10-23-2018 1:30 PM

Cardiodynamic Associations With Resilience in Undergraduate Students and the Effect of a Mentorship Intervention

Rachel J. Knetsch, *The University of Western Ontario*

Supervisor: Shoemaker, J. Kevin, *The University of Western Ontario*
A thesis submitted in partial fulfillment of the requirements for the Master of Science degree in Kinesiology

Abstract

The National College Health Assessment (NCHA) indicates that a majority of Canadian university students report feeling overwhelmed, stressed, and anxious during their undergraduate studies. Resilience refers to positive adaptation, or the ability to maintain or regain mental health, despite experiencing adversity (Herrman et al., 2011). While autonomic indices have been used to describe chronic physiological stress, the role of heart rate variability (HRV) as an index of resilience remains unclear. This research tested the hypotheses that (1) there is a relationship between HRV and resilience scores and (2) a mentorship intervention will improve HRV and resilience outcomes. Fifty-seven first year students participated in a full year Kinesiology course (4444E/3333Y) and were paired with upper year mentors, alongside twelve controls. Twice during the academic year, sleeping HRV was measured using Firstbeat Bodyguard 2 device and resilience and other indices of mental health were assessed using online questionnaires. Regression analysis established the relationship between HRV and resilience scores at baseline ($r=0.30$, $p<0.05$). Neither HRV nor resilience scores improved as a result of the mentorship intervention. In conclusion, there exists a modest relationship between HRV and resilience, neither of which are improved by a mentorship intervention.

.

Keywords

Heart rate variability, RMSSD, mental health, undergraduate students, resilience, mentorship

Acknowledgments

To Dr. Kevin Shoemaker. Your dedication, kindness, and passion for research are inspiring. I cannot thank you enough for stepping outside of the box and allowing me the opportunity to work on this project. Your genuine care for the growth and success of all of your students does not go unnoticed. I am truly grateful for the guidance and support you have provided me over the past two years and cannot imagine having worked alongside anyone else.

Alan Salmoni. You are the heart of Smart, Healthy Campus. Your devotion to changing student lives at Western changed my undergraduate experience and that of countless other students. Thank you for your mentorship and compassion.

Harry Prapavessis. Thank you for your time and contributions to the dissertation, it would not have come together as it did without your expertise.

My lab mates. Thank you for making the time we spent in lab together so wonderful. You are all magnificent scientists and people and I am proud to have worked alongside you in the NVRL. Steve, this dissertation would not have happened without your mentorship and assistance every step of the way. I cannot thank you enough and I cannot wait to see where your unparalleled work ethic takes you. Baraa, your words of encouragement and unwavering support helped me through many stressful days. I admire your resilience and I am so thankful for you.

My family. Mom, dad, Beth, Natasha, and Todd thank you for your endless love, support, and patience throughout this entire experience. Thank you for providing me with the foundation to be successful in any endeavor, for the consistent encouragement, and mostly for your acceptance of my being "very busy" for the past two years. It has been a long ride and I owe this accomplishment to you.

In writing this I have found myself overwhelmed in trying to fully express my gratitude to everyone who has played a role in the completion of this dissertation. I am truly grateful to all who have joined me on this journey and I dedicate this to you.

Table of Contents

List of Tables

List of Figures

List of Appendices

Chapter 1

1 Introduction

The 2017 National College Health Assessment (NCHA) indicates that during the 2016 period, 86.9% of Canadian university students reported feeling ‘overwhelmed by all (they) had to do’, 61.4% reported feeling ‘overwhelming anxiety’, and 33.5% reported stress as having a negative impact on academic performance (American College Health Association, 2018). In 2017, 40.1% of students reports feeling “so depressed it was difficult to function”, yet only 17.9% reported having received formal diagnosis or psychological treatment for depression. These statistics highlight the imbalance between resources accessed by students and those required. This is likely due to many factors including a lack of both help-seeking and resource availability. Of particular concern within student mental health is the knowledge that transition periods in life present the highest risk for mental ill-health and general struggle. The NCHA also indicates that 64.4% of students reported feeling lonely (American College Health Association, 2018). Against these barriers of access, resource availability and emotional “connectedness”, enhancing student resilience to the stressors of university life must become a fundamental strategic priority for Universities.

The Smart, Healthy Campus initiative aimed to study the relationship between lifestyle factors such as physical activity and socialization of undergraduate students at Western University and their mental health outcomes. A mentorship model was introduced connecting first year protégés with upper year mentors, establishing a relationship focused on the promotion of physical activity and mental well-being, as well as assistance in navigating the novel environment of an academic campus and the transition to university life. Perhaps the socialization aspect of being paired with a mentor a group of students in similar scenarios alone may assist in the first-year experience and overall wellbeing.

Mental health is associated with many positive physiological metrics of overall health outcomes. One of these metrics is heart rate variability. Heart rate variability (HRV) is the change in time intervals between adjacent heart beats and is an index of cardiovagal function. A high value demonstrates the inherent flexibility and adaptability or resilience that characterizes healthy function and well-being, while low HRV has been related to existing pathologies and identified as and a predictor of future health problems (Shaffer, McCraty, & Zerr, 2014). Low HRV has been linked to a variety of mental health ailments such as anxiety, depression, and obsessive compulsive disorder. Thus, HRV may provide an index of mental health among first year protégés and prove effective tool to measure and monitor mental and physical well-being of participants through the duration of the mentorship intervention.

Firstbeat designed wearable technology capable of collecting and storing real time R-R interval data were used to obtain HRV data from the first-year students. Participants were given monitors periodically throughout the academic year and instructed to wear the device for 24-72 hours. Parameters used to quantify cardiovagal reactivity included time and frequency domain measures such as high frequency (HF) power, standard deviation of normal-to-normal R-R intervals (SDNN) and the root mean square of successive differences (RMSSD). Participants also completed several questionnaires related to emotional, mental, and physical wellbeing including the Mental Health Inventory (MHI), Brief Resilience Scale (BRS) and the General Anxiety Disorder 7-item scale (GAD-7) to guide baseline and progressive measures of mental health. By collecting both HRV data and questionnaire responses throughout the academic year, we performed analyses to study the relationship between health behaviours, perceived psychological resilience, and autonomic nervous system dynamics. In addition to a longitudinal study method of analyzing data from single individuals at different time points, the data collected from protégés was compared to non-mentored first year counterparts in a cross-sectional manner to determine the effectiveness of the mentorship intervention as one of many resources available to improve the quality of life of undergraduate students.

The **primary purposes** of this investigation were (a) to examine the relationship between cardiac autonomic control and mental health scores, and (b) assess the effectiveness of a mentorship intervention at improving these parameters in first year Western University students. This research tested the **hypotheses** that (a) cardiac autonomic control as measured by RMSSD during sleep would be correlated to resilience and (b) the protégés would show improved RMSSD and resilience scores post-intervention, when compared to controls.

Chapter 2

2 Literature Review

2.1 Heart Rate Variability

Heart rate variability (HRV) is the change in time intervals between adjacent heartbeats (Shaffer, McCraty, & Zerr, 2014) and is reflective of the inherent flexibility of the neurocardiac axis, providing a window into autonomic modulation of the heart. Periodic heart rate fluctuations around the mean represent continuous, dynamic, bidirectional adjustments made by cardiovascular control mechanisms in response to a variety of external factors (McCraty & Shaffer, 2015; Shaffer et al., 2014). Specifically, HRV provides information about balance, or continuous interplay, between parasympathetic and sympathetic branches of the autonomic nervous system (van Ravenswaaij-Arts, Kollee, Hopman, Stoelinga, & van Geijn, 1993). This value is indicative of appropriate physiological responses to a multiplicity of stimuli such as breathing, exercise, mental stress, and hemodynamic, blood pressure, or metabolic alterations. Allostasis is the maintenance of "stability through change", and relies upon the ability to detect and respond to environmental and physiological changes. Researchers have referred to this phenomenon as allostatic regulation (Gary G Berntson, Norman, Hawkley, & Cacioppo, 2008; Danese & McEwen, 2012; Friedman & Thayer, 1998). Variation as a hallmark of proper biological and physiological function has been widely accepted as an intrinsic characteristic of healthy cardiac functioning.

2.1.1 Control of HRV by ANS

Heart rate variability is primarily modulated by the autonomic nervous system (ANS), which consists of sympathetic and parasympathetic branches. Chemo and baroreceptors, located in the carotid bodies and major blood vessels, respectively, are responsible for collecting efferent information regarding blood gas concentrations and mechanical stretch. Sensory information is conveyed to the solitary tract nucleus (NTS), via the glossopharyngeal nerve, allowing for reflex regulation of the heart (Purves D, Augustine

GJ, Fitzpatrick D, et al., 2001; Shaffer et al., 2014). Both parasympathetic and sympathetic branches of the ANS directly innervate the sinoatrial node, targeting smooth cardiac muscle, and can thus control chronotropy of the heart (Draghici & Taylor, 2016). The parasympathetic branch, acts via acetylcholine release, demonstrating a short effect latency and higher turnover rate because the sinus node is rich in acetylcholinesterase. For this reason, the effects of parasympathetic nervous system (PNS) activation are rapid (<1 s) and short-lived. The catecholamines released by the sympathetic branch are reabsorbed and metabolized relatively slowly in comparison (>5 s) (Shaffer & Ginsberg, 2017). The PNS is thought to be responsible for cardiac tone, or activity, under regular resting conditions. Acceleration of heart rate (HR) and increased blood pressure (BP) may results from sympathetic activation, vagal withdrawal, or a combination of the two.

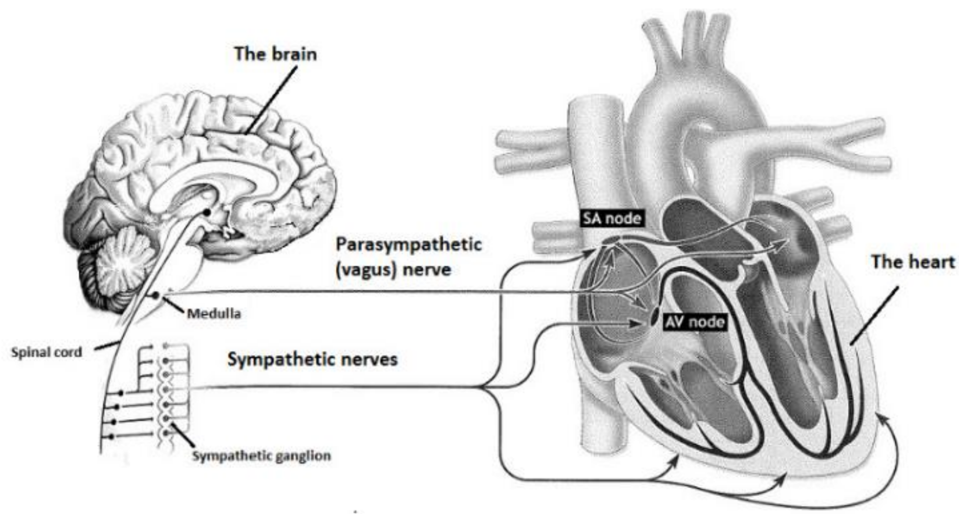

Figure 2.1: Autonomic nervous system controls different target organs via parasympathetic and sympathetic nerves (Firstbeat Technologies Ltd., 2014)

The parasympathetic branch is responsible for vagal tone and is able to exert heart rate control at a beat-by-beat level. Activation of the parasympathetic cholinergic innervation of the heart leads to a decrease in the discharge rate of the cardiac pace maker, and a decrease in blood pressure (Draghici & Taylor, 2016; Purves D, Augustine GJ, Fitzpatrick D, et al., 2001). The PNS is thought to be responsible for short term HRV.

High HRV is typically representative of high vagal tone and indicative of healthy cardiac function (Stein & Kleiger, 1999; van Ravenswaaij-Arts et al., 1993).

In contrast, the sympathetic nervous system (SNS) modulates the fight or flight response to external stress, and activity is characterized by cardiac pacemaker acceleration, increased contractility, and vasoconstriction, resulting in increased blood pressure. The SNS branch of the ANS is responsible for long term HRV activity as norepinephrine is slower in absorption and metabolism. With this, the SNS demonstrates potentially delayed, but also longer term, effects (Draghici & Taylor, 2016).

2.1.2 HRV during sleep

The interaction between ANS and sleep is complex, bidirectional, and regulated by several different factors. The ANS modulates much of cardiovascular function during sleep and transitions between sleep phases (Tobaldini et al., 2013). Studies have shown that acute stress affects sleeping HRV. A stress induced reduction of PNS influence, or vagal withdrawal, leads to decreased HRV as measured by HF power (Hall et al., 2004). Rapid eye movement (REM) sleep is characterized by SNS dominance and vagal withdrawal, while non-REM is characterized by PNS activity (Jurysta et al., 2003). Nighttime HRV recordings have gained research interest because sleep constitutes a condition free of external disruptive events. Researchers have suggested that slow wave sleep good for assessing time and frequency domain HRV indexes (Brandenberger, Buchheit, Ehrhart, Simon, & Piquard, 2005), and have presented an average sleeping RMSSD of 68.5 milliseconds in healthy young adults.

2.1.3 Measurement Techniques

Ease of collection, non-invasive, and its inexpensive nature makes HRV a popular tool to study cardiac autonomic control and ANS functioning. Accuracy of the measurement technique is determined by the sampling rate and meaningful analysis is dependent upon the integrity of the basic cardiac signal input (G. G. Berntson et al., 1997). The standards for HRV measurement were outlined in the Task Force by the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996), extended by Berntston (1997), and recently updated by Laborde and colleagues (2017). Thus, there exists a fairly comprehensive overview outlining measurement standards, suggesting an optimal sampling frequency of 250Hz or greater and collection period of 5 minutes or greater. Limited data assert the stability and reliability of 24-hour ambulatory monitoring ("Heart rate variability: standards of measurement, physiological interpretation and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology.," 1996).

2.1.3.1 Time Domain Analysis

Time domain analysis is the simplest method of HRV analysis and involves QRS complex detection and normal-to-normal interval or instantaneous heart rate determination, followed by application of descriptive statistics on electrocardiographic R waves (i.e. SD, variance, mean successive difference) (Beauchaine, 2001; Malik, 1996). Commonly used time-domain measures include standard deviation of normal-to-normal intervals (SDNN) and root mean square of successive differences (RMSSD). Under normal conditions, SDNN primarily reflects circadian rhythms, while RMSSD and reflect vagal modulation of the sinoatrial node (Stein & Kleiger, 1999). While both are time domain variables, SDNN is derived directly from the N–N interbeat intervals, and RMSSD is calculated from the differences between successive N–N intervals. Analysis using RMSSD has been recommended for short term recordings as guidelines have suggested that RMSSD has the best statistical properties of the time domain measures, and is representative of overall HRV (G. G. Berntson et al., 1997; Laborde, Mosley, & Thayer, 2017; Malik, 1996; Shaffer & Ginsberg, 2017).

Recording time highly influences time-domain measures. Researchers must be careful when comparing time domain measures because it is inappropriate to compare measurements derived from recordings of different lengths. For example, RMSSD derived from short term recordings does not necessarily estimate longer term HRV (Shaffer & Ginsberg, 2017). Time domain analyses are ideal for long term recordings because frequency measures are more mathematically complex and less interpretable.

2.1.3.2 Frequency Domain Analysis

While time-domain measures are simple and global, they cannot discriminate frequency specific effects, nor eliminate noise (Draghici & Taylor, 2016). For this reason, recent research has suggested that spectral analysis is the most precise and widely used technique. This technique involves decomposition of heart rate time series into component frequencies through Fourier transformations (Beauchaine, 2001).

According to studies utilizing pharmacological blockade, high frequency (HF; 0.15-0.4 Hz) power bands are attributed to respiratory sinus arrhythmia (G. G. Berntson et al., 1997). Respiratory sinus arrhythmia (RSA) is nearly abolished by cholinergic blockade and is mediated by fluctuations in vagal-cardiac nerve traffic activity (G. G. Berntson et al., 1997). Notably, although HF power indexes vagal modulation of HR, it does not represent vagal tone (Shaffer & Ginsberg, 2017). Respiratory sinus arrhythmia is associated with a number of parasympathetic parameters including vagal outflow to the heart, cardiac vagal tone, and respiratory modulation of vagal activity (G. G. Berntson et al., 1997). Low frequency (LF) recordings are attributed to arterial baroreflex activity, or "oscillation of sympathetic motor tone", and a mixture of parasympathetic and sympathetic activity (Gary G Berntson et al., 2008; Draghici & Taylor, 2016). Low frequency signal is not as simple as HF because beta adrenergic blockade does not completely abolish the signal, so it cannot be attributed solely to SNS activity.

With this, researchers suggest that LF:HF ratio is a good representation of SNS and PNS interplay, or autonomic balance. This, however, may be a simplified assumption since the relationship is non-linear and non-reciprocal. For example, there exist a number of physiological scenarios during which both branches of the ANS are excited simultaneously, termed autonomic co-activation (Paton, Boscan, Pickering, & Nalivaiko, 2005). These are often protective reflexes including the dive reflex upon cold face immersion and the chemoreflex during apnea (Tobaldini et al., 2013).

2.1.4 Medical Implications

Generally, an increase in sympathetic or decrease in parasympathetic activity is associated with a decrease in HRV indices; a characteristic which has been linked to both psychological and physiological pathologies (Stein, Bosner, Kleiger, & Conger, 1994). Low HRV is indicative of abnormal and inadequate ANS adaptation, and researchers have highlighted the link between low temporal complexity and disease state, suggesting that changes in HRV may signal impairment at multiple levels of the neurocardiac axis and provide information about system integrity (Draghici & Taylor, 2016; Friedman &

Thayer, 1998). The suggestion that stress flexible responsivity is a hallmark of stability, and continuous adaptation by cardiac control mechanisms, highlights the danger of rigid regularity in such a system, as it may indicate a lack of self-regulatory capacity and inability to acclimate to external challenges. Because of this, HRV has been proposed as a promising marker to study autonomic function and pathological states.

Low HRV is also an independent predictor of future health problems and morbidities (Shaffer & Ginsberg, 2017; Shaffer et al., 2014). It has been associated with aging anxiety, depression, cardiovascular disease, autonomic dysfunction, gastrointestinal disorders. Decreased HRV during sleep has also been found as a result of acute stress induced vagal withdrawal (Hall et al., 2004). Research has, however, highlighted the fact that the breadth of vagal correlates to psychological maladaptation itself raises questions about its utility as a measurement tool (Beauchaine, 2001). Thus, when considering the implication and cause of lowered HRV, many factors must be considered

2.1.5 HRV in psychophysiological research

Heart rate variability disturbance is not only an indicator of physiological and biomedical functioning, but also reveals the effects of psychosocial disturbances and conditions (Drury, 2014). Mental ill-health is associated with maladaptive responses to stress. As such, psychological disorders are often defined by their loss of stress resilience and are associated with decreased HRV. Thus, the use of HRV in psychophysiological research may be promising. As reviewed by Laborde and colleagues (2017), there are five theories implying HRV in psychophysiological research: the neurovisceral integration model (Thayer & Lane, 2009), the polyvagal theory (Porges, 2007), the biological behavioral model (Grossman and Taylor, 2007), the resonance frequency model (Lehrer & Gevirtz, 2014), and the psychophysiological coherence model (McCraty and Childre, 2010). The common theme of these five theories is their focus on vagal tone in psychological study.

2.2 Resilience

Resilience is defined as resistance to maladaptive responses to stress, positive adaptation, or the ability to maintain or regain mental health, despite experiencing adversity (Herrman et al., 2011; Pereira, Campos, & Sousa, 2017). Protective factors, processes, and mechanisms that contribute to good outcome allow resilient individuals to experience fewer deleterious outcomes following stressors (Griciūtė, 2016). The medial prefrontal cortex (mPFC) is particularly sensitive to stress, both in terms of its function and structure (Arnsten, 2009; McEwen and Morrison, 2013), and also contributes to stress resilience (Maier and Watkins, 2010). Stress resilience is an active process with different phenotype levels including psychological, behavioral, neuroendocrine, and brain circuitry (Pereira et al., 2017). People that are highly resilient to the negative effects of chronic stress do still perceive the stress, but do not respond to it in a pathological manner. Some studies show that an increase in basal vagal tone is associated with an increase in stress resilience and that vagal tone is associated with faster stress recovery (Pereira et al., 2017). Researchers have referred to HRV as a "resilience reserve" or "autonomic resilience" (Oken, Chamine, & Wakeland, 2015). The question remains whether the effect of high vagal tone is a cause or a consequence of resilience.

A stressor pushes a physiological system away from baseline. While some stress is manageable, and perhaps beneficial according to the hormesis theory, too much can be detrimental. Allostatic load refers to the price of stress accommodation on a physiological system, and high resilience increases likelihood and speed of returning to baseline (Pereira et al., 2017). Higher resilience also means that more stress is required to push a physiological system into what is called a "low utility attractor basin", or an unfavourable dynamic state (Oken et al., 2015).

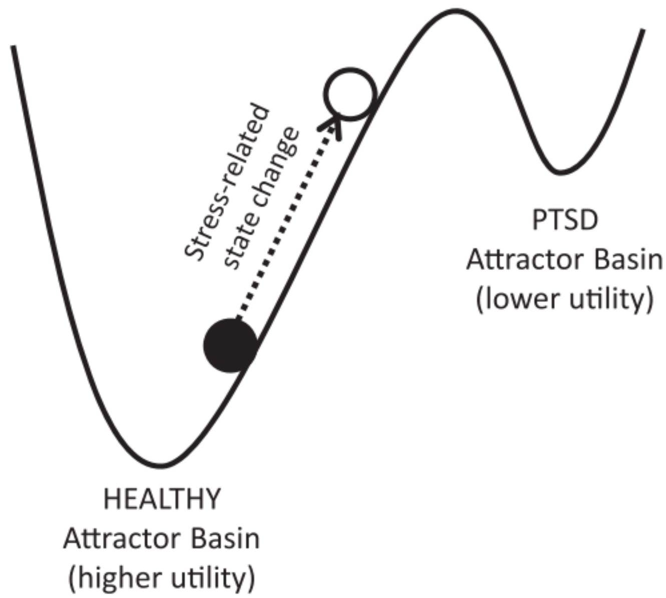

Figure 2.2: Hypothetical schematic of space of possible human physiological states with two attractor basins. Healthy condition with high resilience, and high level of stress required to shift state to the lower utility basin (Oken et al., 2015).

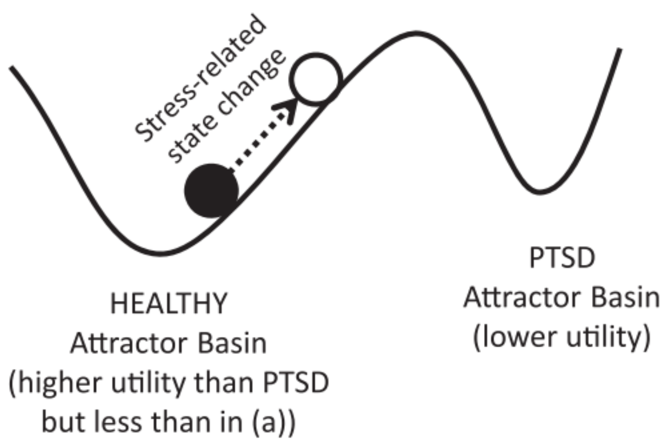

Figure 2.3: Hypothetical schematic of space of possible human physiological states with two attractor basins. Unhealthy condition with low resilience, highly susceptible to shifting state to the lower utility basin even under minor acute stress (Oken et al., 2015).

Exposure to a stressor forces biological adaptation and also primes the system to respond. However, that is true of moderate stress with ample recovery, not high stress over extended time periods. Chronic stress results in decreased ability to return to or stay in a functionally positive attractor basin. Fortunately, resilience is not constant, and can be modified in response to various external stimuli (Pereira et al., 2017)

This is an important area of research given that chronic, sometimes debilitating stress is incredibly common in the North American population. Because work, school, social, and financial stressors are not likely to decrease on a population-based scale, research should focus on strategies aiming to improve resilience so that individuals suffering from acute and chronic stress are better able to cope, if not thrive, during this period.

2.3 Resilience and Physical Activity

Five key resilience protective factors include (1) positive emotions; (2) cognitive flexibility (e.g. acceptance), (3) life meaning, (4) social support, and (5) active coping strategies (Burton, Pakenham, & Brown, 2010). Physical activity is considered an active coping strategy. The relationship between physical activity and mental well-being is well established. Extensive research has linked physical activity and improved depressive symptoms and reduced anxiety (Josefsson, Lindwall, & Archer, 2014; Skrove, Romundstad, & Indredavik, 2013), as well as highlighted the association between low physical activity levels and anxiety prevalence on a global scale (Natale R. Sciolino & Holmes, 2012; Stubbs et al., 2017). Physical activity has also been shown to promote features of resilience at both the behavioural and neural level in rodents (N. R. Sciolino et al., 2015), preventing anxiety- like behavior induced by stress.

2.3.1 Signalling

Galanin has been proposed as a mediator of the relationship between physical activity and resilience. Galanin inhibits locus coeruleus (LC) hyperactivity and supresses spontaneous neuron firing (Weinshenker & Holmes, 2016). The LC is implicated in many aspects of physiology and behavior, including attention, arousal, motivation, and stress, and extensively innervates the medial prefrontal cortex (mPFC). Exercise has been shown to amplify galanin expression in the noradrenergic LC and influence neuroplasticity in the mPFC (Natale R. Sciolino & Holmes, 2012). Trophic signalling in the mesocorticolimbic circuit is important as research has also highlighted the critical role of the mPFC in the detection of stressor controllability, coping, and resilience (Maier & Watkins, 2005) and plasticity in these regions is is "vital for establishing and maintaining resilience to stress" (Holmes, 2014). Plasticity disturbances are linked not only to decreased resilience, but also to MH pathologies including anxiety and depression. Thus, exercise induced trophic signalling may play a role in exercise induced resilience.

In a study by Sciolino and colleagues (2015), both exercise and galanin administration protected the cortex against stress-induced perturbation of dendritic structure and buffered the impact of stress on anxiety related behaviours. The effect of exercise induced galanin augmentation appears to be selective as conflicting research highlights receptor-dependent disparities between positive and negative effects of galanin in the LC. Galanin receptor 1 (GalR1) may acutely supress dopaminergic transmission leading to depressive symptoms, while galanin receptor 2 (GalR2) may exert trophic actions leading to long term antidepressant actions by causing mesocorticolimbic neural adaptations (Weinshenker & Holmes, 2016). The observation that the anxiolytic-like effects of exercise depend upon stress exposure and subsequent responding in a longitudinal manner confirms the idea that exercise promotes resilience, not just acute stress reduction in single exposure scenarios (Holmes, 2014).

2.3.2 Sociological Factors

From a sociological perspective, physical activity has been identified as a potential active coping resource that can provide enduring resilience to stress (Burton, Pakenham, & Brown, 2009) by cultivating social competence, structured style, autonomy, social support, self-esteem, and optimism (Moljord, Moksnes, Espnes, Hjemdal, & Eriksen, 2014). Physical activity induced resilience may also contribute to protection against depressive symptoms (Strohle, 2009), while enhancing self-efficacy. Experiencing positive emotion and cognitive flexibility are two key resilience factors, and the role of exercise in both mood enhancement and improved cognition has been well established (Dishman et al., 2006; Josefsson et al., 2014; Pittenger & Duman, 2008). Physical elicits these effects by modulation of 5-hydroxytryptamine (5-HT), norepinephrine (NE), and dopamine (DA), the major central nervous system (CNS) neurotransmitters involved in anxiety, alertness, and pleasure (Portugal et al., 2013). Additionally, social support and life meaning are principal resilience factors. Physical activity participation allows the opportunity to foster social connections and derive meaning from both relationships and the activity itself. This may be enhanced when physical activity is completed as a team (i.e. intramural sports), or in a group setting (i.e. group fitness). Studies on adolescent participation in group sports have highlighted the relationship between participation and resilience (Griciūtė, 2016). Finally, the autonomous decision to be physically active, often associated with taking care of one's physical health and productivity, and utilization of an active, controllable coping skill, may further enhance self-confidence and quality of life.

2.4 Mental Health Among Students

Oftentimes, the transition to university life presents an array of unique and challenging circumstances including moving away from home, the loss of traditional adult supervision and social support systems, navigating novel academic and social settings, and financial stressors. Thus, the college years represent a developmentally challenging transition to adulthood, and untreated mental illness may have significant implications for academic success, productivity, and social relationships. Personality traits, such as maladaptive perfectionism, have been identified as important moderators in determining the extent of psychological distress that students report as a result of their university studies (Hunt, S, Eisenberg, & Ph, 2010; Rice, Leever, Christopher, & Porter, 2006). In 2017, stress and anxiety were reported as having the biggest impact on academic performance, against a variety of other factors including work, relationships, and finances (Association, 2018).

Mental health is the foundation for individual well-being and the effective functioning of a community (Reddy, 2017), yet the National College Health Assessment (NCHA) indicates that a majority of university students are overwhelmed, anxious, and have had their academic performance negatively impacted by stress (American College Health Association, 2018). Anxiety and depression have been cited as the most common psychological disorders among university students. In 2017, 40.1% of students reports feeling "so depressed it was difficult to function", yet only 17.9% reported having received formal diagnosis or psychological treatment. The considerable gap between the need for mental health treatment and the receipt of mental health services may be attributed to both service availability and accessibility, as well as help seeking behaviours, especially within the student population.

Barriers to seeking professional help for mental health include lack of time, lack of perceived need of help, lack of awareness about available services, and financial constraints. Seeking help is key for management of illness and relapse prevention, however, negative attitudes and beliefs are significant barriers to help seeking among college students (Eisenberg, Hunt, & Speer, 2012). Studies on mental health educational programs have suggested that improvements in knowledge and stigma are necessary primers for changes in behaviour related to mental health (Sontag-Padilla et al., 2018). Thus, continuous psychoeducational efforts and stigma reduction are necessary steps in improving help seeking behaviour.

While opening the dialogue and eliminating the stigma surrounding mental health is imperative to improving help seeking amongst students already suffering from clinical psychological disorders, preventative measures may be effective at aiding students experiencing subclinical psychological distress. For example, the 86.9% of Canadian university students that reported feeling ‘overwhelmed by all (they) had to do’ in 2016 (Association, 2018) may benefit greatly from enhanced stress resilience. Building resilience using tools such as physical activity and social connection, students may find themselves able to better moderate stress and handle the demands of university. Chronic stress leads to neurochemical and anatomical alterations, as well as maladaptive and emotional and behavioural changes. These changes often precede psychological disorders, such as anxiety and depression, thus, prioritizing stress resilience in university may prove a valuable preemptive measure.

2.5 Mentorship

Mentorship is a peer learning strategy that fosters the development of a professional yet caring relationship between two people in a shared environment (Kramer, Hillman, & Zavala, 2018). This involves the exchange of knowledge, support, and skills while also expecting the mentor to provide empathy, support, and guidance to the mentee. Peer mentoring benefits from social and cognitive congruence, leading to positive outcomes for the mentor and mentee alike (Taylor et al., 2013). Mentors are allowed the opportunity to reinforce leadership and collaborative skills, as well as improve confidence and enhance personal development. Thus, the benefits of mentorship are mutual (Kramer et al., 2018; Vandal et al., 2018).

Peer mentorship interventions have been found effective in many domains. For example, peer mentorship interventions for persons with recurrent psychiatric hospitalization have been proven a promising component of behavioural health care. Peer staff are able to build trusting relationships with an otherwise difficult to engage with population (O'Connell et al., 2018), which has been linked to improved clinical outcomes. Similarly, many withdrawal management and addiction recovery facilities employ "peer support mentors", which is a service that may lead to higher levels of empowerment and optimism by building explicitly and directly on a peer's lived experience (O'Connell et al., 2018).

Peer mentorship models in the field of academia have been most widely implemented in the health care realm, including nursing and medical programs. The 2008 Partners in Practice program was implemented in a large baccalaureate nursing program in the mid-western United States and matched senior-level nursing students with first-year students (Kramer et al., 2018). Teaching Academy (TA) which was implemented for students attending Alpert Medical School whereby second year students were selected and trained as TA fellows to mentor first year peers (Taylor et al., 2013). Among many reported benefits of these types of mentorship programs are decreased stress levels, increased sense of responsibility, and improved organizational and collaborative skills. These are benefits that may be generalized to many academic programs outside of nursing and medicine, as academic success within any faculty requires these fundamental skills and traits.

In addition to improving academic performance and self-efficacy, findings suggest that campuses might consider the benefits from incorporating student-led mental health programming in their efforts to support student mental health (Sontag-Padilla et al., 2018). It has been shown that attitudes and knowledge surrounding treatment options are imperative for determining help-seeking behaviours (Eisenberg et al., 2012). Mentors in a mental health promotion setting can help to ameliorate the stigma surrounding mental health struggles and seeking help, as well as provide insight and resources. Additionally, research has shown that students with mental health problems seek help from non-professionals, particularly peers, more frequently than they do from professional sources. This is termed 'informal help seeking' (Eisenberg et al., 2012), and the nurturing of a mentor-mentee relationship may provide a platform for this type of support.

2.6 Summary and Purpose

Mental health issues are increasingly common amongst university students. Due to its association with a number of psychopathological states, heart rate variability may provide a quantitative means for interpreting the gradation of stress and anxiety experienced by undergraduate students. The implementation of a mentorship model may act to increase stress resilience by providing first year students with education surrounding time management, study skills, physical activity, as well as social support and the opportunity to physically active with a group.

The **primary purpose** of this investigation was (a) to analyze the predictive relationship between cardiac autonomic control and mental health scores and (b) assess the effectiveness of a mentorship intervention at improving these parameters in first year Western University students. This research tested the **hypotheses** that (a) cardiac autonomic control as measured by RMSSD during sleep would be correlated to resilience and (b) the protégés would show improved RMSSD and resilience scores post-intervention, when compared to controls.

Chapter 3

3 Methods

3.1 Participants

Fifty-seven undergraduate Kinesiology students enrolled in the mentorship program as protégés and twelve non-mentored controls participated in the current investigation. Participants were all enrolled as first year Kinesiology students. Protégés were recruited via email during the pilot year, enrolled, and paired with a mentor prior to the fall semester. During the second year, participants were able to directly enrolled themselves into the Kinesiology course available to them during course selection. Following enrollment in Smart, Healthy Campus, both protégés and controls were recruited following a research presentation in a Kinesiology 1070 lecture during which they were presented the opportunity to participate in the study.

Participants not screened for clinical mental health diagnoses, medication including oral contraceptives, or existing health conditions. Students were included so long as they were enrolled in first year undergraduate studies at Western University. Forty-four participants (five control) discontinued participation in the study between the first and second round of data collection. Participation in the investigation was voluntary and no compensation was associated with completion of the study.

All participants provided written informed consent and received detailed explanations of all experimental protocols prior to participation. The study was approved by the Health Sciences Research Ethics Board at Western University.

3.2 Materials

3.1.1 Questionnaires

3.1.1.1 Brief Resilience Scale

The brief resilience scale was developed by Smith and colleagues in 2008 and assesses the “ability to bounce back” or recover from stress. The scale instructs participants to “Please indicate the extent to which you agree with each of the following statements by using the following scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 =

strongly agree." The scale is scored by finding the mean of six items. Items 1,3, and 5 are positively worded, while items 2,4, and 6 are negatively worded and scored by reverse coding (Smith et al., 2008). The score is positively related to coping, optimism, social support, and negatively related to anxiety, depression, and negative affect.

3.1.1.2 Generalized Anxiety Disorder 7 Item Scale

The GAD-7 is a seven item self-report questionnaire developed by Spitzer and colleagues in 2006 to screen for the presence of, and asses the severity of, generalized anxiety disorder. The scale prompts participants to answer questions related to acute anxiety by asking, "Over the last 2 weeks, how often have you been bothered by the following problems?" (Spitzer, Kroenke, Williams, & Löwe, 2006). Scores are assessed on the following scale: minimal (0-4), mild (5-9), moderate (10-14), and severe anxiety (15-21).

3.1.1.3 Mental Health Inventory

The MHI measures emotional distress and wellbeing in the general population by assessing anxiety, depression, positive affect, and behavioral control (Veit & Ware, 1983). This survey has 18 items, each scored using a six-point Likert scale with answers ranging from "all of the time, most of the time, a good bit of the time, some of the time, a little bit of the time, and none of the time". Participants are instructed to formulate responses based on their experiences over the past four weeks.

3.1.2 Activity Diary

Students recorded daily activities including approximate time and duration of sleep, physical activity, academic activity (i.e. exam writing), and caffeine intake in an activity diary provided to them during lab visits. Activity diaries were used by researchers to assist in data analysis when looking at changes in heart rate and heart rate variability over a 24-72h collection period.

3.1.3 Firstbeat Bodyguard 2

Firstbeat wearable technology heart rate monitors were employed to collect heart rate data. The Firstbeat bodyguard 2 measures heartbeat with 1000Hz (1ms) accuracy and can collect and store many days' worth of data. Monitors are attached using disposable electrodes (Figure 3) and can be taken off and reattached by users. Measurement begins automatically upon device attachment. Devices are rechargeable with a battery life of approximately 6 days and approximately 20 days' worth of storage capacity (FirstBeat, n.d.).

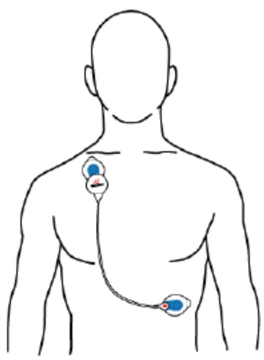

Figure 3.1: Firstbeat bodyguard 2 device placement

3.2 Protocol

3.2.1 Mentorship model

In preparation for their roles as mentors, upper year students participated in a two-day leadership effectiveness training (L.E.T) workshop, focused on developing and applying a comprehensive set of leadership and problem-solving skills, and were granted a certification upon completion. Following mentorship training, first year students were paired with an upper year mentor at a ratio of 1:3 during the pilot year, and a ratio of 1:6-8 during the second year. The groupings were made randomly, independent of sex/gender, age, lifestyle, or interests.

Each week, students were presented with the opportunity to attend one 50-minute lecture weekly, taught by Professor Salmoni, covering topics related to leadership, time management, study skills, and mental health during the transition into university. Students were allotted a second 50-minute lecture slot to spend time in their mentor/protégé groups. With this mentorship model students were presented with the tools to activate internal coping mechanisms, and access external support systems, which are both essential in effective stress management. During the 2016-17 pilot year, protégé attendance and participation in group activity was optional. During the 2017-18 year, when the model became an active and graded course for both first year protégés (KIN 1070) and upper year mentors (KIN 3333Y), attendance became mandatory and was reflected in the students' overall course grade. Participation in this investigation by consenting to the use of mental health data and providing HRV data, however, was not a mandatory component of the course at any time.

Because of the reported benefits that physical activity has for mental resilience (Holmes, 2014; Moljord et al., 2014) and because exercise is a sociological "connector", students were encouraged to spend their time together being physically active as a group. Extensive research has highlighted the importance of physical activity not only in maintaining skeletal and cardiovascular health, but also in improving cognitive function, promoting neuroplasticity, and protecting overall brain health (Voss, Vivar, Kramer, & van Praag, 2013). Research has associated physical activity with improved learning and memory, increased hippocampal volume, and a reduction in depressive symptoms, and is a means to mitigate the longitudinal and cumulative impact of the repeated stressors (Holmes, 2014). Activity choices included going to the gym, playing sports, walking to get coffee, and study sessions during high stress academic periods. Groups were also encouraged to intermingle and participate in activities together which provided a unique and beneficial social networking opportunity for the first-year students. This protocol targets two key resilience factors: social support and active coping.

3.2.2 Questionnaire Distribution

Questionnaires were distributed twice throughout the year, in concert with the HRV data collection sessions. During the first year, data collection rounds 1 and 2 took place in December 2016 and April 2017, respectively. During the second year, data collection rounds 1 and 2 took place in October 2017 and December 2018. Questionnaires were distributed to all students via email to be completed online including the BRS, GAD-7, and MHI. Active protégés were allowed one in class session each time the questionnaires were distributed to complete the forms accordingly, while controls were to complete questionnaires on their own time. All participants were to have questionnaires completed and submitted online prior to their scheduled in lab data collection sessions.

3.2.3 HRV Data Collection

Participants attended two lab sessions in Health Sciences Building 416 for heart rate data collection. At the beginning of each session, anthropometric measurements (height and weight) were collected and recorded. Students were equipped with a Firstbeat bodyguard 2 and instructed to wear the monitor for 24-72 hours and continue daily activities. Because of extensive battery life and storage capacity, monitors did not need to be removed during the study period unless a participant chose to swim or shower, at which point they were free to remove and reattach the monitors as required. Students were instructed to complete an activity diary during their time wearing the HRM and log physical activity, exam writing, studying, and sleep (sample in appendix). Participants returned devices to the lab at any time suitable to their schedules, following a minimum 24h time period.

3.3 Data Analysis

3.3.1 Questionnaire Data

All recorded responses to the distributed questionnaires were saved to Qualtrics, accessible only by investigators handling the questionnaire data, and anonymously sorted based on participant ID. Questionnaire scoring was done through Qualtrics to enhance accuracy. Individual total scores for each completed questionnaire were exported as a raw data to an excel spreadsheet and organized in the proper format to be analyzed alongside corresponding heart rate data.

3.3.2 HRV Data

Data from the Firstbeat bodyguard devices were offloaded onto a laboratory computer within a study-specific folder on a secure R drive. Firstbeat software was employed to analyze heart rate variability data. This software automatically corrects artifacts in R-R interval based on a specific threshold to identify irregular beats and noise, which can be caused by a variety of sources (Sami, Mikko, & Antti, 2004). From here, Firstbeat software follows a stepwise algorithm to process the ECG signal into quantitative time and frequency domain indices of heart rate variability.

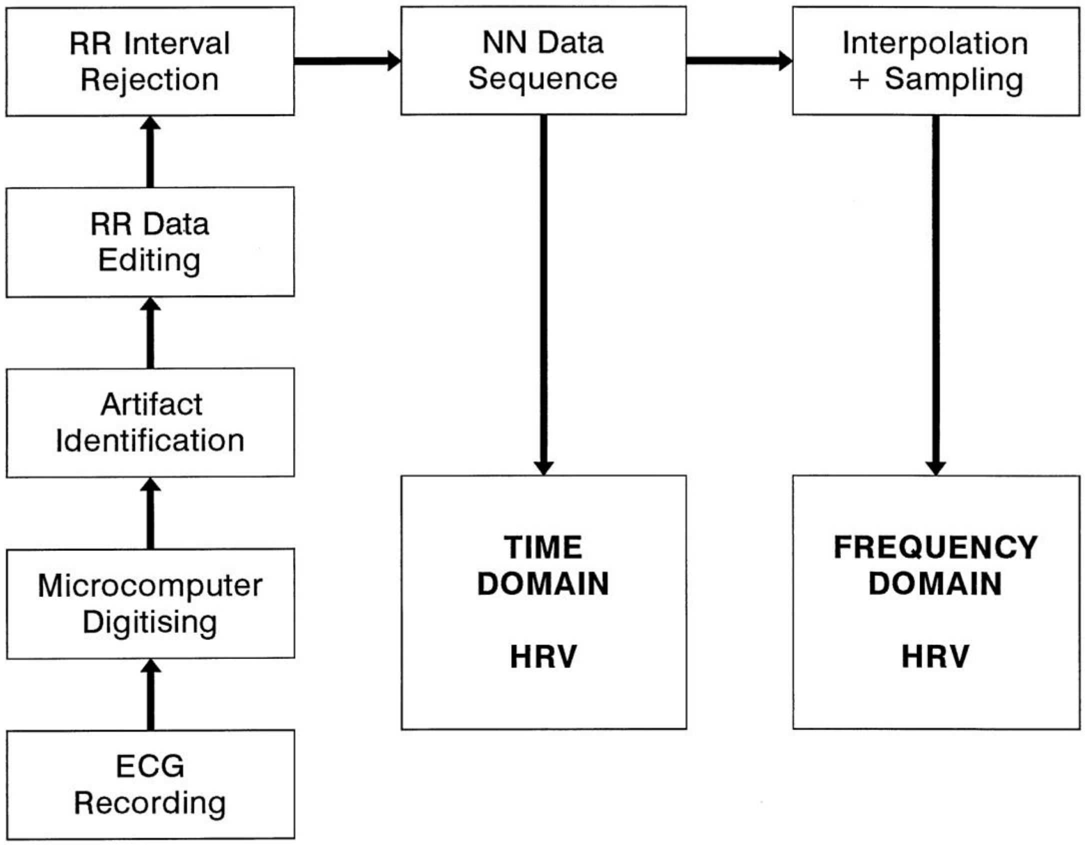

Figure 3.2: Flow chart summarizing individual steps used when recording and processing the ECG signal in order to obtain data for HRV analysis (1996)

Firstbeat software further analyzed heart rate recordings to identify various physical states including physical activity, stress, and recovery, to produce a comprehensive data report. Activity diaries were used in concert with heart rate variability data to analyze and isolate important individual events: sleep, exam, physical activity, and caffeine.

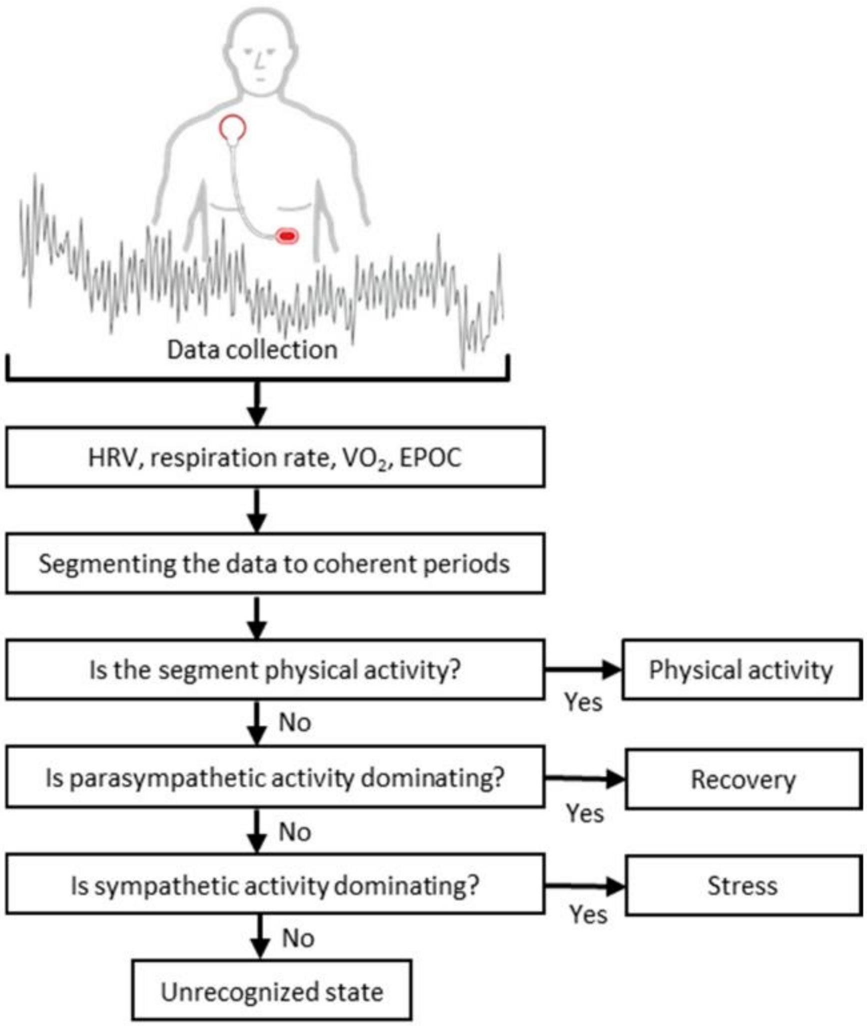

Figure 3.3: Simplified illustration of Firstbeat analysis procedure (Firstbeat Technologies Ltd., 2014)

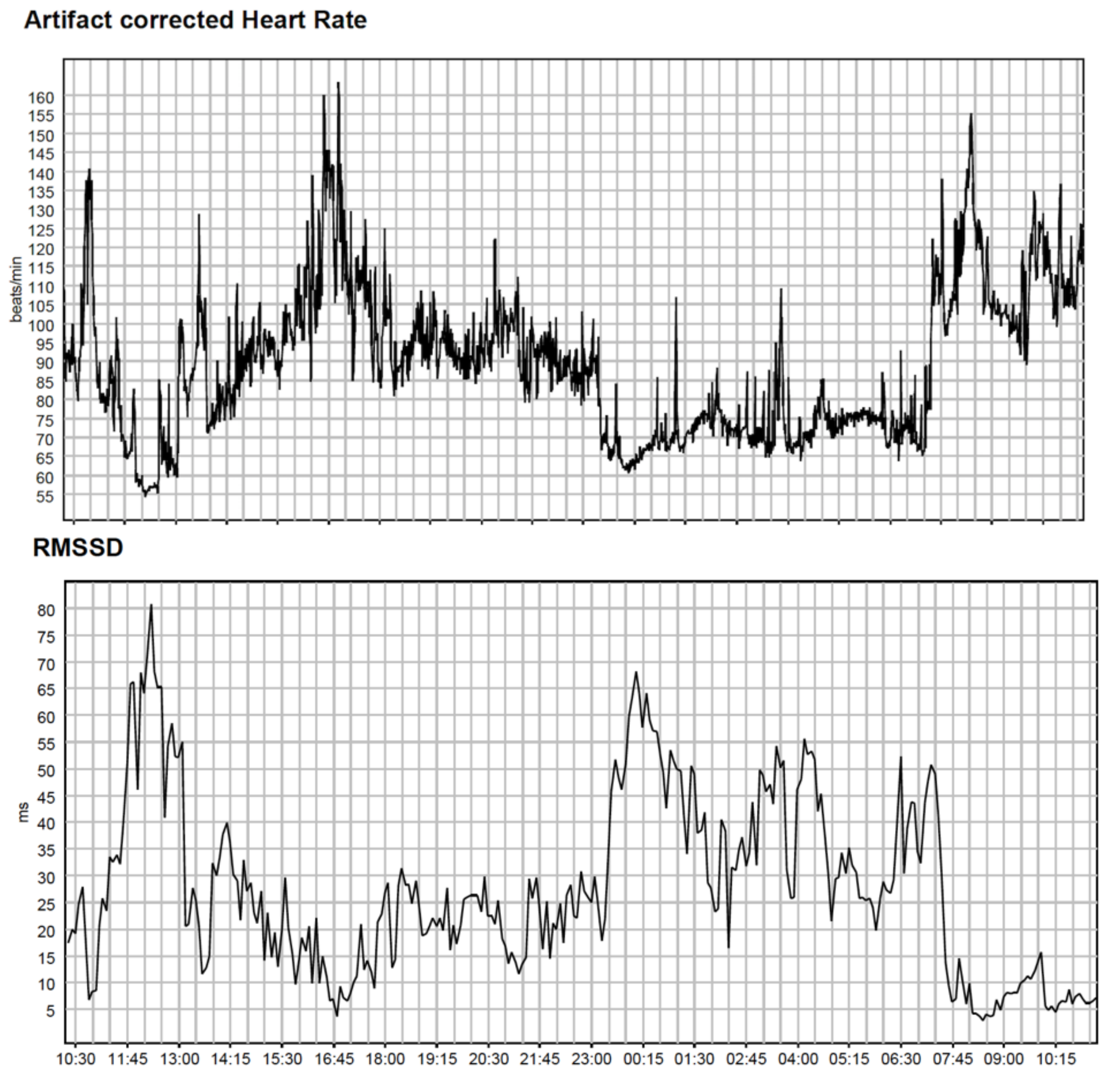

Figure 3.4: Schematic representation of heart rate (bpm) over a 24-hour period, artifact corrected by Firstbeat software (top panel) and schematic representation of RMSSD (ms) over a 24-hour period, artifact corrected by Firstbeat software (bottom panel) from the same individual over the same time-course.

Visual analysis of artifact corrected heart rate tracings, alongside analysis of the participants' activity diaries, allowed for isolation of key events during long-term recordings, as illustrated below.

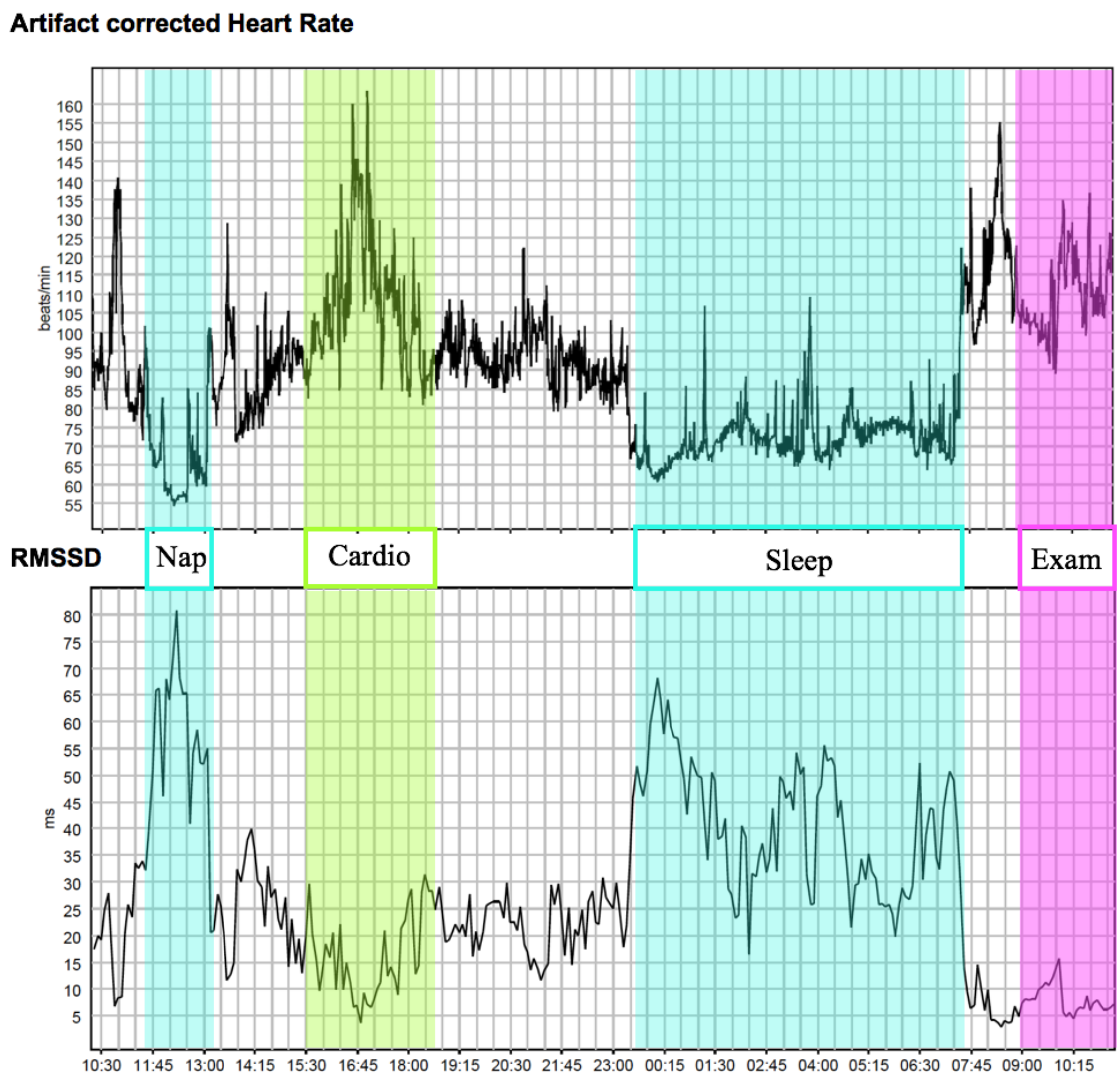

Figure 3.5: Schematic representation of heart rate (bpm) over a 24-hour period, artifact corrected by Firstbeat software, highlighting daily activities including sleep, exercise, and exam writing.

From the 24-72 hour heart rate recordings, 1-2 hours of uninterrupted, non- rapid eye movement (non-REM) sleep from the first night was isolated and analyzed to calculate sleep heart rate variability parameters including RMSSD, SDNN, HF, LF, and LF:HF ratio.

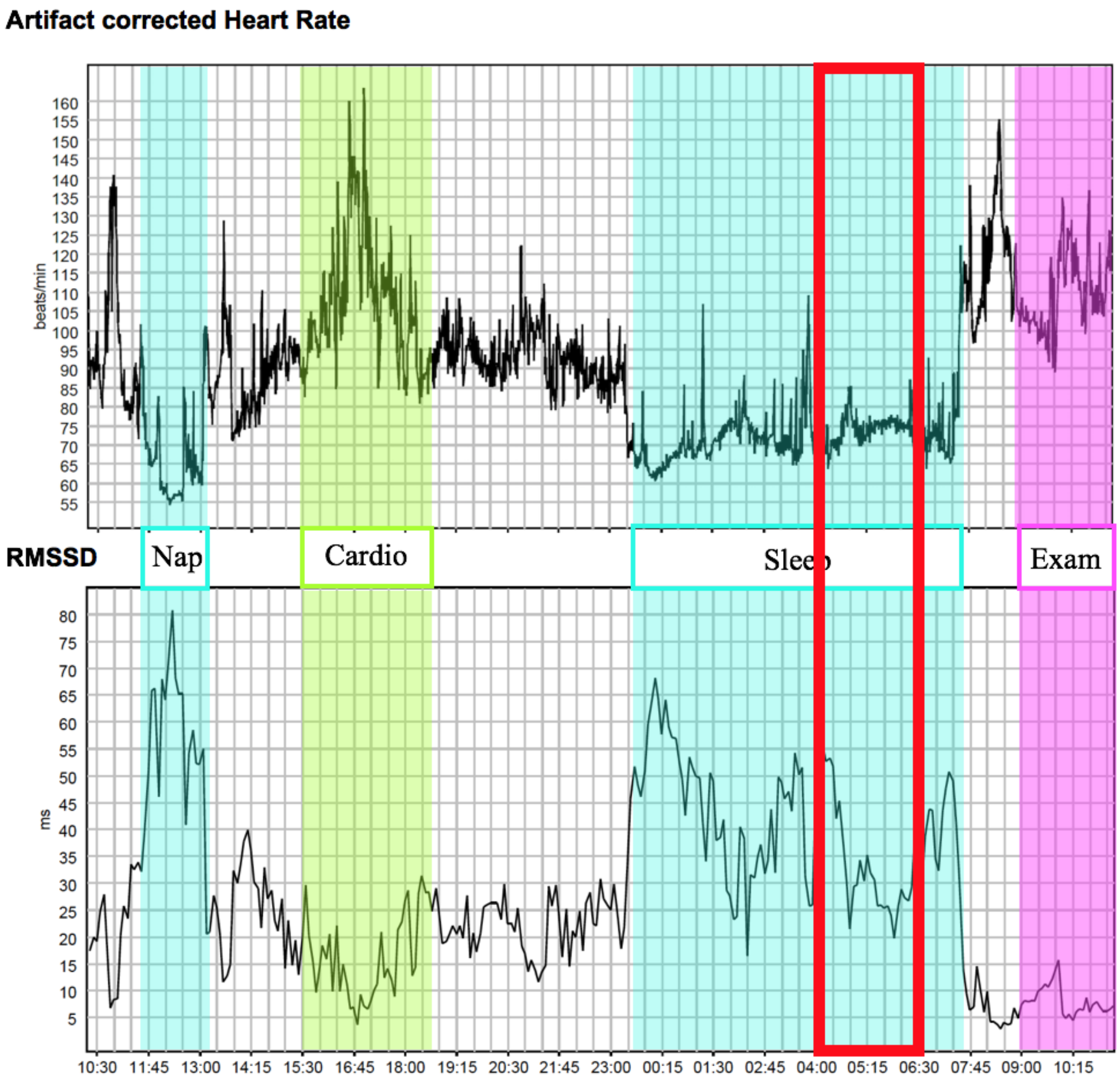

Figure 3.6: Segment highlighted in red is approximately two hours of uninterrupted, non-REM sleep that was extracted and analyzed to calculate sleeping HRV values for this participant.

3.4 Statistical Analysis

Data are presented as mean±SD unless otherwise specified. SigmaPlot 12.5 and IBM SPSS Statistics 25 were used for statistical analysis. Participant groups from years one and two were combined for all statistical analyses. Participant characteristics were evaluated between control and protégé groups using unpaired *t*-tests. Further, baseline heart rate variability parameters and mental health questionnaire scores were compared between the control and protégé groups using unpaired *t*-tests. Individual Pearson correlations were used to evaluate the relationship between heart rate variability (HRV), as measured by RMSSD, and each questionnaire score, including BRS, GAD-7, and MHI, at each of the two time points. Comparisons of round one and round two HRV and mental health parameters between the controls and protégés were made with a two-way repeated measures analysis of variance (ANOVA). A Bland-Altman test was employed to assess the agreement between pre and post-intervention BRS and RMSSD scores.

Chapter 4

4 Results

4.1 Participant Characteristics and Baseline HRV and Questionnaire Scores

Eighty-six healthy, normotensive first year Western University students were recruited as either full time protégés or control participants. Of the 86 recruited participants, 69 completed the first round of data collection (12 controls) and 25 remained throughout the year to complete the second round of data collection (7 controls). Participant physical characteristics are presented in Table 4.1. Participant physical characteristics including age, height, weight, and body mass index (BMI) were not statistically different between the protégé and control groups. The baseline HRV, as indicated by RMSSD, was not statistically different between the protégé and control groups. The baseline mental health questionnaire outcomes were not statistically different between groups.

Table 4.1: Baseline Participant Characteristics

	Control	Protégé
Physical Characteristics		
n, *males/females*		
Age (y)	18-24	18-24
Height (cm)	169 (8)	169 (8)
Weight (kg)	71 (17)	71 (17)
BMI (kg/m^2)	25 (5)	25 (5)
Hemodynamic and HRV Parameters		
HR (bpm)	62 (9)	61 (12)
MABP (mmHg)	84 (7)	85 (9)
RMSSD (ms)	71 (35)	69 (29)
SDNN (ms)	99 (37)	99 (35)
HF (ms^2)	4197 (3750)	4317 (3483)
Mental Health Scores		
BRS	3.2 (0.4)	3.4 (0.6)
GAD-7	6.9 (4.9)	5.8 (5.3)
MHI	68 (6.5)	70 (12)

Values are mean±SD. BMI, body mass index; HR, heart rate; MABP, mean arterial blood pressure; RMSSD, root mean square of successive differences; SDNN, standard deviation of normal-to-normal intervals; HF, high frequency power; BRS, brief resilience scale; GAD-7, generalized anxiety disorder 7-item scale; MHI, mental health inventory.
*significantly different from control $P \leq 0.05$.

4.2 Heart Rate Variability and Mental Health

Regression analysis established the predictive relationship between RMSSD and psychological survey scores during the baseline data collection for the entire group, prior to intervention. The RMSSD index correlated positively with BRS (n=69, r=0.30, $p<0.05$). The RMSSD index correlated negatively with GAD-7 (n=63, r=-0.26, $p<0.05$). The RMSSD index did not correlate with MHI.

Table 4.2: Sleeping HRV correlates of baseline mental health questionnaire scores

	BRS	*GAD-7*	*MHI*
RMSSD	0.298*	-0.261*	0.073
Pearson Correlation			
SDNN	0.209	-0.206	0.083
Pearson Correlation			
HF	0.213	-0.243	0.062
Pearson Correlation			

Values are reported as Pearson correlation coefficients (r). BRS, brief resilience scale; GAD-7, generalized anxiety disorder 7-item scale; MHI, mental health inventory; RMSSD, root mean square of successive heartbeat interval differences; SDNN, standard deviation of normal to normal R-R intervals; HF, high frequency

*, correlations are significant at the 0.05 level (2-tailed)

Table 4.3: Sleeping HRV correlates of MHI questionnaire subscale scores

MHI Subscale	*RMSSD*
Anxiety	-0.101
Pearson Correlation	
Depression	-0.066
Pearson Correlation	
Behavioural Control	-0.006
Pearson Correlation	
Positive Affect	0.139
Pearson Correlation	

Values are reported as Pearson correlation coefficients (r). MHI, mental health inventory; RMSSD, root mean square of successive heartbeat interval differences

*, correlations are significant at the 0.05 level (2-tailed)

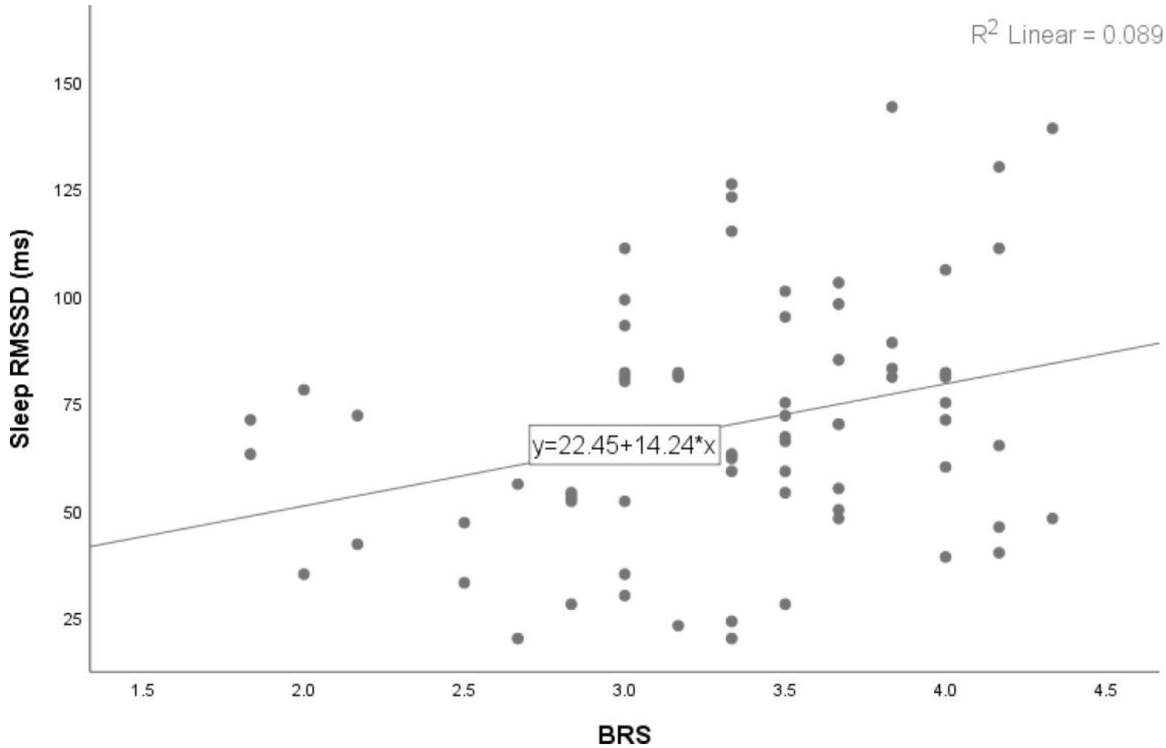

Figure 4.1: Correlation between sleeping RMSSD and resilience score at baseline for all participants (n=69)

4.3 Mentorship Effect on Predictive Relationships

Regression analysis found no relationship between RMSSD and BRS for protégés at baseline (n=18, r=0.25, p=0.3) or after four months of mentorship participation (n=18, r=0.04, p=0.9).

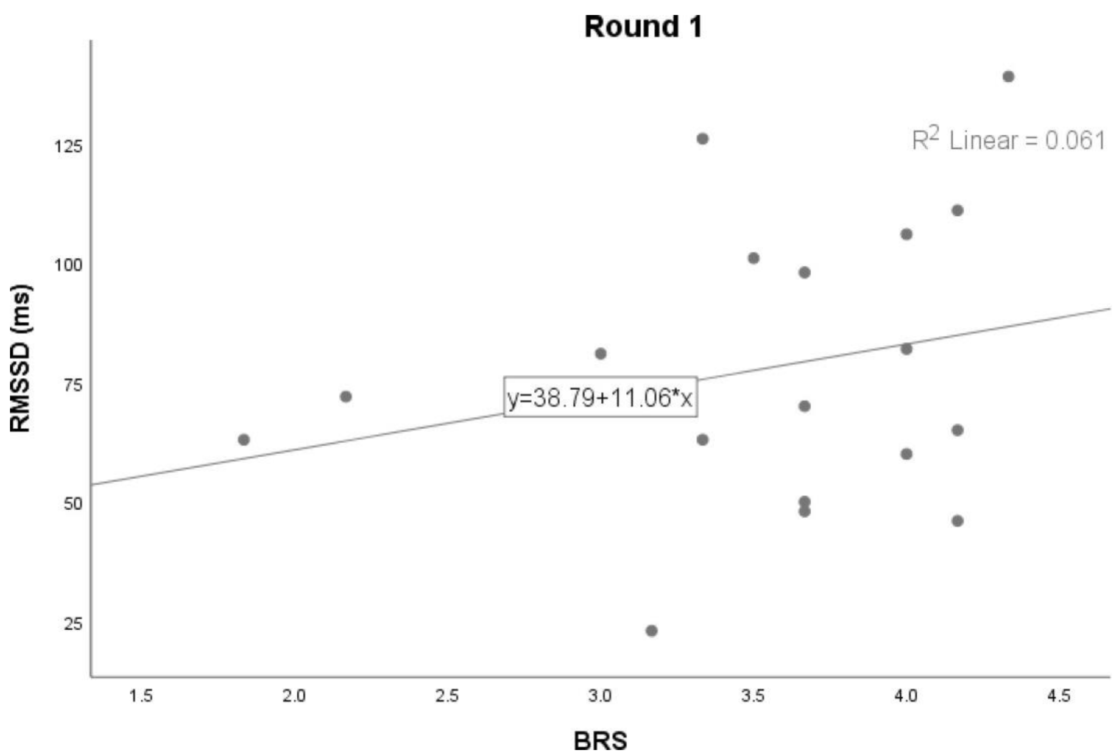

Figure 4.2: Correlation between sleeping RMSSD and resilience score at baseline for protégés (n=25)

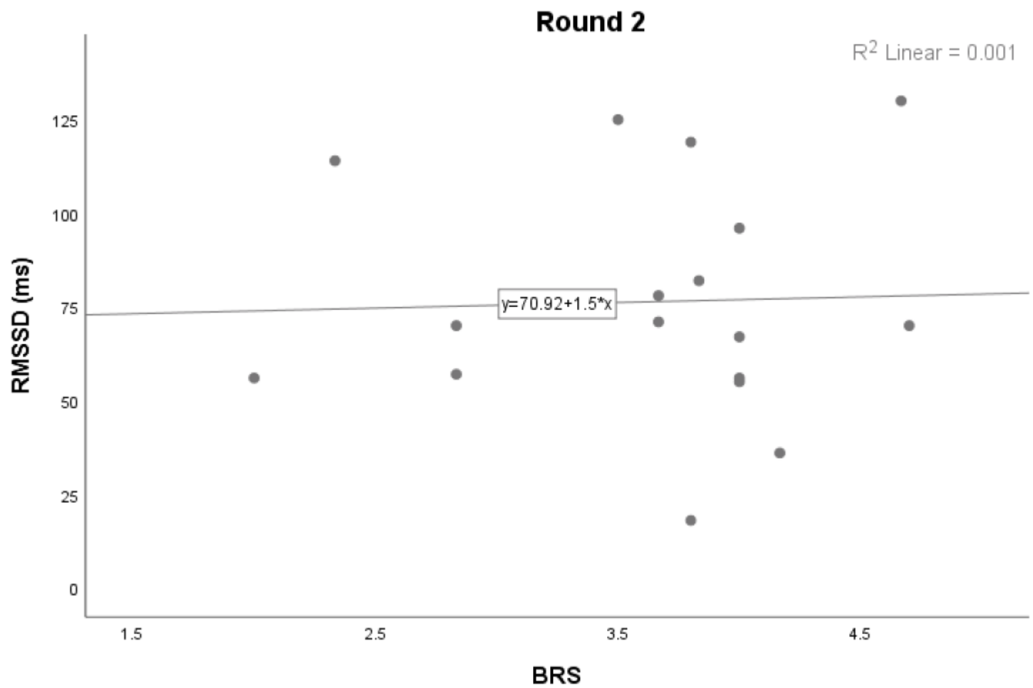

Figure 4.3: Correlation between sleeping RMSSD and resilience score at second time point, following mentorship intervention, for protégés (n=25)

Regression analysis established a positive correlation between RMSSD and BRS in the control group during baseline (n=7, r=0.85, $p<0.05$) which remained during the four month follow up data collection (n=7, r=0.78, $p<0.05$).

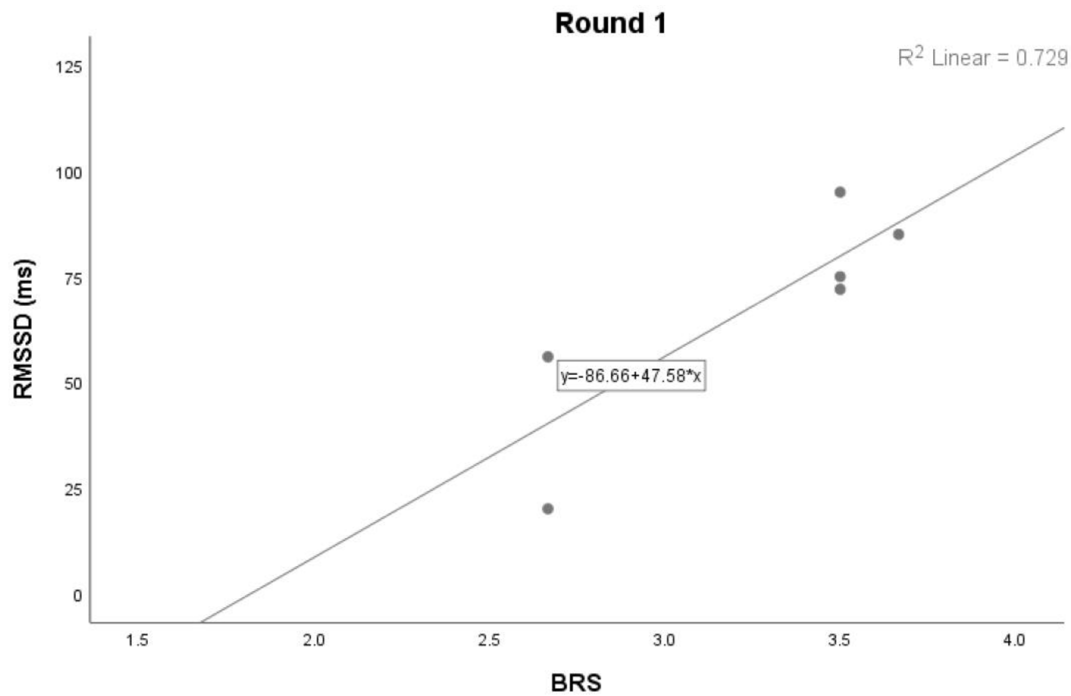

Figure 4.4: Correlation between sleeping RMSSD and resilience score at baseline for controls (n=7)

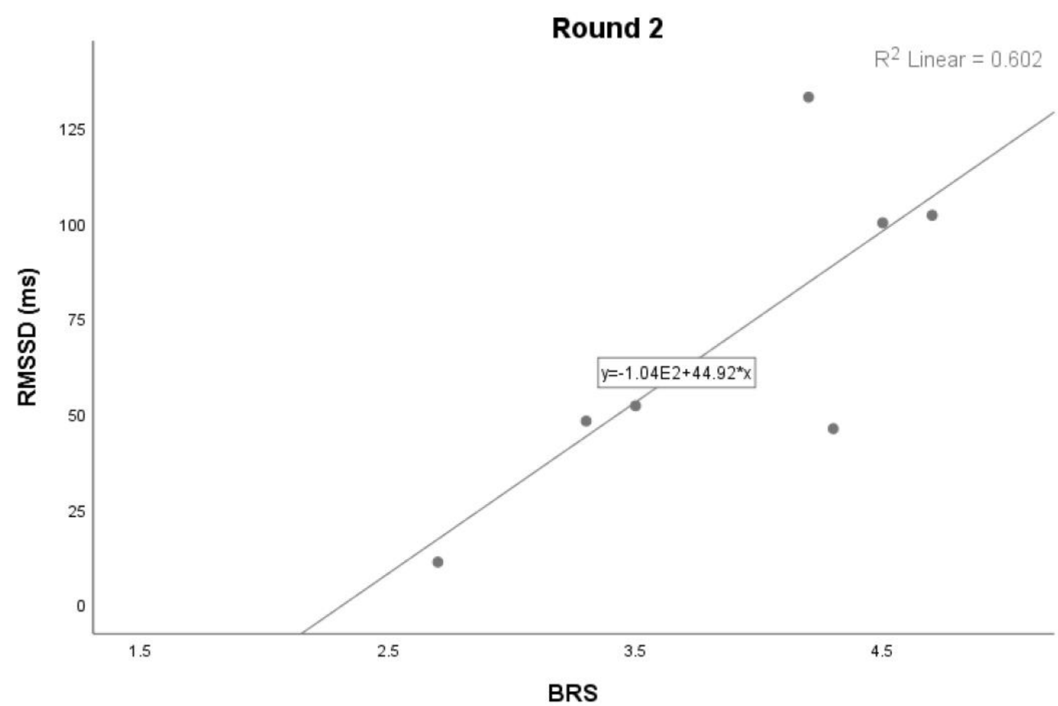

Figure 4.5: Correlation between sleeping RMSSD and resilience score at second time point for controls (n=7)

4.2 Mentorship Effect on HRV and Mental Health

Repeated measures analyses of variance were conducted with group (protégé or control) and time period (1, pre-mentorship or 2, post-mentorship) as factors. Analysis determined that RMSSD, BRS, GAD-7, and MHI were not different pre and post intervention for the protégé group (78.0±30.3, 76.3±30.5) or after four months in the control group (65.1±24.8, 70.3±-42.3).

Table 4.4: Heart rate variability and mental health indices before and after mentorship intervention

	Control (n=7)		**Protégé (n=18)**	
Heart Rate Variability	*Round 1*	*Round 2*	*Round 1*	*Round 2*
RMSSD	65.1 (25)	70.3 (42)	78.0 (30)	76.3 (31)
SDNN	97.6 (29)	97.1 (48)	96.5 (39)	109 (36)
HF	3390 (1873)	3159 (2918)	3508 (2592)	4165 (2536)
Mental Health Scores	*Round 1*	*Round 2*	*Round 1*	*Round 2*
BRS	3.19 (0.5)	3.89 (0.7)	3.55 (0.7)	3.61 (0.7)
GAD-7	7.71 (6.1)	2.71 (2.7)	3.50 (3.5)	6.72 (6.6)
MHI	67.7 (8.1)	67.9 (5.1)	74.8 (9.6)	69.7 (16.7)

Values are mean±SD. RMSSD, root mean square of successive differences; SDNN, standard deviation of normal-to-normal intervals; HF, high frequency power BRS, brief resilience scale; GAD-7, generalized anxiety disorder 7-item scale; MHI, mental health inventory. *main effect of round †main effect of group ‡round x group interaction, $P \leq 0.05$

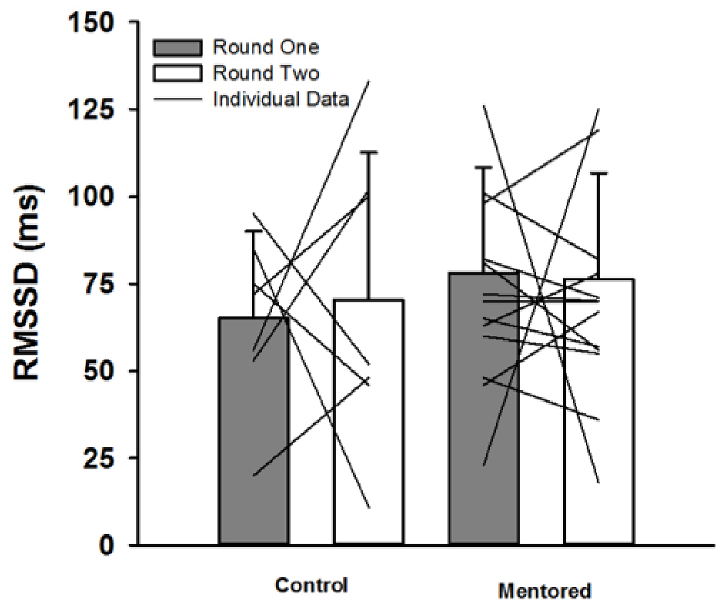

Figure 4.6: Changes in RMSSD pre-and post-mentorship intervention (protégés) or time point 1 and 2 (controls)

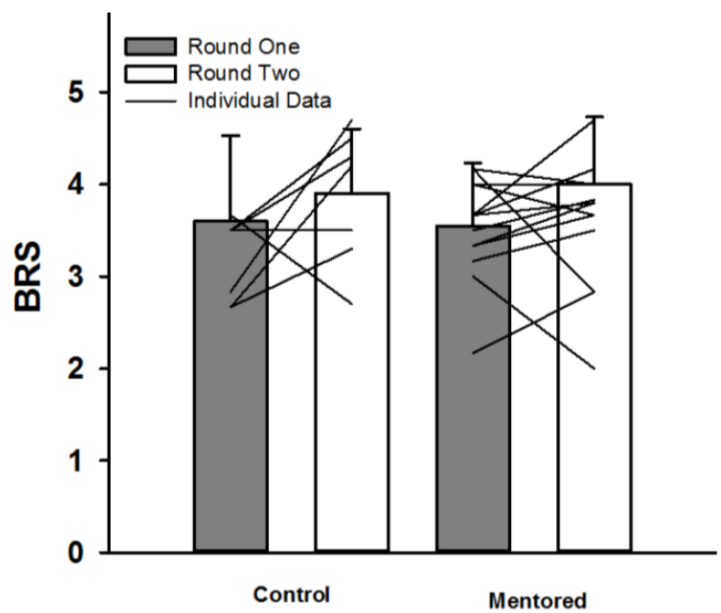

Figure 4.7: Changes in BRS score pre-and post-mentorship intervention (protégés) or time point 1 and 2 (controls)

Bland-Altman plots showed strong agreement for RMSSD (mean difference: 5.1± 0.98 ms, p > 0.05) and BRS (mean difference: 0.5 ± 0.3 , p > 0.05) values across visits for control participants with no fixed bias and the scatter of differences falling within ±2 SD of the mean (RMSSD: -104.0 to 114.3 ms; BRS: -1.2 to 2.3). Values did not exhibit proportional bias for either measure (RMSSD: b = -81.5; BRS: b = -0.77; both p > 0.05).

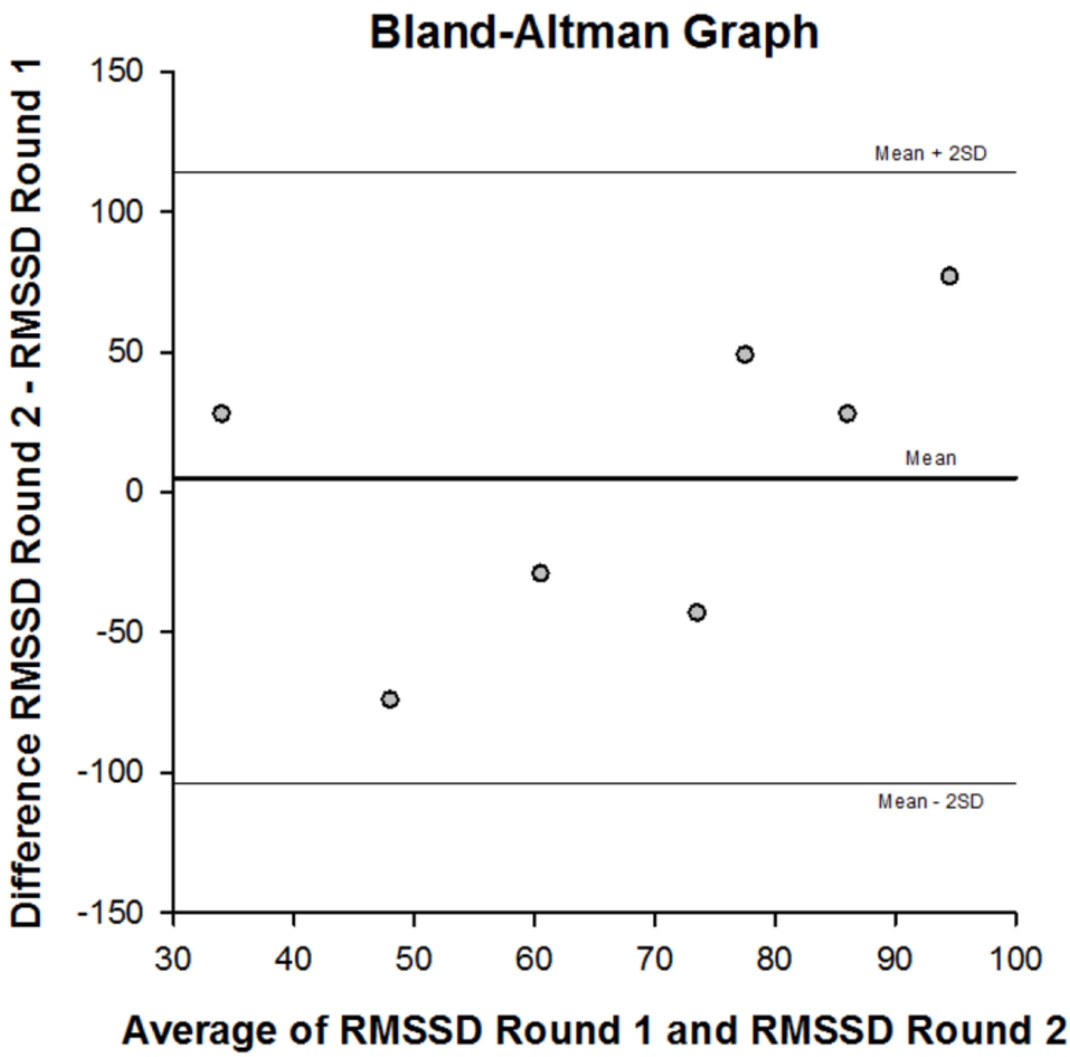

Figure 4.8: Bland-Altman plot of agreement displaying the difference in RMSSD between visits for control group as a function of the mean of RMSSD across visits. The mean

difference between visits (5.1ms; solid black line denoted by mean) and confidence limits of the mean difference (±2 SD: -104.0 to 114.3 ms; solid gray lines) are plotted.

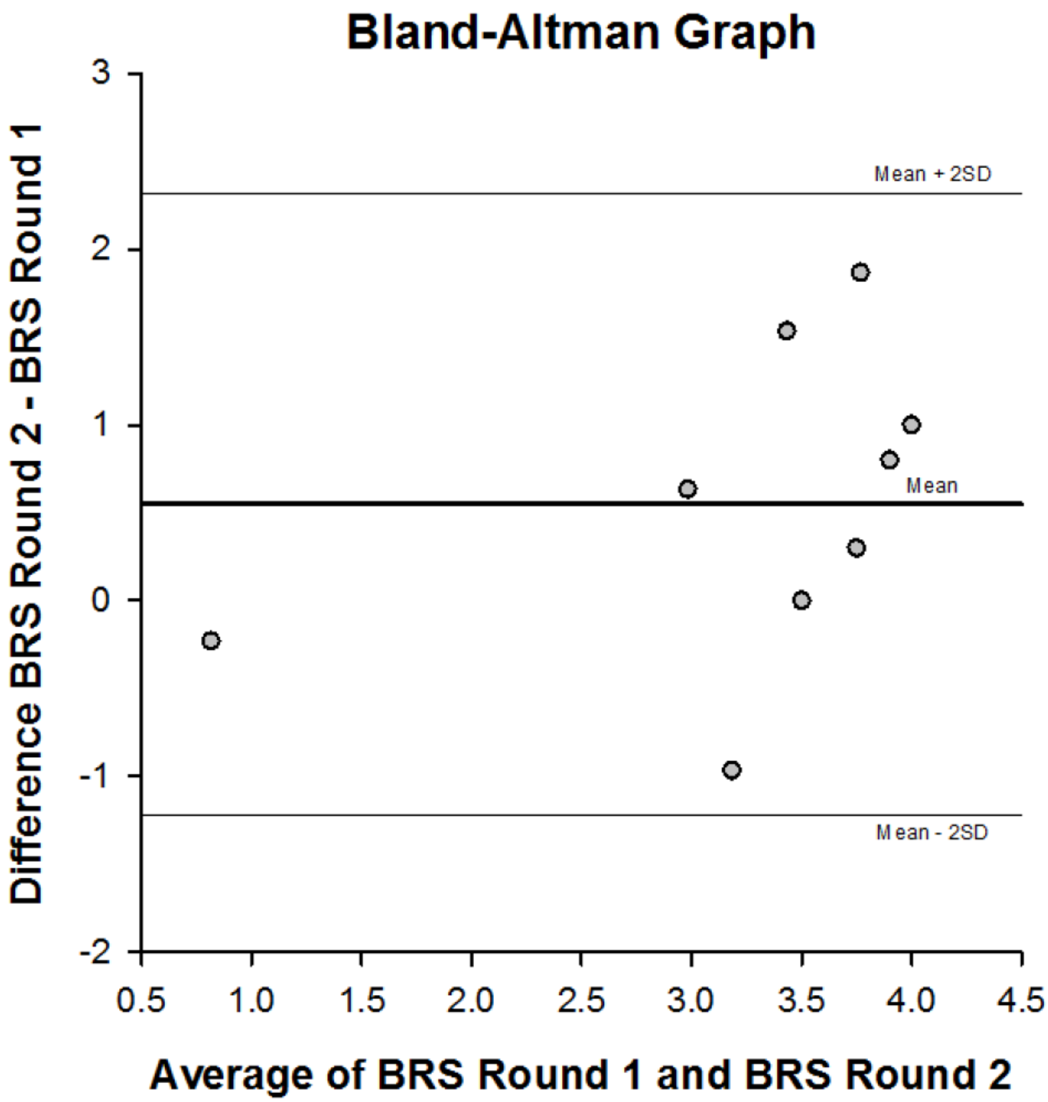

Figure 4.9: Bland-Altman plot of agreement displaying the difference in BRS between visits for control group as a function of the mean of BRS across visits. The mean difference between visits (0.5; solid black line denoted by mean) and confidence limits of the mean difference (±2 SD: -1.2 to 2.3; solid gray lines) are plotted.

Bland-Altman plots showed strong agreement for RMSSD (mean difference: -1.7 ms ± 0.4 ms, $p > 0.05$) and BRS (mean difference: 0.1 ± 0.2, $p > 0.05$) values across visits for protégés with no fixed bias. The scatter of differences did not fall within ±2 SD of the mean (RMSSD: -78.1 to 74.7 ms; BRS: -0.3 to 0.4). Values did not exhibit proportional bias for either measure (RMSSD: b = -2.35; BRS: b = -0.11; both $p > 0.05$).

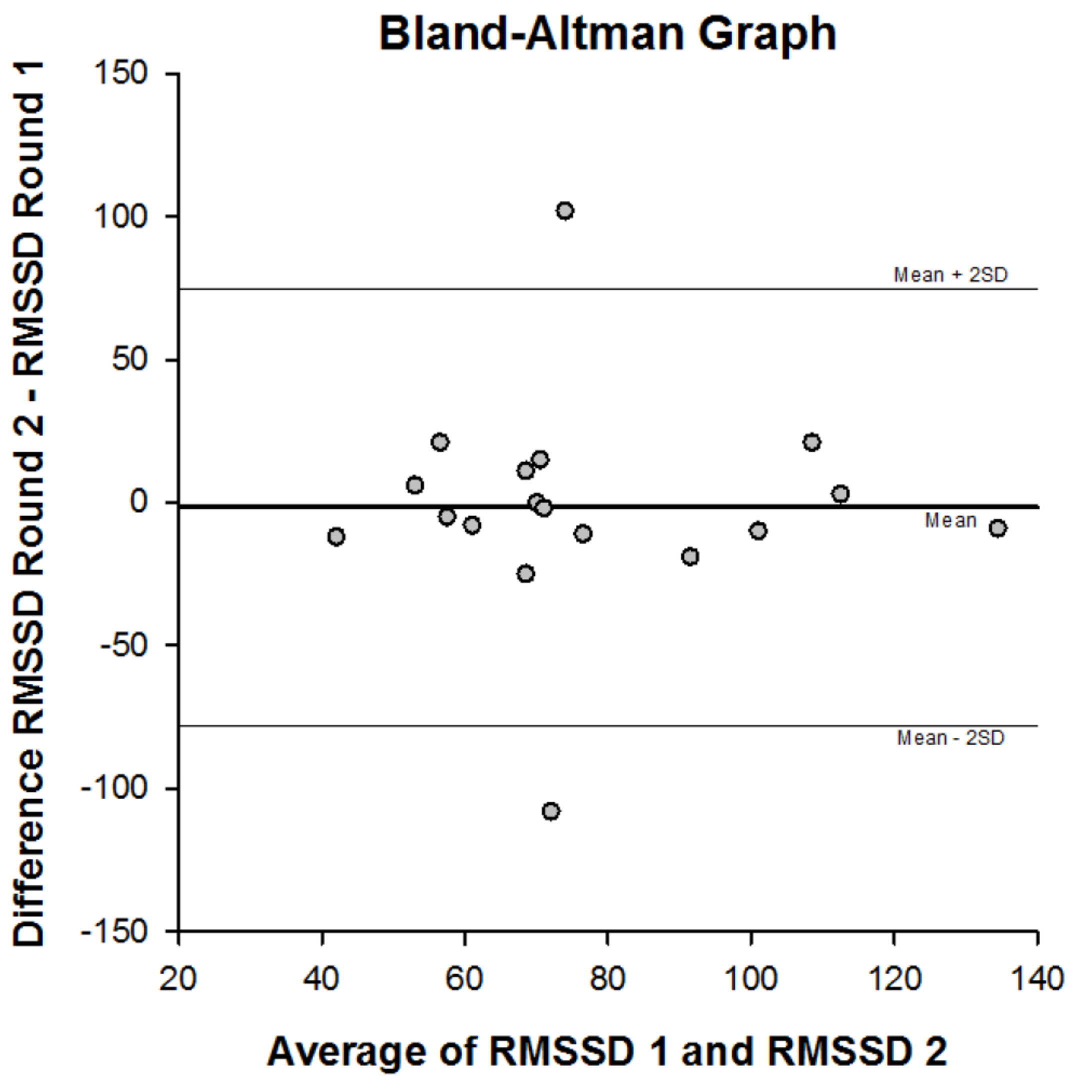

Figure 4.10: Bland-Altman plot of agreement displaying the difference in RMSSD between visits for protégé as a function of the mean of RMSSD across visits. The mean

difference between visits (-1.7 ms; solid black line denoted by mean) and confidence limits of the mean difference (±2 SD: -78.1 to 74.7 ms; solid gray lines) are plotted.

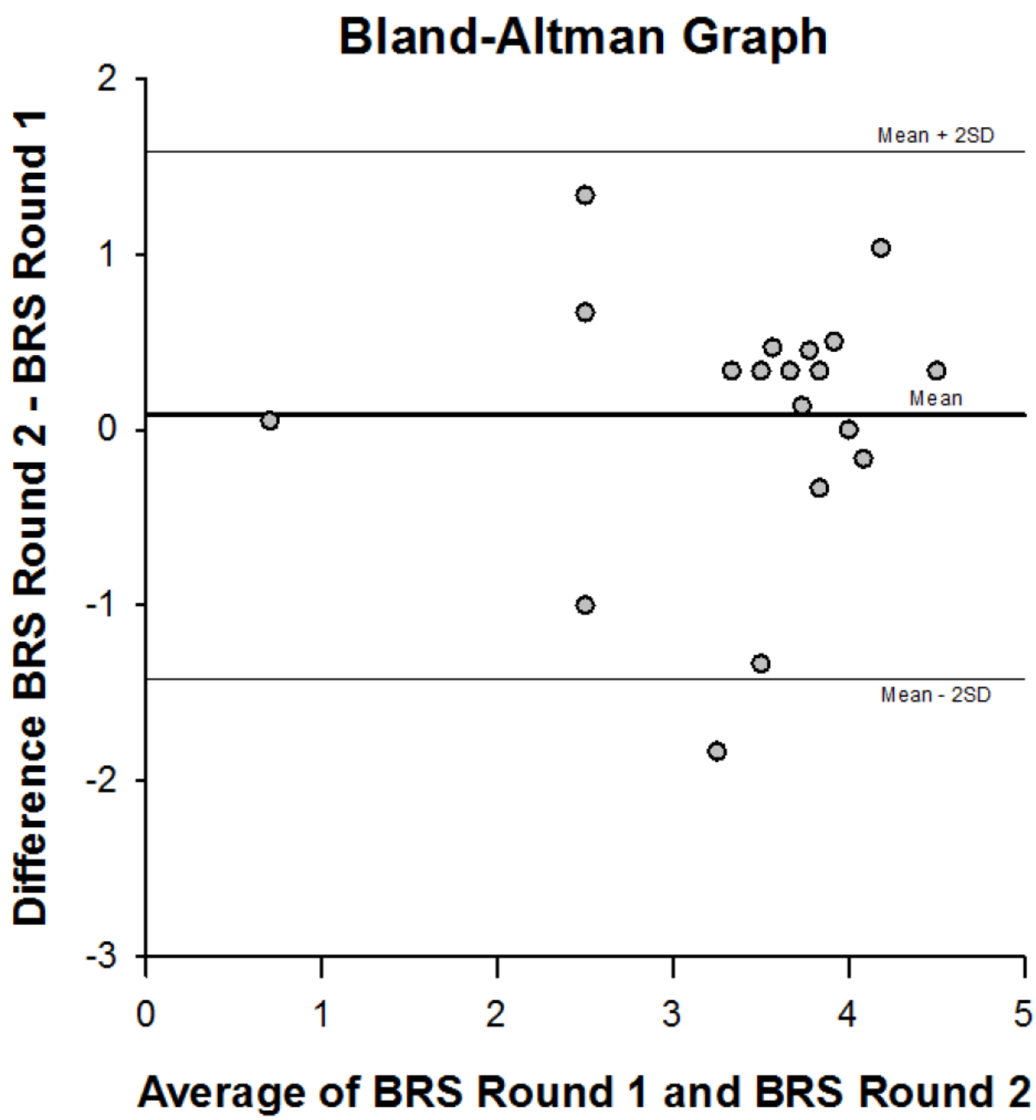

Figure 4.11: Bland-Altman plot of agreement displaying the difference in BRS between visits for protégés as a function of the mean of BRS across visits. The mean difference between visits (0.1; solid black line denoted by mean) and confidence limits of the mean difference (±2 SD: -0.3 to 0.4; solid gray lines) are plotted.

Chapter 5

5 Discussion

The main findings of the present study are as follows: (1) there exists a modest relationship between psychological resilience and heart rate variability as measured by the brief resilience scale and RMSSD, respectively, (2) the mentorship intervention has no effect on individual indices of HRV or mental health, nor the relationship between the two. Of note, this dissertation outlines the potential difference between psychological resilience to stress and the expression of mental health indices.

5.1 Relationship between HRV and resilience

During the first round of baseline data collection, RMSSD as a measure of HRV correlated positively with resilience scores, and negatively to anxiety. Because neither set of students had received an intervention at this time point, the group of 69 first year students were analyzed as a whole. The relationship presented was modest with resilience scores explaining about ten percent of the variance seen in RMSSD measured during sleep. A relationship between HRV and mental health scores was expected as research has linked daytime work stress to impaired HRV (Firstbeat Technologies Ltd., 2014), referred to HRV as a “resilience reserve” (Oken et al., 2015), and shown that increase in basal vagal tone is associated with an increase in stress resilience (Pereira et al., 2017). These relationships suggest that amongst first year University students, HRV monitoring may provide a quantitative means for interpreting the gradation of stress and anxiety experienced.

5.2 Effect of mentorship on relationship between HRV and resilience

The mentorship intervention appears to have no effect on the relationship between HRV and mental health. The initial correlation between RMSSD and BRS, while modest, persisted in the control participant group at the four-month follow-up point. The lack of relationship between RMSSD and BRS in the protégé group also persisted and was not observed after four months of mentorship. The consistent relationship over time, while not the same in both groups, speaks to the stability of these factors over a long period of time. The Bland-Altman analyses support the suggest that these observations were stable over four months in the control group suggesting that the lack of any change in the mentored group is real. Unless the physiological and psychological adaptations to stress differ temporally, we would not necessarily expect mentorship to alter this relationship. Instead, we would expect that an increase in HRV would be accompanied by an increase in resilience, and thus, the correlation would remain. The lack of relationship found within the protégé group may suggest that there exists a physiological response across some range of resilience so that one is not dependent upon the other. It has been suggested that HRV is simply a resilience factor (Drury, 2014). If so, then this interaction needs to be studied further. The current data indicate that although weakly related, RMSSD and BRS are stable but poorly affected by the four-month mentorship intervention.

It is possible that 3-4 months of intervention, or time between data collection sessions in the case of controls, is not enough time to see a change in RMSSD or resilience scores. The psychological survey assessing resilience is phrased in a way that evaluates "trait" resilience, for example, "I tend to bounce back quick". Because this is a trait based self-assessment, it is possible that even students who are improving their daily psychological resilience might not recognize these seemingly small changes over a short time frame. It is likely that someone who self-identifies as "taking long to recover from a stressful event" will not alter his or her self-perception built over several years in a matter of one semester. This means it is also possible that, while the mentorship model is not acutely effective, it may prove beneficial in the long term, or positively impact protégés further into their academic careers.

The finding that RMSSD and resilience do not improve following a mentorship intervention indicates that mentorship does not enhance HRV or resilience. Heart rate variability and resilience were also not different between protégé and control groups at any time, and the control values did not decrease throughout the semester. Thus the intervention did protect the HRV or resilience reserve of the protégés. That being said, the lack of change also indicates that the mentorship model was not harmful to participants and did not lead to a decrease in HRV or resilience, despite being demanding of time and energy. Participation required protégés to devote a minimum of two hours a week to group gatherings and lecture attendance, as well as complete graded reflections and assignments, participate in class discussions, attend class organized events such as fundraising or dodgeball games, and interact with peers regularly. This experience had the capacity to overwhelm first year students, especially those easily stressed out by timelines, responsibilities, and socially challenging situations. Yet, students displayed no markers for poor coping such as increased anxiety or decreased HRV and resilience.

5.3 Effect of mentorship on HRV and MH parameters

An analysis of variance shows that the average HRV and mental health scores also remain unchanged over time. It was hypothesized that we would see an increase in indices of HRV and improved scores on the BRS, GAD-7 and MHI in the protégé group, if the mentorship model was effective at improving resilience and the ability to cope with stress in the first-year students. Oppositely, we expected to see no change, or a decrease in HRV and resilience in the control group during their first four months of university. Instead, in both protégé and control groups, we saw no change in HRV or mental health indices. This finding speaks to the stability of these parameters and their resistance to change over a relatively short period of time.

The MHI does not show a relationship to RMSSD at any point, nor does the mean MHI score change over time. While the MHI has been identified as an index of overall mental health, it is less focused than the resilience and anxiety scales as it involves measures of depression, positive affect, and behavioral control. The testing for more psychological maladaptive states, as well as having 18 questions allows for more variability as well as the capturing of scores and factors not necessarily focused on resilience.

5.4 Limitations

Circadian rhythms, core body temperature, metabolism, the sleep cycle, physical activity, acute stress and a number of physiological systems contribute to 24 h HRV recordings. We analyzed sleeping RMSSD because it is the least interrupted physiological state, and the only period during which we could be relatively consistent in controlling for external factors. Taking long term 24h recordings would require sophisticated data processing to control for exercise and other things unrelated to stress activities, although 24h recordings are suggested as the “gold standard” for HRV recording (Shaffer & Ginsberg, 2017). Additionally, short term recordings are not necessarily a good estimate of long term values, thus, analyzing only a short period of sleeping RMSSD limits us in making inferences about the presented data. Notably, participants’ perception of stress related to being monitored may affect physiological HRV outcomes. While a limitation, the equipment we used does not allow for monitoring without the knowledge of the participant.

A second limitation posed by this study is the method of questionnaire completion. Students were allotted class time to complete the online questionnaires to ensure that they were submitted in a timely manner, and that students did not have to find extra time in their schedules to do so. However, completing questionnaires in class meant the students were both surrounded by peers, and possibly in a rush to finish in order to leave class early. Additionally, because sleeping values of RMSSD were used, HRV and questionnaire scores were not recorded simultaneously. While questionnaires were completed during the same two-week period as HRV was collected, the time between questionnaire completion and HRV recording varied among participants.

In terms of analysis, Firstbeat software artifact corrects based on a threshold for erroneous beats. Because this is automated, Firstbeat may eliminate R spikes that are real heartbeats, or include noise that is not attributed to real cardiac activity, affecting the HRV output. According to recent work by Laborde and colleagues (2017), visualizing the ECG signal and manually artifact correcting superior to automatic artifact correction. This contrasts our method and may prove superior in future studies. Additionally, the researcher analyzing heart rate tracings and selecting the sleep periods to analyze was not blinded to the participant number and should be in future studies to eliminate any bias for the protégé versus control group.

Finally, we struggled significantly with participant retention. Based on unpaired t-tests, there were no baseline differences in RMSSD (65.8±28.7, 73.4±30.8) or BRS scores (3.3±0.6, 3.4±0.6) for participants that dropped out after round one in comparison to those that completed the entire protocol. Thus we conclude that the dropout was not related to the baseline scores of a specific cohort within the population. The high rate of attrition may be a result of the long period of time between data collection sessions, leaving participants disengaged and uninterested in returning to participate at the end of the term. This was especially problematic during the pilot year when class attendance and intervention participation were not mandatory. Providing incentive in order to retain participants, such as research participation credit as employed in the psychology faculty, may prove an effective approach.

5.5 Conclusion

This study was the first to analyze sleeping RMSSD as a cardiac autonomic index of resilience in undergraduate students. This finding highlights the cardiodynamic associations with mental health and emphasizes the stability of this relationship as it remains unchanged over a 3-4 month time period. Finally, this study suggests that a mentorship intervention aimed at improving HRV and resilience among first year students has no impact and is neither helpful nor harmful. This may aid in research moving forward, focused on improving mental health and psychological resilience in the university student population.

References

Association, A. C. H. (2018). *American College Health Association-National College Health Assessment II: Undergraduate Student Reference Group Data Report Fall 2017*. Hanover, MD. Retrieved from http://www.acha-ncha.org/docs/NCHA-II_FALL_2017_REFERENCE_GROUP_EXECUTIVE_SUMMARY_UNDERGRADS_ONLY.pdf

Beauchaine, T. P. (2001). Vagal tone, development, and Gray's motivational theory: Toward an integrated model of autonomie nervous system functioning in psychopathology. *Development and Psychopathology*, *13*(2), 183–214. https://doi.org/10.1017/S0954579401002012

Berntson, G. G., Bigger, J. T. Jr., Eckberg, D. L., Grossman, P., Kaufmann, P. G., Malik, M., Nagaraja, H. N., … Van Der Molen, M. (1997). Heart Rate Variability: Origins, Methods and Interpretive Caveats. *Psychophysiology*. https://doi.org/10.1111/j.1469-8986.1997.tb02140.x

Berntson, G. G., Norman, G. J., Hawkley, L. C., & Cacioppo, J. T. (2008). Cardiac Autonomic Balance vs. Cardiac Regulatory Capacity. *Psychophysiology*, *45*(4), 643–652. https://doi.org/10.1111/j.1469-8986.2008.00652.x

Brandenberger, G., Buchheit, M., Ehrhart, J., Simon, C., & Piquard, F. (2005). Is slow wave sleep an appropriate recording condition for heart rate variability analysis? *Autonomic Neuroscience: Basic and Clinical*, *121*(1–2), 81–86. https://doi.org/10.1016/j.autneu.2005.06.002

Burton, N. W., Pakenham, K. I., & Brown, W. J. (2009). Evaluating the effectiveness of psychosocial resilience training for heart health, and the added value of promoting physical activity: A cluster randomized trial of the READY program. *BMC Public Health*, *9*, 1–9. https://doi.org/10.1186/1471-2458-9-427

Burton, N. W., Pakenham, K. I., & Brown, W. J. (2010). Feasibility and effectiveness of psychosocial resilience training: A pilot study of the READY program. *Psychology*, *Health and Medicine*, *15*(3), 266–277. https://doi.org/10.1080/13548501003758710

Danese, A., & McEwen, B. S. (2012). Adverse childhood experiences, allostasis, allostatic load, and age-related disease. *Physiology and Behavior*, *106*(1), 29–39. https://doi.org/10.1016/j.physbeh.2011.08.019

Dishman, R. K., Berthoud, H.-R., Booth, F. W., Cotman, C. W., Edgerton, V. R., Fleshner, M. R., … Zigmond, M. J. (2006). Neurobiology of Exercise. *Journal of Obesity*, *14*(3), 345–356. https://doi.org/10.1038/oby.2006.46

Draghici, A. E., & Taylor, J. A. (2016). The physiological basis and measurement of heart rate variability in humans. *Journal of Physiological Anthropology*, *35*(1), 22. https://doi.org/10.1186/s40101-016-0113-7

Drury, R. L. (2014). Wearable biosensor systems and resilience: A perfect storm in health care? *Frontiers in Psychology*, *5*(AUG), 1–5. https://doi.org/10.3389/fpsyg.2014.00853

Eisenberg, D., Hunt, J., & Speer, N. (2012). Help seeking for mental health on college campuses: Review of evidence and next steps for research and practice. *Harvard Review of Psychiatry*, *20*(4), 222–232. https://doi.org/10.3109/10673229.2012.712839

FirstBeat. (n.d.). Firstbeat BODYGUARD Quick Guide, 2.

Firstbeat Technologies Ltd. (2014). Stress and Recovery Analysis Method Based on 24-hour Heart Rate Variability, 1–13.

Friedman, B. H., & Thayer, J. F. (1998). Autonomic balance revisited: Panic anxiety and heart rate variability. *Journal of Psychosomatic Research*, *44*(1), 133–151. https://doi.org/10.1016/S0022-3999(97)00202-X

Griciūtė, A. (2016). Optimal Level of Participation in Sport Activities According to Gender and Age can be Associated with Higher Resilience: Study of Lithuanian Adolescents. *School Mental Health*, *8*(2), 257–267. https://doi.org/10.1007/s12310-

015-9155-y

Hall, M., Vasko, R., Buysse, D., Ombao, H., Chen, Q., Cashmere, J. D., … Thayer, J. F. (2004). Acute Stress Affects Heart Rate Variability During Sleep. *Psychosomatic Medicine*, *62*(1), 56–62. https://doi.org/10.1097/01.PSY.0000106884.58744.09

Heart rate variability: standards of measurement, physiological interpretation and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. (1996). *Circulation*, *93*(5), 1043–1065.

Herrman, H., Stewart, D. E., Diaz-Granados, N., Berger, E. L., Jackson, B., & Yuen, T. (2011). What is resilience? *Canadian Journal of Psychiatry*, *56*(5), 258–265. https://doi.org/10.1177/070674371105600504

Holmes, P. V. (2014). Trophic Mechanisms for Exercise-Induced Stress Resilience: Potential Role of Interactions between BDNF and Galanin. *Frontiers in Psychiatry*, *5*(July), 1–5. https://doi.org/10.3389/fpsyt.2014.00090

Hunt, J., S, M., Eisenberg, D., & Ph, D. (2010). Mental Health Problems and Help-Seeking Behavior Among College Students. *Journal of Adolescent Health*, *46*(1), 3–10. https://doi.org/10.1016/j.jadohealth.2009.08.008

Josefsson, T., Lindwall, M., & Archer, T. (2014). Physical exercise intervention in depressive disorders: meta-analysis and systematic review. *Scandinavian Journal of Medicine & Science in Sports*, *24*(2), 259–72. https://doi.org/10.1111/sms.12050

Jurysta, F., Van De Borne, P., Migeotte, P. F., Dumont, M., Lanquart, J. P., Degaute, J. P., & Linkowski, P. (2003). A study of the dynamic interactions between sleep EEG and heart rate variability in healthy young men. *Clinical Neurophysiology*, *114*(11), 2146–2155. https://doi.org/10.1016/S1388-2457(03)00215-3

Kramer, D., Hillman, S. M., & Zavala, M. (2018). Developing a Culture of Caring and Support Through a Peer Mentorship Program. *Journal of Nursing Education*, *57*(7), 430–435. https://doi.org/10.3928/01484834-20180618-09

Laborde, S., Mosley, E., & Thayer, J. F. (2017). Heart rate variability and cardiac vagal tone in psychophysiological research - Recommendations for experiment planning, data analysis, and data reporting. *Frontiers in Psychology*, *8*(FEB), 1–18. https://doi.org/10.3389/fpsyg.2017.00213

Lehrer, P. M., & Gevirtz, R. (2014). Heart rate variability biofeedback: how and why does it work? *Frontiers in Psychology*, *5*(JUL), 756. https://doi.org/10.3389/fpsyg.2014.00756

Maier, S. F., & Watkins, L. R. (2005). Stressor controllability and learned helplessness: The roles of the dorsal raphe nucleus, serotonin, and corticotropin-releasing factor. *Neuroscience and Biobehavioral Reviews*, *29*(4–5), 829–841. https://doi.org/10.1016/j.neubiorev.2005.03.021

Malik, M. (1996). Heart Rate Variability. *Annals of Noninvasive Electrocardiology*, *1*(2), 151–181. https://doi.org/10.1111/j.1542-474X.1996.tb00275.x

McCraty, R., & Shaffer, F. (2015). Heart rate variability: New perspectives on physiological mechanisms, assessment of self-regulatory capacity, and health risk. *Global Advances In Health and Medicine*, *4*(1), 46–61. https://doi.org/10.7453/gahmj.2014.073

Moljord, I. E. O., Moksnes, U. K., Espnes, G. A., Hjemdal, O., & Eriksen, L. (2014). Physical activity, resilience, and depressive symptoms in adolescence. *Mental Health and Physical Activity*, *7*(2), 79–85. https://doi.org/10.1016/j.mhpa.2014.04.001

O'Connell, M. J., Sledge, W. H., Staeheli, M., Sells, D., Costa, M., Wieland, M., & Davidson, L. (2018). Outcomes of a Peer Mentor Intervention for Persons With Recurrent Psychiatric Hospitalization. *Psychiatric Services*, (July), appi.ps.2016004. https://doi.org/10.1176/appi.ps.201600478

Oken, B. S., Chamine, I., & Wakeland, W. (2015). A systems approach to stress, stressors and resilience in humans. *Behavioural Brain Research*, *282*, 144–154.

https://doi.org/10.1016/j.bbr.2014.12.047

Paton, J. F. R., Boscan, P., Pickering, A. E., & Nalivaiko, E. (2005). The yin and yang of cardiac autonomic control: Vago-sympathetic interactions revisited. *Brain Research Reviews*, *49*(3), 555–565. https://doi.org/10.1016/j.brainresrev.2005.02.005

Pereira, V. H., Campos, I., & Sousa, N. (2017). The role of autonomic nervous system in susceptibility and resilience to stress. *Current Opinion in Behavioral Sciences*, *14*, 102–107. https://doi.org/10.1016/j.cobeha.2017.01.003

Pittenger, C., & Duman, R. S. (2008). Stress, Depression, and Neuroplasticity: A Convergence of Mechanisms. *Neuropsychopharmacology Reviews*, *33*, 88–109. https://doi.org/10.1038/sj.npp.1301574

Portugal, E. M. M., Cevada, T., Sobral Monteiro-Junior, R., Teixeira Guimarães, T., Da Cruz Rubini, E., Lattari, E., … Camaz Deslandes, A. (2013). Neuroscience of exercise: From neurobiology mechanisms to mental health. *Neuropsychobiology*, *68*(1), 1–14. https://doi.org/10.1159/000350946

Purves D, Augustine GJ, Fitzpatrick D, et al., E. (2001). *Autonomic Regulation of Cardiovascular Function. Neuroscience* (2nd ed.). Sunderland (MA): Sinauer Associates. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK11075/

Reddy, P. V. (2017). Awareness on Mental Health Problems and Help Seeking. *Original Research Paper The International Journal of Indian Psychology ISSN*, *5*(1), 2348–5396. https://doi.org/10.25215/0501.082

Rice, K. G., Leever, B. A., Christopher, J., & Porter, J. D. (2006). Perfectionism, stress, and social (dis)connection: A short-term study of hopelessness, depression, and academic adjustment among honors students. *Journal of Counseling Psychology, 53*(4), 524–534. https://doi.org/10.1037/0022-0167.53.4.524

Sami, S., Mikko, S., & Antti, K. (2004). Artefact Correction for Heart Beat Interval Data, 1–10.

Sciolino, N. R., & Holmes, P. V. (2012). Exercise offers anxiolytic potential: A role for stress and brain noradrenergic-galaninergic mechanisms. *Neuroscience and Biobehavioral Reviews*, *36*(9), 1965–1984. https://doi.org/10.1016/j.neubiorev.2012.06.005

Sciolino, N. R., Smith, J. M., Stranahan, A. M., Freeman, K. G., Edwards, G. L., Weinshenker, D., & Holmes, P. V. (2015). Galanin mediates features of neural and behavioral stress resilience afforded by exercise. *Neuropharmacology*, *89*, 255–264. https://doi.org/10.1016/j.neuropharm.2014.09.029

Shaffer, F., & Ginsberg, J. P. (2017). An Overview of Heart Rate Variability Metrics and Norms. *Frontiers in Public Health*, *5*(September), 1–17. https://doi.org/10.3389/fpubh.2017.00258

Shaffer, F., McCraty, R., & Zerr, C. L. (2014). A healthy heart is not a metronome: an integrative review of the heart’s anatomy and heart rate variability. *Frontiers in Psychology*, *5*(September), 1040. https://doi.org/10.3389/fpsyg.2014.01040

Skrove, M., Romundstad, P., & Indredavik, M. S. (2013). Resilience, lifestyle and symptoms of anxiety and depression in adolescence: The Young-HUNT study. *Social Psychiatry and Psychiatric Epidemiology*, *48*(3), 407–416. https://doi.org/10.1007/s00127-012-0561-2

Smith, B. W., Dalen, J., Wiggins, K., Tooley, E., Christopher, P., & Bernard, J. (2008). The brief resilience scale: Assessing the ability to bounce back. *International Journal of Behavioral Medicine*, *15*(3), 194–200. https://doi.org/10.1080/10705500802222972

Sontag-Padilla, L., Dunbar, M. S., Ye, F., Kase, C., Fein, R., Abelson, S., … Stein, B. D. (2018). Strengthening College Students’ Mental Health Knowledge, Awareness, and Helping Behaviors: The Impact of Active Minds, a Peer Mental Health Organization. *Journal of the American Academy of Child and Adolescent Psychiatry*, *57*(7), 500–507. https://doi.org/10.1016/j.jaac.2018.03.019

Spitzer, R. L., Kroenke, K., Williams, J. B. W., & Löwe, B. (2006). A Brief Measure for Assessing Generalized Anxiety Disorder. *Archives of Internal Medicine*, *166*(10), 1092. https://doi.org/10.1001/archinte.166.10.1092

Stein, P. K., Bosner, M. S., Kleiger, R. E., & Conger, B. M. (1994). Heart rate variability: a measure of cardiac autonomic tone. *American Heart Journal*, *127*(5), 1376–1381.

Stein, P. K., & Kleiger, R. E. (1999). Insights from the study of heart rate variability. *Annual Review of Medicine*. https://doi.org/10.1146/annurev.med.50.1.249

Stubbs, B., Koyanagi, A., Hallgren, M., Firth, J., Richards, J., Schuch, F., … Vancampfort, D. (2017). Physical activity and anxiety: A perspective from the World Health Survey. *Journal of Affective Disorders*, *208*. https://doi.org/10.1016/j.jad.2016.10.028

Taylor, J. S., Faghri, S., Aggarwal, N., Zeller, K., Dollase, R., & Reis, S. P. (2013). Developing a Peer-Mentor Program for Medical Students. *Teaching and Learning in Medicine*, *25*(1), 97–102. https://doi.org/10.1080/10401334.2012.741544

Thayer, J. F., & Lane, R. D. (2009). Claude Bernard and the heart-brain connection: Further elaboration of a model of neurovisceral integration. *Neuroscience and Biobehavioral Reviews*. https://doi.org/10.1016/j.neubiorev.2008.08.004

Tobaldini, E., Nobili, L., Strada, S., Casali, K. R., Braghiroli, A., & Montano, N. (2013). Heart rate variability in normal and pathological sleep. *Frontiers in Physiology*, *4*(October), 1–11. https://doi.org/10.3389/fphys.2013.00294

van Ravenswaaij-Arts, C. M., Kollee, L. A., Hopman, J. C., Stoelinga, G. B., & van Geijn, H. P. (1993). Heart rate variability. *Annals of Internal Medicine*, *118*(6), 436–447.

Vandal, N., Leung, K., Sanzone, L., Filion, F., Tsimicalis, A., & Lang, A. (2018). Exploring the Student Peer Mentor's Experience in a Nursing Peer Mentorship Program. *Journal of Nursing Education*, *57*(7), 422–425. https://doi.org/10.3928/01484834-20180618-07

Veit, C. T., & Ware, J. E. (1983). The structure of psychological distress and well-being in general populations. *Journal of Consulting and Clinical Psychology*, *51*(5), 730–742. https://doi.org/10.1037/0022-006X.51.5.730

Voss, M. W., Vivar, C., Kramer, A. F., & van Praag, H. (2013). Bridging animal and human models of exercise-induced brain plasticity. *Trends in Cognitive Sciences*. https://doi.org/10.1016/j.tics.2013.08.001

Weinshenker, D., & Holmes, P. V. (2016). Regulation of neurological and neuropsychiatric phenotypes by locus coeruleus-derived galanin. *Brain Research, 1641*, 320–337. https://doi.org/10.1016/j.brainres.2015.11.025

Appendices

Appendix A: Ethics Approval

Western Research

Research Ethics

Western University Health Science Research Ethics Board
HSREB Delegated Initial Approval Notice

Principal Investigator: Dr. Kevin Shoemaker
Department & Institution: Health Sciences/Kinesiology, Western University

Review Type: Delegated
HSREB File Number: [illegible]
Study Title: Smart, Healthy Campus

HSREB Initial Approval Date: November 11, 2016
HSREB Expiry Date: November 11, 2017

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Revised Western University Protocol	Received November 10, 2016	
Letter of Information & Consent	Phase 2 - Version 2	2016/11/01
Letter of Information & Consent	Phase 3 - Version 2	2016/11/01
Instruments	Sense of Belonging Scale	
Instruments	SF-36	
Instruments	Mental Health Survey	
Instruments	NVRL health questionnaire	2016/05/24
Instruments	Brief Resilience Scale	
Instruments	Flourishing Scale	
Instruments	International Physical Activity Questionnaire	
Instruments	anxiety, visual analog scale	
Instruments	Thriving CIT	
Instruments	Alcohol Use Questionnaire	
Instruments	GAD-7	
Instruments	24 hour diet recall	
Other	Academic counselor discharge codes	
Other	Notification Letter re: access to student health services database	2016/09/29
Other	Notification Letter re: permission to access Student Experience Databases	2016/10/17
Advertisement	Received November 4, 2016	
Instruments	December Interviews/Focus Groups	
Instruments	Appendix A - Semi Structured Interview Guide for Mentors	2016/09/29

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the above named study, as of the HSREB Initial Approval Date noted above.

HSREB approval for this study remains valid until the HSREB Expiry Date noted above, conditional to timely submission and acceptance of HSREB Continuing Ethics Review.

The Western University HSREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use Guideline for Good Clinical Practice Practices (ICH E6 R1), the Ontario Personal Health Information Protection Act (PHIPA, 2004), Part 4 of the Natural Health Product Regulations, Health Canada Medical Device Regulations and Part C, Division 5, of the Food and Drug Regulations of Health Canada.

Members of the HSREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

Western University, Research, Support Services Bldg., Rm. 5150
London, ON, Canada N6G 1G9 t. 519.661.3036 f. 519.850.2466 www.uwo.ca/research/ethics

Western Research

Research Ethics

Western University Health Science Research Ethics Board
HSREB Amendment Approval Notice

Principal Investigator: Dr. Kevin Shoemaker
Department & Institution: Health Sciences\Kinesiology,Western University

Review Type: Delegated
HSREB File Number: 108318
Study Title: Smart, Healthy Campus

HSREB Amendment Approval Date: September 15, 2017
HSREB Expiry Date: November 11, 2017

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Revised Western University Protocol	Received August 28, 2017	
Revised Letter of Information & Consent	Phase 2	2017/08/26
Revised Letter of Information & Consent	Phase 3	2017/08/26
Other	Publication re: Recovery-Stress Questionnaire	2017/08/26
Instruments	Engage Grant RESTQ Adaptation	
Other	Logit AI app - Explanation	
Instruments	Lubben Social Network Scale	
Instruments	Survey	2017/08/25
Instruments	Objectives for restq1 questionnaire	
Other	RESTQ Interpretation of Results	
Instruments	Screenshot of Wellness Log	
Instruments	TEIQue-SF	

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the amendment to the above named study, as of the HSREB Initial Approval Date noted above.

HSREB approval for this study remains valid until the HSREB Expiry Date noted above, conditional to timely submission and acceptance of HSREB Continuing Ethics Review.

The Western University HSREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use Guideline for Good Clinical Practice Practices (ICH E6 R1), the Ontario Personal Health Information Protection Act (PHIPA, 2004), Part 4 of the Natural Health Product Regulations, Health Canada Medical Device Regulations and Part C, Division 5, of the Food and Drug Regulations of Health Canada.

Members of the HSREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

Western University, Research, Support Services Bldg., Rm. 5150
London, ON, Canada N6G 1G9 t. 519.661.3036 f. 519.850.2466 www.uwo.ca/research/ethics

Appendix B: Letter of Information and Consent

Western HealthSciences

LETTER OF INFORMATION AND CONSENT

A prospective population study on ambulatory heart-rate variability (HRV)

Principal Investigator: Kevin Shoemaker, PhD

Co-Investigators:
Baraa Al-Khazraji, PhD
Arlene Fleischhauer, RN
Dave Humphreys, MScPT
Kolten Abbott, MSc
Mark Badrov, MSc
Stephen Klassen, MSc
Katelyn Norton, MSc

Contact Information:
Neurovascular Research Laboratory
Thames Hall Rm 3110
Western University
London ON N6A 3K7

Name of Sponsor: *Natural Sciences and Engineering Research Council* of Canada

Conflict of Interest: There are no conflict of interests to declare

Introduction and Purpose:

The pronouns “you” and “your” in the letter should be read as referring to the participant rather than the substitute decision maker who may be signing the consent form. If you are a substitute decision maker (i.e. someone who makes the decision about participation on behalf of a study participant) please remember that “you” refers to the study participant.

You are being asked to voluntarily take part in a research study that will examine the relationship between your personal and physical characteristics and your heart’s pattern of beating. It is believed that your heart’s pattern of beating could be a good measure of your health; however, we do not know which lifestyle variables influence this measure. In order to answer this question, you will be asked to complete a series of questionnaires regarding your health, personality, job and social class and then wear a monitor that measures your heart rate and how you move. This small device (about the size of a small cookie) may be worn for up to 72 hours. To complete this study we will be recruiting approximately 2000 individuals between 14-30 years of age.

Before agreeing to participate, please read this Letter of Information and ask any questions you may have.

Participant Inclusion Criteria:

To be included in this study you must be able to walk without assistance, and be between 14-30 years old.

Participant Exclusion Criteria:

You will not be included in the study if you have been or are: 1) diagnosed with a terminal illness, 2) prescribed anti-hypertensive/ADHD/ADD/depression medications 3) pregnant or 4) unable to provide written informed consent, due to language or cognitive difficulties.

Study Design and Procedures:

If you agree to participate in this study, you will be asked to wear the heart rate (HR) monitor for up to 72 hours. You will be required to meet with the research team for up to 1 hour at baseline (prior to enrolling in the investigation), and for 15 minutes at each subsequent data collection period (up to 10 times, while enrolled in the study). The baseline examination will consist of blood pressure, height and weight measurements, pencil and paper questionnaires on your health, personality, job and social class and 10 minutes of HR analysis while lying on your back in a quiet room. The 15 minute meeting at each subsequent data collection period will consist of 10 min of HR analysis, height and weight measurements and a single questionnaire, which details any changes in your health status. Baseline and pre-collection meetings will either take place at Western University (Neurovascular Research Laboratory or Laboratory for Brain and Heart Health) or at location that works best for you or your team (i.e. your team's practice facility, the soccer pitch etc.). It's important to note that data collection may be for 72 hours straight or over several time periods, such as 10 hours each for 7 days. While wearing the HR monitor you will be asked to document your sleep, physical activity, diet and mood, periodically.

<u>Experimental Measures</u>:

1. <u>Firstbeat HR Monitors</u>: The heart rate (HR) monitor will be connected to your skin either via an elastic strap or 2 adhesive electrodes. Once attached the Firstbeat monitor will begin to record and store HR data.
2. <u>Blood Pressure</u>: Blood pressure will be assessed prior to data collection using a blood pressure cuff like they do in a doctor's office.
3. <u>General Health and Contact Information</u>: You will be asked to provide us with your first and last name, year of birth, sex, postal code, email and a list of current medications/contraceptives.
4. <u>Tanner Puberty Scale</u>: If you are between the age of 14 and 18 you will be asked to complete the Tanner questionnaire, which requires you to circle the images that best reflect your current body status.
5. <u>Anxiety Questionnaires</u>: Two paper and pencil measures of anxiety are included: The GAD-7 evaluates your anxiety over the last week. The Visual Analog Scale evaluates your anxiety at that specific moment in time.
6. <u>International Physical Activity Questionnaire:</u> A 27-question survey regarding your physical activity over the last 7 days.
7. <u>Mental Health Inventory (MHI):</u> A set of 18 questions about how you felt over the past four weeks.
8. <u>Health Status Questionnaire:</u> A 36-question survey, which asks your views on your health and daily activities.
9. <u>Alcohol Use Disorders Identification Questionnaire (AUDIT):</u> A 10-question survey devised by the World Health Organization (WHO) to quantify your frequency and volume of alcohol

consumption.

10. WHO MONICA Project Smoking Questionnaire: A 14-question survey, which evaluates your current and historical use of tobacco.
11. NVRL Concussion Questionnaire: After being read a standardized definition of concussion, you will be asked 4 questions regarding your concussion history.
12. Brief Resilience Scale: A 6-item questionnaire that asses how you bounce back/recover from stress.
13. NVRL Socioeconomic Questionnaire: A 5-question survey which will provide insight into your education, employment and salary, if applicable.
14. 24-hour Dietary Recall: With the aid of a research assistant you will be asked to recall your food and beverage consumption over the past 24 hours.
15. Log-book: While wearing the HR monitor, you will be asked to record your sleep, physical activity, mood and diet, periodically. To evaluate sleep you will complete a 15-question true/false survey, each morning of data collection.

Voluntary Participation:

Your participation in this study is voluntary. You may refuse to participate or answer any questions.

Withdrawal from Study:

You may withdraw from the study at any time with no effect on your future academic status or employment.

Risks:

1. Firstbeat HR Monitors: Heart rate (HR) monitors will be attached to your skin either via an elastic chest strap or two adhesive electrodes (similar to a conventional electrocardiogram at a doctor's office). It is possible that the electrode paste and/or chest strap could cause skin irritation or a small rash. However, this irritation/rash should disappear in a day or two.
2. Questionnaires: Some of the questionnaires may be upsetting. If you experience feelings of anxiety or become upset by the nature of the questions, please speak to the researcher immediately and referral to adequate support will be provided.

Benefits:

There may be no benefit to participate in this investigation.

Reminders and Responsibilities:

If you are participating in another study at this time, please inform the study coordinator right away to determine if it is appropriate for you to participate in this study.

Whether you agree to participate in this study or not, you will be asked if you consent to having your name and contact information added to a master database of individuals who would be willing to be contacted in the future regarding your interest in other research studies.

Representatives of the Western University Health Sciences Research Ethics Board may contact you or require access to your study-related records to monitor the conduct of the research.

Alternatives to Being in the Study:
You may choose not to participate in this study.

Confidentiality:

Your research records will be stored for up to 20 years in a secure office at Western University. To further protect your confidentiality, your name will be replaced with a subject ID number on all documents. The master list linking your identity and subject ID number and your contact information will be stored separately in a secure office at Western University. Your contact information will be securely maintained at Western University to allow for setting up follow up visits. If the results of the study are published, your name will not be used and no information that discloses your identity will be released or published. No information that could reveal your identity will be released to anyone. If you decide to leave the study, the information about you that was collected before you left the study will be deleted upon your request.

If we find information we are required by law to disclose, we cannot guarantee confidentiality.

Please be aware that Representatives of the Western University Health Sciences Research Ethics Board and/or Lawson Quality Assurance Education Program may contact you or may require access to your study related records to monitor the conduct of the research.

Costs:
There is no cost to participate in this study.

Compensation

You will not be compensated for your participation in this study.

Rights as a Participant:

If you have any questions about your rights as a research participant or the conduct of the study you may contact: UWO Office of Research Ethics, Support Services Building, Western University, London, Ontario, Canada N6A 3K7

You will receive a copy of the fully signed informed consent document for your records. You do not waive any legal rights by signing the consent form.

Questions about the Study:

If you have any questions about the study, please contact:

Research Coordinator: Arlene Fleischhauer
Principal Investigator: Dr. Kevin Shoemaker

Please note that email is not considered a secure method of communication and you should not send any personal health information via email.

Principal Investigator: Dr. Kevin Shoemaker

CONSENT

I have read the letter of information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

SIGNATURES

Name of Participant (print):

____

Signature of Participant: ____________________________________ Date:

____

Name of Substitute Decision Maker (print):

____

Signature of Substitute Decision Maker: __________________________ Date:

____

Name of Person Obtaining Consent (print):

____

Signature of Participant: ____________________________________ Date: __________________

Do you consent to be contacted by the investigators for future research? YES ☐ NO ☐

Signature: ______________________________________

Appendix C: Mental Health Questionnaires

GENERALIZED ANXIETY QUESTIONNAIRE

Generalized Anxiety Disorder 7-item (GAD-7) scale

Over the last 2 weeks, how often have you been bothered by the following problems?	Not at all sure	Several days	Over half the days	Nearly every day
1. Feeling nervous, anxious, or on edge	0	1	2	3
2. Not being able to stop or control worrying	0	1	2	3
3. Worrying too much about different things	0	1	2	3
4. Trouble relaxing	0	1	2	3
5. Being so restless that it's hard to sit still	0	1	2	3
6. Becoming easily annoyed or irritable	0	1	2	3
7. Feeling afraid as if something awful might happen	0	1	2	3
Add the score for each column	+	+	+	
Total Score *(add your column scores)* =				

If you checked off any problems, how difficult have these made it for you to do your work, take care of things at home, or get along with other people?

Not difficult at all __________
Somewhat difficult _________
Very difficult _____________
: Extremely difficult _________

BRIEF RESILIENCE SCALE

Please respond to each item by marking one box per row:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I tend to bounce back quickly after hard times					
I have a hard time making it through stressful events					
It does not take me long to recover from a stressful event					
It is hard for me to snap back when something bad happens					
I usually come through difficult times with little trouble					
I tend to take a long time to get over set-backs in my life					

MENTAL HEALTH INVENTORY (MHI)

The next set of questions are about how you feel, and how things have been for you during the past 4 weeks. If you are marking your own answers, please circle the appropriate response (0, 1, 2,...). If you need help in marking your responses, tell the interviewer the number of the best response. Please answer every question. If you are not sure which answer to select, please choose the one answer that comes closest to describing you. The interviewer can explain any words or phrases that you do not understand.

During the past 4 weeks, how much of the time...

	All of the time	Most of the time	A good bit of the time	Some of the time	A little bit of the time	None of the time
1. has your daily life been full of things that were interesting to you?	1	2	3	4	5	6
2. did you feel depressed?	1	2	3	4	5	6
3. have you felt loved and wanted?	1	2	3	4	5	6
4. have you been a very nervous person?	1	2	3	4	5	6
5. have you been in firm control of your behavior, thoughts, emotions, feelings?	1	2	3	4	5	6

During the past 4 weeks, how much of the time...

	All of the time	Most of the time	A good bit of the time	Some of the time	A little bit of the time	None of the time
6. have you felt tense or high-strung?	1	2	3	4	5	6
7. have you felt calm and peaceful?	1	2	3	4	5	6
8. have you felt emotionally stable?	1	2	3	4	5	6
9. have you felt downhearted and blue?	1	2	3	4	5	6
10. were you able to relax without difficulty?	1	2	3	4	5	6
11. have you felt restless, fidgety, or impatient?	1	2	3	4	5	6
12. have you been moody, or brooded about things?	1	2	3	4	5	6
13. have you felt cheerful, light-hearted?	1	2	3	4	5	6
14. have you been in low or very low spirits?	1	2	3	4	5	6
15. were you a happy person?	1	2	3	4	5	6

During the past 4 weeks, how much of the time...

	All of the time	Most of the time	A good bit of the time	Some of the time	A little bit of the time	None of the time
16. did you feel you had nothing to look forward to?	1	2	3	4	5	6
17. have you felt so down in the dumps that nothing could cheer you up?	1	2	3	4	5	6
18. have you been anxious or worried?	1	2	3	4	5	6

Appendix D: Activity Diary

<u>Daily Log:</u>

Please record all relevant and necessary information regarding the next *<u>24-48 hours</u>*

Time	**Caffeine Consumption**	**Alcohol Consumption**	**Exercise** (type & duration)	**Academic Activity** (type & duration)	**Sleep** (duration)
e.g. 16h10	*1 medium coffee*	*5oz red wine*	*Cardio (45mins)*	*Wrote exam (2h)*	*Nap (30mins)*
06h00					
07h00					
08h00					
09h00					
10h00					
11h00					
12h00					
13h00					
14h00					
15h00					
16h00					
17h00					
18h00					
19h00					
20h00					
21h00					
22h00					
23h00					
00h00					
01h00					
02h00					
03h00					
04h00					
05h00					

Curriculum Vitae

Rachel Knetsch

EDUCATION

Western University
MSc Kinesiology, Integrative Biosciences, 2018 (expected)
Thesis: Cardiodynamic Associations with Resilience in Undergraduate Students and the Effect of a Mentorship Intervention
Advisor: Kevin Shoemaker

Western University
BMSc Physiology and Interdisciplinary Medical Science, 2016

HONOURS & AWARDS

2016- 2017 Western Graduate Research Scholarship ($5,700 CAD)
2017- 2018 Western Graduate Research Scholarship ($5,700 CAD)

RESEARCH CONTRIBUTIONS

Knetsch, R et al. (2018). Cardiodynamic Associations with Mental Health and Resilience in Undergraduate Students. *Experimental Biology*, San Diego, CA, USA. April 2018. Poster.

TEACHING ASSISTANTSHIPS

Western University, School of Kinesiology, Kinesiology 3330F, Laboratory in Exercise Physiology. September-December 2016.

Western University, School of Kinesiology, Kinesiology 4433B, Physiology of Exercise Training. January-April 2017.

Western University, School of Kinesiology, Kinesiology 3333Y, Leadership in Physical Activity. September 2017-April 2018.