-8.438	-.298	-.054
ln HF(ms^2)						

Step 1: BL ln HF(ms^2)	.659	.434	--	--	--	--
Step 2: FFMQ-SF Nonreact	.660	.435	.001	-.011	-.245	-.038
HF(nu)						
Step 1: BL HF(nu)	.445	.198	--	--	--	--
Step 2: FFMQ-SF Nonreact	.445	.198	.000	.014	.024	.004
LF(ms^2)						
Step 1: BL LF(ms^2)	.445	.198	--	--	--	--
Step 2: FFMQ-SF Nonreact	.451	.203	.005	18.148	.400	.074
LF(nu)						
Step 1: BL LF(nu)	.478	.228	--	--	--	--
Step 2: FFMQ-SF Nonreact	.478	.228	.000	-.001	-.001	.000
LF/HF						
Step 1: BL LF.HF	.298	.089	--	--	--	--
Step 2: FFMQ-SF Nonreact	.345	.119	.030	-.094	-.908	-.174
ln LF/HF						
Step 1: BL ln LF/HF	.427	.182	--	--	--	--
Step 2: FFMQ-SF Nonreact	.432	.187	.004	-.011	-.364	-.067

Note. BP = Blood pressure, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HR = Heart rate, SDNN = Standard Deviation of the R to R Intervals, RMSSD=Root Mean Square of Successive Difference, HF=High frequency spectral power, LF=Low frequency spectral power, ms^2=milliseconds squared, nu=normalized units, ln = natural logarithm, LF/HF=Ratio of Low frequency to High frequency spectral powers.
All non-significant.

Figures

Figure 1

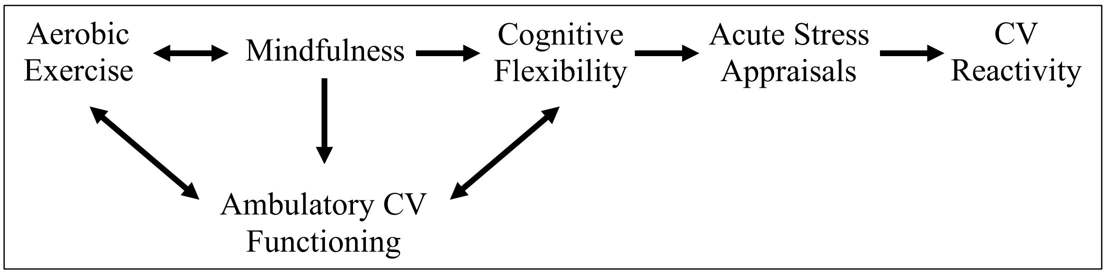


Figure 1. Chart representing the integration of exercise, stress, and mindfulness and the contributions of each variable on cardiovascular functioning. CV = Cardiovascular.

Appendices

Appendix A: Student Athlete Flyer

The CHAMPS Study   Student Athlete Participation Information

This research study is examining the prevention of cardiovascular disease with exercise and psychological health. We are looking for healthy participants, age 18 or older, who engage in aerobic exercise year round. Aerobic exercise examples include cross-country, track, cycling, and swimming. If you have exercised at least 46 weeks out of the last year and missed no more than 2 back-to-back weeks, you may qualify to be part of this study. Your aerobic exercise met a minimum intensity of 150 minutes per week of moderate intensity, or 75 minutes per week of vigorous intensity, or a combination of the 2 previous options. The duration of the aerobic exercise is sustained for at least 10 minutes, too. In addition, participants who qualify for the study must be individuals who do not regularly practice seated meditation or moving meditation (for example, yoga, Tai Chi, Qigong).

Exclusionary criteria* for medical and psychiatric conditions are the following:
-A family history of heart attack or stroke prior to age 50
-Any implanted medical device
-Medical or psychiatric conditions that could affect cardiovascular functioning (high blood pressure, heart attack, stroke, chest pain, irregular heartbeat, cardiovascular problems, asthma, diabetes, kidney disease, psychiatric disorders)
-Medications that could affect cardiovascular functioning (stimulants, steroids, anti-inflammatory medications, blood pressure medications, anti-depressants, anti-anxiety, mood stabilizers, or other psychiatric medications)
-Current over the counter medications for cold, flu, pain, or allergy
-Pregnant or breast-feeding
***Please do not consume alcohol or caffeine within the 12 hours or tobacco within the 4 hours prior to study participation; if not followed, participants will be excluded.**

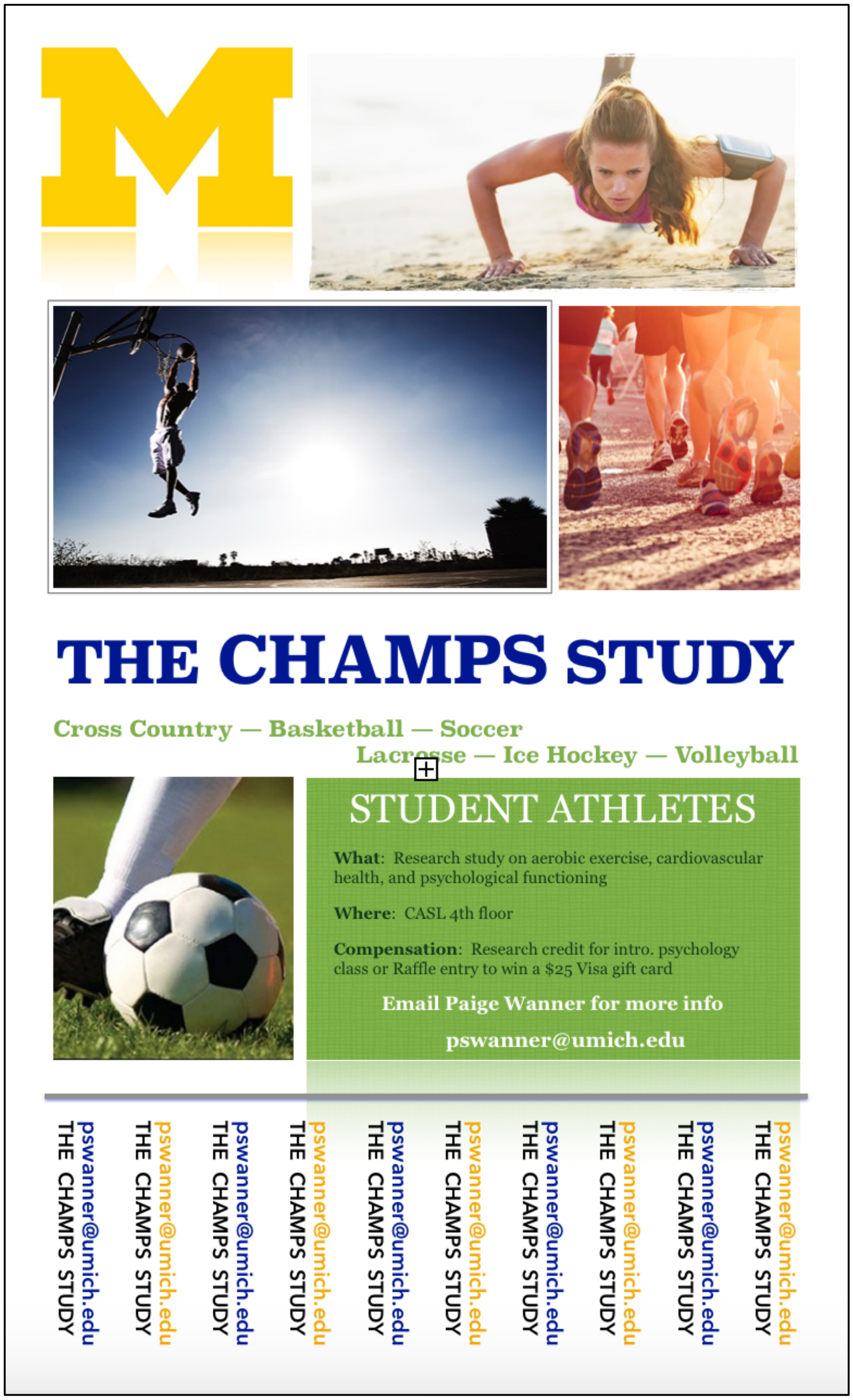
Participation will last about 80 minutes, which will involve a consent form; a demographics and screening questionnaire, which includes medical and behavioral questions that can affect the study, and several questionnaires about emotional and cognitive functioning. In addition, the study will involve taking your blood pressure and heart functioning. Blood pressure will be monitored using a non-invasive blood pressure arm cuff, similar to what you would experience at a physician's office. Heart functioning will be assessed with a non-invasive electrocardiogram via three electrodes on the front of your torso. No voltage is applied to these electrodes. The researchers will demonstrate how and where to place electrodes on your own skin, so that you personally can do it in privacy. (Only your shirt is necessary for removal; for females, please wear a bathing suit top). To protect equipment, you will be asked to redress in a medical gown; however, additional clothing (i.e., a large medical sheet or a long sleeve button down shirt) will be provided or your clothing can be worn for modesty. We will also ask you to discuss your career aspirations and solve some math problems.

You will receive compensation for participation by selecting one of two options. *Option 1*: You will be entered into a drawing to win a $25.00 Visa gift card which will be awarded to one out of every 10 participants; raffle entry is provided if you complete the entire study or if you are only able to complete the demographics questionnaire. *Option 2*: You will receive 1.5 credits toward your research requirement in your Introductory Psychology class if you complete the entire study or 0.5 credits if you are able to only complete the demographics questionnaire. You may choose not to serve as a research subject at no expense to your academic or athletic record or standing. You may withdraw at any time from the study without penalty as participation is voluntary. If you are interested in participating in the study or if you have any questions regarding the study, please contact Paige Wanner, the principal investigator, at **pswanner@umich.edu** for questions or to schedule a time for participation.

Thank you very much for participating in The CHAMPS Study! I look forward to hearing from you.

– Paige Wanner
Clinical Health Psychology
Behavioral Sciences

Appendix B: Student Athlete Advertisement



Note: Original formatting for advertisement is a legal size document.

Appendix C: Demographics and Exercise Screening Questionnaire

IDENTIFICATION CODE # _______________________

Preliminary Questions

A. Have you had any food or drink with caffeine or alcohol in the last 12 hours?
YES____ NO____

B. Have you had any tobacco products in the last 3 hours?
YES____ NO____

If you answered YES to either of the above questions, please STOP and return the questionnaire to the researcher

---

1. Age: ________

2. Gender:
____ Male
____ Female
____ Other: ___________.

3. Religion:
____ Atheism
____ Agnosticism
____ Buddhism
____ Christianity
____ Hinduism
____ Islam
____ Judaism
____ Other: ________________.

4. Are you <u>currently</u> taking any of the following types of medications?

Stimulants (for example, Ritalin, Concerta)
Steroids (for example, prednisone, asthma medications)
Anti-inflammatory medications (for example, NSAIDs, Motrin/ibuprofen)
Blood pressure medications
Anti-depressants
Anti-anxiety medications
Mood stabilizers
Other psychiatric medications
YES___ NO___

5. Within the past week, have you used/are you using any over-the-counter medications for cold, flu, allergy, or pain?
YES___ NO___

6. Have you ever been told that you have high blood pressure by a medical provider?
YES___ NO___

7. Do you have, or have had, any of the following medical disorders?

Heart Attack
Chest Pain
Irregular Heart Beat
Stroke
Cardiovascular Problems
Asthma
Diabetes
Kidney Disease
Current Diagnosis of a Psychiatric Disorder such as depression or anxiety
YES___ NO___

8. Have you ever been diagnosed with migraine headaches?
YES___ NO___

9. Are you pregnant or breast feeding?
YES___ NO___

10. Do you have a family history of heart attack or stroke prior to age 50?
YES___ NO___

11. Do you have any other chronic illnesses?
YES___ NO___

12. Do you smoke?
YES___ NO___

13. If you smoke cigarettes, on average, how many cigarettes do you smoke per day?
Amount: __________

14. If you smoke something other than cigarettes (for example, cigars, flavored tobacco), on average, how much do you smoke per day?
Amount: __________

15. Do you regularly practice seated meditation?
YES____ NO____

16. Do you regularly practice moving meditation (for example, yoga, Tai Chi, Qigong)?
YES____ NO____

17. Is meditation a regular part of your spiritual practice?
YES____ NO____

EXERCISE SCREENING QUESTIONNAIRE

1. Do you engage in any type of physical exercise?
YES____ NO____
If no, please continue to Question #2. If yes, please move to Question #3.

2. Because you answered "no" to Question #1, over the last year did you engage in any regular exercise? If you do engage in any type of exercise, it occurs less than 4 of the 52 weeks per year and has not occurred within the last 8 weeks. Activity examples are cardiorespiratory/aerobic exercise (for example, running, cycling, swimming) and strength training (for example, weight lifting, Pilates).
YES____ NO____
If yes, please skip Questions #3–8 and return the form to the researcher.

3. Because you answered "yes" to Question #1, do you engage in a cardiorespiratory/aerobic exercise activity at least 46 weeks out of the year with no more than 2 back-to-back weeks missed? Activity examples of cardiorespiratory/aerobic exercise are cross-country, track, cycling, and swimming.
YES____ NO____

4. Does your cardiorespiratory/aerobic exercise activity meet a minimum intensity of 150 minutes per week of moderate intensity, or 75 minutes per week of vigorous intensity, or a combination of the two previous options? Duration of the activity must be sustained for at least 10 minutes. *(150 minutes = 2 hours 30 minutes = 30 minutes at 5 days/week; 75 minutes = 1 hour 15 minutes = 45 minutes at 2 days/week).*
YES____ NO____

---

5. What is your primary form of cardiorespiratory/aerobic exercise? ______________________.

6. How often in minutes have you engaged in this activity in the past 7 days? _______________.

7. How many days have you engaged in this activity in the past 7 days? ___________________.

8. How many days have you engaged in this activity in the past 4 weeks? _________________.

To be filled out by researcher:

1. Height: __________in. 2. Weight: __________lbs.

Appendix D: SAM—Speech Task

This questionnaire is concerned with your thoughts about the speech task (i.e., your presentation) that you are about to engage in. There are no right or wrong answers. Please respond according to how you view this situation right NOW. Please answer ALL questions.

Answer by CIRCLING the appropriate number corresponding to the following scale.

		Not At All	Slightly	Moderately	Considerably	Extremely
1.	Does this situation create tension in me?	1	2	3	4	5
2.	Does this situation make me feel anxious?	1	2	3	4	5
3.	Does this situation have important consequences for me?	1	2	3	4	5
4.	Is this going to have a positive impact on me?	1	2	3	4	5
5.	How eager am I to tackle this problem?	1	2	3	4	5
6.	How much will I be affected by the outcomes of this situation?	1	2	3	4	5
7.	To what extent can I become a stronger person because of this problem?	1	2	3	4	5
8.	Will the outcome of this situation be negative?	1	2	3	4	5
9.	Do I have the ability to do well in this situation?	1	2	3	4	5
10.	Does this situation have serious implications for me?	1	2	3	4	5

		Not At All	Slightly	Moderately	Considerably	Extremely
11.	Do I have what it takes to do well in this situation?	1	2	3	4	5
12.	Does this situation tax or exceed my coping resources?	1	2	3	4	5
13.	To what extent am I excited thinking about the outcome of this situation?	1	2	3	4	5
14.	How threatening is this situation?	1	2	3	4	5
15.	Will I be able to overcome the problem?	1	2	3	4	5
16.	To what extent do I perceive this situation as stressful?	1	2	3	4	5
17.	Do I have the skills necessary to achieve a successful outcome to this situation?	1	2	3	4	5
18.	To what extent does this event require coping efforts on my part?	1	2	3	4	5
19.	Does this situation have long-term consequences for me?	1	2	3	4	5
20.	Is this going to have a negative impact on me?	1	2	3	4	5

Appendix E: SAM—Math Task

This questionnaire is concerned with your thoughts about the math task that you are about to engage in. There are no right or wrong answers. Please respond according to how you view this situation right NOW. Please answer ALL questions.

Answer by CIRCLING the appropriate number corresponding to the following scale.

		Not At All	Slightly	Moderately	Considerably	Extremely
1.	Does this situation create tension in me?	1	2	3	4	5
2.	Does this situation make me feel anxious?	1	2	3	4	5
3.	Does this situation have important consequences for me?	1	2	3	4	5
4.	Is this going to have a positive impact on me?	1	2	3	4	5
5.	How eager am I to tackle this problem?	1	2	3	4	5
6.	How much will I be affected by the outcomes of this situation?	1	2	3	4	5
7.	To what extent can I become a stronger person because of this problem?	1	2	3	4	5
8.	Will the outcome of this situation be negative?	1	2	3	4	5
9.	Do I have the ability to do well in this situation?	1	2	3	4	5
10.	Does this situation have serious implications for me?	1	2	3	4	5

		Not At All	Slightly	Moderately	Considerably	Extremely
11.	Do I have what it takes to do well in this situation?	1	2	3	4	5
12.	Does this situation tax or exceed my coping resources?	1	2	3	4	5
13.	To what extent am I excited thinking about the outcome of this situation?	1	2	3	4	5
14.	How threatening is this situation?	1	2	3	4	5
15.	Will I be able to overcome the problem?	1	2	3	4	5
16.	To what extent do I perceive this situation as stressful?	1	2	3	4	5
17.	Do I have the skills necessary to achieve a successful outcome to this situation?	1	2	3	4	5
18.	To what extent does this event require coping efforts on my part?	1	2	3	4	5
19.	Does this situation have long-term consequences for me?	1	2	3	4	5
20.	Is this going to have a negative impact on me?	1	2	3	4	5

Appendix F: MAAS

Below is a collection of statements about your everyday experience. Using the 1-6 scale below, please indicate how frequently or infrequently you currently have each experience. Please answer according to what really reflects your experience rather that what you think your experiences should be.

Answer by CIRCLING the appropriate number corresponding to the following scale.

		Almost Always	Very Frequently	Somewhat Frequently	Somewhat Infrequently	Very Infrequently	Almost Never
1.	I could be experiencing some emotion and not be conscious of it until some time later.	1	2	3	4	5	6
2.	I break or spill things because of carelessness, not paying attention, or thinking of something else.	1	2	3	4	5	6
3.	I find it difficult to stay focused on what's happening in the present moment.	1	2	3	4	5	6
4.	I tend to walk quickly to get to where I'm going without paying attention to what I experience along the way.	1	2	3	4	5	6
5.	I tend not to notice feelings of physical tension or discomfort until they really grab my attention.	1	2	3	4	5	6

		Almost Always	Very Frequently	Somewhat Frequently	Somewhat Infrequently	Very Infrequently	Almost Never
6.	I forget a person's name almost as soon as I've been told it for the first time.	1	2	3	4	5	6
7.	It seems I am "running on automatic" without much awareness of what I'm doing.	1	2	3	4	5	6
8.	I rush through activities without really being attentive to them.	1	2	3	4	5	6
9.	I get so focused on the goal I want to achieve that I lose touch with what I am doing right now to get there.	1	2	3	4	5	6
10.	I do jobs or tasks automatically, without being aware of what I'm doing.	1	2	3	4	5	6
11.	I find myself listening to someone with one ear, doing something else at the same time.	1	2	3	4	5	6
12.	I drive places on "automatic pilot" and then wonder why I went there.	1	2	3	4	5	6
13.	I find myself preoccupied with the future or the past.	1	2	3	4	5	6
14.	I find myself doing things without paying attention.	1	2	3	4	5	6
15.	I snack without being aware that I'm eating.	1	2	3	4	5	6

Appendix G: FMI

Below are a collection of statements about your experience over the last 30 days. Provide an answer for every statement as best as you can. Please answer as honestly and spontaneously as possible. There are neither "right" nor "wrong" answers, nor "good" or "bad" responses. What is important to us is your own personal experience.

Answer by CIRCLING the appropriate number corresponding to the following scale.

		Rarely	Occasionally	Fairly Often	Almost Always
1.	I am open to the experience of the present moment.	1	2	3	4
2.	I sense my body, whether eating, cooking, cleaning, or talking.	1	2	3	4
3.	When I notice an absence of mind, I gently return to the experience of the here and now.	1	2	3	4
4.	I am able to appreciate myself.	1	2	3	4
5.	I pay attention to what's behind my actions.	1	2	3	4
6.	I see my mistakes and difficulties without judging them.	1	2	3	4
7.	I feel connected to my experience in the here-and-now.	1	2	3	4
8.	I accept unpleasant experiences.	1	2	3	4
9.	I am friendly to myself when things go wrong.	1	2	3	4

		Rarely	Occasionally	Fairly Often	Almost Always
10.	I watch my feelings without getting lost in them.	1	2	3	4
11.	In difficult situations, I can pause without immediately reacting.	1	2	3	4
12.	I experience moments of inner peace and ease, even when things get hectic and stressful.	1	2	3	4
13.	I am impatient with myself and with others.	1	2	3	4
14.	I am able to smile when I notice how I sometimes make life difficult.	1	2	3	4

Appendix H: FFMQ-SF

The questions in this scale ask you about your everyday feelings and thoughts. Using the 1-5 scale below, please indicate how frequently or infrequently you currently have each experience Please answer according to what really reflects your experience rather that what you think your experiences should be.

CIRCE the appropriate number corresponding to the following scale.

		Never or Rarely True	Not Often True	Sometimes True and Sometimes Not True	Often True	Very Often or Always True
1.	I'm good at finding words to describe my feelings.	1	2	3	4	5
2.	I can easily put my beliefs, opinions, and expectations into words.	1	2	3	4	5
3.	I watch my feelings without getting carried away by them.	1	2	3	4	5
4.	I tell myself I shouldn't be feeling the way I'm feeling.	1	2	3	4	5
5.	It's hard for me to find the words to describe what I'm thinking.	1	2	3	4	5
6.	I pay attention to physical experiences, such as the wind in my hair or sun on my face.	1	2	3	4	5
7.	I make judgments about whether my thoughts are good or bad.	1	2	3	4	5
8.	No item *MAAS 3*	-	-	-	-	-

		Never or Rarely True	Not Often True	Sometimes True and Sometimes Not True	Often True	Very Often or Always True
9.	When I have distressing thoughts or images, I don't let myself be carried away by them.	1	2	3	4	5
10.	Generally, I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing.	1	2	3	4	5
11.	When I feel something in by body, it's hard for me to find the right words to describe it.	1	2	3	4	5
12.	No item *MAAS 7*	-	-	-	-	-
13.	When I have distressing thoughts or images, I feel calm soon after.	1	2	3	4	5
14.	I tell myself I shouldn't be feeling the way I'm feeling.	1	2	3	4	5
15.	I notice the smells and aromas of things.	1	2	3	4	5
16.	Even when I'm feeling terribly upset, I can find a way to put it into words.	1	2	3	4	5
17.	No item *MAAS 8*	-	-	-	-	-
18.	Usually when I have distressing thoughts or images, I can just notice them without reacting.	1	2	3	4	5
19.	I think some of my emotions are bad or inappropriate, and I shouldn't feel them.	1	2	3	4	5

		Never or Rarely True	Not Often True	Sometimes True and Sometimes Not True	Often True	Very Often or Always True
20.	I notice visual elements in art or nature, such as colors, shapes, textures, or patterns of light and shadow.	1	2	3	4	5
21.	When I have distressing thoughts or images, I just notice them and let them go.	1	2	3	4	5
22.	No item *MAAS 10*	-	-	-	-	-
23.	No item *MAAS 14*	-	-	-	-	-
24.	I disapprove of myself when I have illogical ideas.	1	2	3	4	5

Appendix I: PSS

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, please indicate with a CHECK how often you felt or thought a certain way.

1. In the last month, how often have you been upset because of something that happened unexpectedly?
   0=never ___ 1=almost never __2=sometimes ___3=fairly often ___ 4=very often

2. In the last month, how often have you felt that you were unable to control the important things in your life?
   0=never ___ 1=almost never __2=sometimes ___3=fairly often ___ 4=very often

3. In the last month, how often have you felt nervous and "stressed"?
   0=never ___ 1=almost never __2=sometimes ___3=fairly often ___ 4=very often

4. In the last month, how often have you felt confident about your ability to handle your personal problems?
   0=never ___ 1=almost never __2=sometimes ___3=fairly often ___ 4=very often

5. In the last month, how often have you felt that things were going your way?
   0=never ___ 1=almost never __2=sometimes ___3=fairly often ___ 4=very often

6. In the last month, how often have you found that you could not cope with all the things that you had to do?
   0=never ___ 1=almost never __2=sometimes ___3=fairly often ___ 4=very often

7. In the last month, how often have you been able to control irritations in your life?
   0=never ___ 1=almost never __2=sometimes ___3=fairly often ___ 4=very often

8. In the last month, how often have you felt that you were on top of things?
   0=never ___ 1=almost never __2=sometimes ___3=fairly often ___ 4=very often

9. In the last month, how often have you been angered because of things that were outside of your control?
   0=never ___ 1=almost never __2=sometimes ___3=fairly often ___ 4=very often

10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?
    0=never ___ 1=almost never __2=sometimes ___3=fairly often ___ 4=very often

Appendix J: Debriefing Form

University of Michigan – Dearborn
POST PARTICIPATION INFORMATION

Thank you for your participation in this research project. This sheet is provided to inform you that no video recording actually occurred during your participation and that your performance will not be analyzed at a later date. The deception was important to the study protocol. Research shows that this type of deception increases your cardiovascular reactivity to the stress tasks, which helps to provide clearer data for our analyses. We ask that you do not discuss the study protocol with anyone. By not discussing the protocol with anyone, you are able to help this research project look for ways to help people with heart disease. As a reminder that should your participation in this project lead to a desire to seek additional services, you may contact any of the agencies listed below.

- UM-D Counseling and Support Services (UM-D students only)
    - 313-593-5430
- Henry Ford Medical Center- Fairlane for Students, Faculty and Staff (UM-D students only)
    - 313-982-8495

Please feel free to contact either of these agencies, and once again thank you for your participation.