Anne Burnett School of Medicine at Texas Christian University

Heart Rate Variability Training in U.S. Military Veterans and their Caregivers—The Power of Two

Research Project Final Thesis

Josiah Snowden

3/21/2024

Abstract

Research Question

In United States Armed Forces veterans with invisible wounds of war, such as posttraumatic stress (PTS) and traumatic brain injury (TBI), does training Heart Rate Variability (HRV) in sessions with a trusted companion going through the training with the participant lead to significant further improvement in self-reported executive cognitive function, and general mental and physical well-being for the veteran when compared to the improvements seen in veterans who are trained in one-on-one sessions with a licensed coach?

Background, Significance, and Rationale for the Question

HRV, which is a measurement of how "in sync" our bodily systems are, is an important indicator of health, fitness, and stress resilience. Low variability can indicate that an individual is functioning below optimal physical, cognitive, or emotional levels. Conversely, optimal HRV reflects a healthy balance between both branches of the autonomic nervous system (ANS) and represents an individual's resilience and ability to adapt to physical and mental stress. Negative emotions such as stress, anger, and worry foster ANS imbalance. In contrast, sincere, positive feeling states result in balance, order, and stability that, when practiced regularly, with deep breathing, improve HRV. While there have been many studies that have illustrated the benefits of HRV training for those coping with emotional distress, there is a lack of robust research exploring the effects of simultaneously training close friends or family in HRV.

Materials and Methods

A prospective cohort study was performed. Veterans enrolled in Boot Campaign's Stress and Resilience program and an identified trusted caregiver/companion underwent an individual, but simultaneous, interactive HRV-training program based upon a standardized, culturally competent curriculum for a period of 5 weeks. This program, led by a credentialed and experienced coach teaches evidence-based tools that can be used in real-time to help manage stress, build resilience capacity, and optimize performance. Outcomes were collected prior to the commencement of the coaching protocol and again at the conclusion of training. Standardized self-report outcome measures were then utilized to assess program efficacy. We compared pre and post intervention survey results to measure participant progress over the course of our study using both paired t-tests and nonparametric independent t-tests.

Results

We found that veterans who have a trusted companion (caregiver or significant other) that simultaneously undergoes the HRV training had greater improvements in a reduction of stress, anxiety, fatigue, burnout, and depression and a greater improvement in executive cognitive function, and general mental and physical well-being when compared to their baseline values obtained before the simultaneous training began.

Discussion/Conclusion

We believe that these improvements were due to improvements in the HRV measures of the veterans. While these results can be used by Boot Campaign and similar veteran-centered

organizations to drive treatment, other professional groups such as first responders and physicians, who deal with high rates of stress, including posttraumatic stress, could also benefit from the therapeutic implications of this study.

Research Question

In United States Armed Forces veterans with invisible wounds of war, such as posttraumatic stress and traumatic brain injury, does the simultaneous training of a trusted caregiver/companion in HRV in addition to the veteran's training in HRV lead to improvement in self-reported executive cognitive function, and general mental and physical well-being for the veteran when compared to their baseline values obtained before the simultaneous training began?

Hypothesis: We hypothesize that veterans trained with trusted companions will have greater increases in their self-reported executive cognitive function, and general mental and physical well-being after HRV training both compared to their baseline before the simultaneous training began and their peers who underwent the same training just without a trusted companion.

Introduction, Significance, and Rationale

Introduction

It is no secret that chronic stress is highly linked to declines in well-being and can be a precursor to depression, cardiovascular disease, the progression of chronic disease, and cancer.[1] What has stumped researchers has been why certain individuals experience long-term impact on mental health, such as posttraumatic stress disorder (PTSD), following stressful events and others do not. In the traditional model, factors such as the cognitive appraisal of the event, coping mechanisms, and other behavioral differences have been attributed to these differences.[2] On the other hand, newer models illustrate the benefits of including psychophysiological responses for a more complete understanding of the beforementioned differences.[3]

It has been noted that higher perceived levels of chronic stress can lead to future stress hypersensitivities as observed through maladaptive responses by participants to a novel stressor.[4] PTSD has been seen to be a major cause of chronic stress.[5] Some of the core features of PTSD are the persistence of intense, distressing, and fearfully avoided reactions to reminders of the triggering event. This condition also leads to alteration in mood and cognition, pervasive sense of threat, disturbed sleep, and hypervigilance.[6] These symptoms all lead to decreases in the overall wellbeing of the affected individuals.

A major area of research is how the prefrontal cortex (PFC), the region of the brain known for controlling executive function, is affected by exposure to trauma and its sequelae, and how this can lead to lasting psychological injuries. It has been documented that most forms of psychological injuries, including PTSD, are linked to PFC dysfunction.[7,8] In order to study the PFC in states of stress, researchers look to respiratory sinus arrhythmia (RSA) and HRV as peripheral biomarkers for PFC function.[9] RSA is a naturally occurring variation in heart rate that occurs during the breathing cycle and HRV is the variation in the interval between heartbeats.[10] RSA is directly proportional to HRV. It is important to note that the basis for measuring HRV as a proxy for PFC function, as well as parasympathetic and sympathetic nervous system (PSNS and SNS) health, stems from the knowledge that the vagus nerve links the brain and heart in both structure and function.[11] There have been many studies outlining the link between HRV and general affect and HRV has been shown to be an effective biomarker of top-down self-regulation (regulation of behavior, cognitive, and emotional processes).[12] The state of physiological balance that is achieved when HRV, respiration, and the baroreflex are in equilibrium is referred to as HRV coherence. In coherence, the vagal parasympathetic tone increases, pulmonary gas exchange is optimized, and balance between the ANS and cardiopulmonary system is achieved.[13]

Individuals with lower HRV report overall more negative moods when compared to those with high HRV.[14] Additionally, those with lower HRV have an even greater negative emotional effect when exposed to the same psychological stressor.[15] This is very significant because not only will

those with lower HRV have generally worse emotional regulation and affect, but they will also be affected more negatively by stressors throughout their lives. Improvements in HRV have the potential to stop the negative snowball of emotional dysregulation that can result from a low initial HRV and the onset of additional traumas. It is also important to note that HRV is considered a highly heritable trait.[16] Differences in heritability among individuals may partially explain why some are able to make it through traumatic situations without lasting psychopathologies while others are exposed to similar or the same trauma experience injury.

Luckily, HRV is not a fixed physiologic trait and can be improved through training.[17] Furthermore, HRV biofeedback training alone has been shown to be associated with large reductions in self-reported stress and anxiety over many different studies, many of which have focused specifically on patients with PTSD.[18,19]

There are many different proposed ways to improve HRV through training. Breathing at resonance frequency (RF, about 6 breaths/ min), is a technique included in many HRV training models and has been shown to not only improve HRV but also to increase mood and decrease blood pressure.[20] While there are a variety of factors shown to improve HRV, such as exercise, our study focuses on the use of resonance breathing and positive emotion recall training to improve HRV in Boot Campaign's veteran families[21,22]

Significance

According to the American Psychiatric Association, PTSD is defined as a psychiatric condition that may occur in people who have experienced or witnessed a traumatic event such as a natural disaster, a serious accident, a terrorist act, war/combat, or rape or who have been threatened with death, sexual violence, or serious injury. Members of the United States armed forces have been describing the diagnosis of what we now call PTSD in numerous ways over the past century. In World War I, this condition was referred to as "shell shock", in World War II, it was called "battle fatigue", and in the Vietnam war, "post-Vietnam syndrome". As awareness of PTSD has risen, so have the number of US military members who have sought treatment for this condition. It is estimated that about 700,000 Vietnam veterans, 25% of those who served, have been treated for PTSD-related symptoms.[23] A 2013 study of Iraq and Afghanistan veterans found that 13.5% of deployed and nondeployed veterans screened positive for PTSD.[24]

Veterans with PTSD have been shown to have significantly less responsive HRV when compared to those without PTSD. Furthermore, HRV biofeedback training has been shown to significantly improve the PTSD symptoms of combat veterans.[25] In one pilot study, a veteran offered the following quote about the effects of HRV biofeedback training in his own life, "*I am an OIF and Gulf War veteran. I recently returned from Iraq, where I experienced 5 IEDs and 1 RPG explosions. To deal with all the pain I felt after I got back I self-medicated for several months with alcohol and marijuana, but after weaning off of both I was determined not to use narcotics of any kind to cope with the pain. Being part of this experimental HRV biofeedback program has changed my life and given me a practical, non-medicated way to reduce the pain and handle the*

stress. One time in particular, stress from [the] relationship with my wife was robbing me of sleep and causing me to lose control. I remembered the biofeedback tool and after about 30 minutes of practice I was calm and able to go back to sleep. The benefits of HRVB are so much better than medication because I am learning a way to self-regulate anywhere, anytime without risk of dependency or that drugged feeling. I'm so grateful for being part of this pilot study. My last BP reading was 115/76, compared to previously when it was 120/95. My heart rate has dropped from the 90s to the 70s."[19]

The following testimonials were taken from recent participants in the HRV coaching offered by Boot Campaign.

"I just finished my last session with [the coach] and it was a great experience. I cannot thank you guys enough. The techniques and resources that were provided over the past few weeks have made a big difference in how I am able to handle stressors both at work and at home. Additionally, this could not have landed at a better time. It has been a very hectic month with major transitions. I have restarted working on my degree, have been recently transferred from uniform patrol to Detective and starting SWAT school. Everything I have been learning and practicing with [my coach] has made all of this much less stressful and more manageable." - USMC Veteran and active-duty law enforcement officer

"I just completed my last session yesterday. I would like to thank you for accepting me into the Boot Campaign program. The coaching that I received has been transformative for my personal growth. I now have the proper tools to respond to emotions that are not healthy." - Post-911 USMC Veteran and single mother

"My Coach was so knowledgeable, easy to talk to, and a great teacher. The program was so helpful because it gave me simple tools to use and apply. This really helped with general stress, relationships and overall well-being of me! Overall, it was wonderful!!!!! So grateful!" - USN Spouse

"I had a loving knowledgeable coach, gained real life usable tools/practical application, and gained great foundational information. Thank you to all involved, this program was amazing. Every aspect of my life has benefitted from this program." - USAF Veteran

"The coach was awesome, personable, extremely knowledgeable and put the process in terms that made it easy to employ the techniques as we learned each aspect. My sleep, stress, and relationships saw the most improvement." - Retired USN Veteran

Rationale

As presented above, HRV training has been identified as an effective modality in the treatment of PTSD in combat veterans. This study hopes to expand the effectiveness of PTSD therapies by incorporating the concept of social coherence into the already beneficial physiological coherence provided by HRV training. Improving patients' ability to participate in healthy relationships could prove extremely beneficial for increasing their sense of wellbeing and

decreasing overall PTSD symptoms as well as improving family unit cohesion. This concept is supported by the findings of researchers who found that those who have healthy social relationships have a significantly lower risk for mortality.[26] These findings could be in part to the concept of social coherence.

Social coherence relates to groups where there is a stable and harmonious alignment of relationships that allow for communication required for effective action.[27] This concept can be envisioned when we think about a championship-winning sports team. To the outside observer, the players often seem to have an unspoken connection and are in unparalleled “sync” when compared to their adversaries. However, it has been observed that elite-level European soccer players have overall higher HRVs when compared to their counterparts in lesser leagues.[28] While it is understandable to think that the elite players are individually better than their peers and therefore have higher HRVs, we believe this is only part of the equation.

For example, a study that examined HRV synchronization between groups found that being in an HRV coherent state helped others who were not in a coherent state shift into one.[29] One proposed mechanism for this observed change is the idea that HRV waveforms are encoded in the heart’s electromagnetic field and therefore can be radiated into the environment where they can interact with and alter the electromagnetic field produced by those nearby.[30] This leads us to believe that it is reasonable to assume that the high HRV of the elite players is not only due to their prowess, but also the fact that they are on teams with other elite players where they spend a lot of time practicing and interacting with one another in synergistic ways.

Just as individual's HRV can be influenced in positive ways by those around them, researchers have found that couples who engage in disagreements can synchronize their HRVs with one another, leading to a greater stress-related inflammatory response.[31] This outlines the importance of couples implementing HRV training and mindfulness techniques into their lives, together, so that they may benefit from the positive effects of a coherent HRV synchronization, rather than the negative effects of noncoherent HRV synchronization.

Materials and Methods

General Study Details and Resources

Individuals selected for participation were enrolled in Boot Campaign's Stress and Resilience program which is based on the principles of HRV training and conducted by a certified coach. All members enrolled in Boot Campaign's services are veterans of the United States Armed Forces who sustained invisible wounds of war, such as post-traumatic stress (PTS) or brain injury, during their service. Enrollment in our study and HRV training was open to the trusted caregiver/companion of each veteran. Criteria for enrollment as a caregiver/companion consist of having an active role in the veteran's life and spending at least 8 hours per day in proximity of the veteran. All trusted companions agreed to make an earnest attempt to practice HRV coherence techniques each day with their veteran counterparts using methods and training intervals prescribed by their HRV training coach.

This study used materials, participants, and professional personnel affiliated with Boot Campaign. The study will specifically utilize resources from Boot Campaign's Health and Wellness program. This program is built on the principles of providing holistic care and working to identify the root cause of hidden wounds of war by delivering personalized treatment plans to veterans and their families. Boot Campaign provides care to treat diverse health challenges connected to Posttraumatic Stress and/or Traumatic Brain Injury, as well as addressing trauma-based insomnia, chronic pain, substance abuse, nutrition, and fitness. Boot Campaign serves veterans of any era and any branch.

Inclusion criteria for participation in this study specifically will be that the participant is a US military veteran, aged 20-70, who are proficient English speakers and have at least one invisible wound of war to include posttraumatic stress. Exclusion criteria include those in acute crisis, those with severe psychopathology or brain injury, and those who cannot commit to five 60-90 minute weekly virtual HRV sessions. The informed consent process will take place prior to study participation and will be conducted by Boot Campaign staff or designated research personnel. Informed consent will be discussed verbally but will be collected and kept electronically. Participants will not be directly compensated for their time; however, they will be receiving HRV training and supportive materials at no cost. They are free to withdraw from study participation at any time without an interruption in services received should they wish to continue HRV training without research participation.

Veterans and their trusted caregiver/companion will begin training within the same week if possible. Baselines will be collected by Boot Campaign within the week prior to training. Post-training measures will be captured by Boot Campaign immediately (within one week) post-training. We will also have access to pre-and post-outcome measure data from veterans who did not have a qualifying caregiver undergo training, which may serve as additional data to help establish a baseline improvement rate without synergistic HRV training in the future. Subsequent data points may be taken from each group as we see fit after the training period.

Subject Identification and Privacy

For outcome measures collected, each participant will be assigned a unique code that will enable research staff to easily conduct group analysis and protect participant identity. Once coded, information obtained will be input into secure devices owned by Boot Campaign, as defined by industry best practices, accessible only to designated research staff. No individual outside Boot Campaign Health and Wellness Staff or those designated as part of this research project will have access to identifiable data. All data provided for this project will be provided by Boot Campaign already de-identified.

Statistical Analysis

We used paired t-test to analyze changes in the rate of improvement, as measured by our standardized self-report measures, in the veterans undergoing HRV training with and without a trusted companion pre and post-HRV training. These groups were assessed for their rates of improvement at two different time points (baseline and post-training). Significant results will be assessed using a p-value = 0.05.

We then used nonparametric independent t-tests to further analyze our pre and post intervention data using subgroups based on participant demographics such as presence of TBI, PTSD, insomnia, chronic pain, self-medication / addiction, and presence of VA disability rating. We also used nonparametric independent t-tests to compare outcomes between participants based on which of the 2 HRV Coaches trained them.

We enrolled 30 veterans for this study to achieve statistical significance with each experiments group containing 15 members.

Training Programs and Data Collection

The following describes the HRV training program offered to both the veterans and their trusted companions.

1. Individual Veteran Coaching (multi-week program)

This offering is a one-on-one multi-session program for individuals. The coaching protocol typically lasts four weeks but can be customized for longer protocols. Individuals are provided with tools, techniques, and interventions and coached in ways to use them in their lives to manage stress and optimize energy and performance. Interventions consist of the following primary components: 1) Shifting attention away from the mind to convert draining mental and emotional reactions into proactive mental processes, by intentionally generating and focusing on sincere gratitude, care, or other positive emotional states; 2) Sustaining positive emotion states such as love or appreciation to maintain mental sharpness and emotional steadiness, even as emotional inputs shift; 3) Restructuring reactions so the default response to recurring negative or counterproductive emotions and patterns becomes neutral or even constructive. Coaching is provided by Masters or Doctoral level specialists who are also HeartMath Certified Coaches or Mentors.

Outcome measures will be collected before and after coaching as indicated by the statistical analysis section. The following outcome measures were utilized to assess efficacy, as a stand-alone measures and in combination with one another:

- Depression: PROMIS SF v1.0 - ED-Depression 4a
    - "The PROMIS Depression item banks assess self-reported negative mood (sadness, guilt), views of self (self criticism, worthlessness), and social cognition (loneliness, interpersonal alienation), as well as decreased positive affect and engagement (loss of interest, meaning, and purpose). Somatic symptoms (changes in appetite, sleeping patterns) are not included, which eliminates consideration of these items' confounding effects when assessing patients with comorbid physical conditions. The depression short forms are universal rather than disease-specific. All assess depression over the past seven days."
- Anger: PROMIS Short Form v1.1 - Anger 5a
    - "The PROMIS Anger item banks assess self-reported angry mood (irritability, frustration), negative social cognitions (interpersonal sensitivity, envy, disagreeableness), and efforts to control anger. Often associated with episodes of frustration that impede goal-directed behavior, anger is marked by attitudes of hostility and cynicism. Specific components relate to verbal and non-verbal evidence of anger. Physical aggression items are not included. The anger short forms are universal rather than disease-specific. All assess anger over the past seven days."
- Anxiety: PROMIS Short Form v1.0 - Anxiety 4a
    - "The PROMIS Anxiety item banks assess self-reported fear (fearfulness, panic), anxious misery (worry, dread), hyperarousal (tension, nervousness, restlessness), and somatic symptoms related to arousal (racing heart, dizziness). Anxiety is best differentiated by symptoms that reflect autonomic arousal and experience of threat. Only one behavioral avoidance item is included in the adult item bank; therefore, behavioral fear avoidance is not fully evaluated. The anxiety measures are universal rather than disease-specific. All assess anxiety over the past seven days."
- Meaning and Purpose (M&P): PROMIS Short Form v1.0 - Meaning and Purpose 6a
    - "The PROMIS Meaning and Purpose item banks assess one's sense of life having purpose and that there are good reasons for living. Higher scores indicate hopefulness, optimism, goal-directedness, and feelings that one's life is worthy. All item banks do not use a recall period"
- Cognitive Function: Neuro-QOL Item Bank v.2.0 - Cognitive Function - Short Form
    - "Neuro-QoL measures quantify the physical, mental, and social effects experienced by adults and children living with neurological conditions"
    - "Neuro-QoL measures can be used in a range of adult and pediatric neurological conditions including but not limited to: stroke, multiple sclerosis, Parkinson's disease, epilepsy, amyotrophic lateral sclerosis (ALS), traumatic brain injury (TBI), military deployment–related traumatic brain injury (MDR-TBI), spinal cord injury (SCI), and Huntington's disease (HD). The Neuro-QoL HDQLIFE measures are

particularly suited for individuals with HD. The Neuro-QoL TBI-CareQOL measures were developed for caregivers for people with TBI, but may be useful for other caregivers as well"

- Sleep: PROMIS Short Form v1.0 - Sleep Disturbance 4a
    - "The PROMIS Sleep Disturbance instruments assess self-reported perceptions of sleep quality, sleep depth, and restoration associated with sleep. This includes perceived difficulties and concerns with getting to sleep or staying asleep, as well as perceptions of the adequacy of and satisfaction with sleep. Sleep Disturbance does not focus on symptoms of specific sleep disorders, nor does it provide subjective estimates of sleep quantities (total amount of sleep, time to fall asleep, amount of wakefulness during sleep). The Sleep Disturbance short form is universal rather than disease-specific. It assesses sleep disturbance over the past seven days."
- Quality of Life (QOL): NIH Toolbox Fixed Form v2.0 - Domain-Specific Life Satisfaction (Ages 18+)
    - "The NIH Toolbox Domain Specific Life Satisfaction Survey is a supplemental self-report measure that assesses feelings and attitudes about specific domains of one's life (e.g., family, health, work, leisure). A 13-item fixed length form is used for adults"
- Pain: PROMIS Item Bank v.10 - Pain Interference - Short Form 6a
    - "The PROMIS Pain Interference item banks assess self-reported consequences of pain on relevant aspects of one's life. This includes the extent to which pain hinders engagement with social, cognitive, emotional, physical, and recreational activities. Pain Interference also incorporates items probing sleep and enjoyment in life, though the item bank only contains one sleep item. The pain interference short forms are universal rather than disease-specific. All assess pain interference over the past seven days."
- Post Traumatic Stress (PTS): PCL-C – Abbreviated
    - "The PTSD Checklist for DSM-5 (PCL-5) is a 20-item self-report measure that assesses the presence and severity of PTSD symptoms. Items on the PCL-5 correspond with DSM-5 criteria for PTSD. The PCL-5 can be used to quantify and monitor symptoms over time, to screen individuals for PTSD, and to assist in making a provisional or temporary diagnosis of PTSD"
- SWBA: HeartMath Stress and Well-being Assessment
    - 72 question assessment developed by HeartMath Institute to help people and providers better understand how specific aspects of stress, well-being, and resilience affect their quality of life. It gives participants a summative score based on the following: How many life changes they are experiencing, total stress (along with 8 subcomponents: physical stress, work stress, relationship stress, financial stress, social support stress, other stress, emotional stress, and stress response), and total wellbeing (along with 4 subcomponents: stress management, adaptability, resilience, and emotional vitality).

2. Trusted Companion Coaching

The coaching for trusted companions will mirror that of the veteran coaching. These sessions occured simultaneously with the same private instructor who coaches the veterans. While we did not specifically gather survey results on the trusted companions, it was expected that they practice and implement the techniques learned in coaching session with their veteran counterpart.

Results

A total of 30 participants were analyzed through pre and post survey results with half of our participants being in the group that underwent training with their trusted companion (S), and half not undergoing training with a trusted companion (NS) (Table 1). Of this sample, 10 participants were enrolled with HRV Coach A and 20 were enrolled with HRV coach B (Table 2). Only 6 of our participants were female with the remaining 24 being male (Table 3). Our participants self-identified with the following ethnicities, Black/African American (1), Hispanic/Latino (5), White/Caucasian (24) (Table 4). The participants were from a wide variety of states across the United States, with Texas (4), North Carolina (5), and Virginia (8), being the three most common states (Table 5). The majority of our participants were in either the Army (11), or Navy (11), with an additional participant having served with both the Army and Navy (Table 6). Of the 30 participants, 24 were married, with 3 being separated, and 3 in an engaged/ live in relationship (Table 7). 14 participants worked full time, 4 worked part time, 3 were unemployed, and 9 were medically unable to work (Table 8).

Table1: Experimental Group

		Frequency	Percent
Table 1	NS	15	50.0
	S	15	50.0
	Total	30	100.0

Table 2: HRV Coach

		Frequency	Percent
Table 2	A	10	33.3
	B	20	66.7
	Total	30	100.0

Table 3: Subject Gender

		Frequency	Percent
Table 3	Female	6	20.0
	Male	24	80.0
	Total	30	100.0

Table 4: Subject Ethnicity

		Frequency	Percent
Table 4	Black/African American	1	3.3
	Hispanic/Latino	5	16.7
	White/Caucasian	24	80.0
	Total	30	100.0

Table 5: Mailing State

		Frequency	Percent
Table 5	California	1	3.3
	Florida	2	6.7
	Mississippi	1	3.3
	Missouri	1	3.3
	Montana	1	3.3
	Nevada	1	3.3
	New York	1	3.3
	North Carolina	5	16.7
	South Carolina	1	3.3
	South Dakota	1	3.3
	Tennessee	2	6.7
	Texas	4	13.3
	Virginia	8	26.7
	Washington	1	3.3
	Total	30	100.0

Table 6: Branch of Service

		Frequency	Percent
Table 6	Air Force	2	6.7
	Army	11	36.7
	Army; Navy	1	3.3
	Marine Corps	5	16.7
	Navy	11	36.7
	Total	30	100.0

Table 7: Marital Status

		Frequency	Percent

Table 7	Engaged/Live in Relationship	3	10.0
	Married	24	80.0
	Separated	3	10.0
	Total	30	100.0

Table 8: Employment Status

		Frequency	Percent
Table 8	Full time	14	46.7
	Medically Unable to work	9	30.0
	Part time	4	13.3
	Unemployed	3	10.0
	Total	30	100.0

Additional demographic information collected on each participant included presence of the following medical conditions and statuses: traumatic brain injury (TBI), post-traumatic stress disorder (PTSD), chronic pain, insomnia, self-medication/ addiction, and presence of Veterans Affairs disability rating. The majority of our participants had TBI (23), PTSD (27), chronic pain (21), insomnia (18), and a VA disability rating status (17), whereas only 9 admitted to struggling with self-medication/ addiction. This data is reflected in Tables 9-14 with “no” being represented by a “0” and “yes” being represented by “1”.

Table 9: TBI

		Frequency	Percent
Table 9	0	7	23.3
	1	23	76.7
	Total	30	100.0

Table 10: PTSD

		Frequency	Percent
Table 10	0	3	10.0
	1	27	90.0
	Total	30	100.0

Table 11: Chronic Pain

		Frequency	Percent
Table 11	0	9	30.0

	1	21	70.0
	Total	30	100.0

Table 12: Insomnia

		Frequency	Percent
Table 12	0	12	40.0
	1	18	60.0
	Total	30	100.0

Table 13: Self Medication/Addiction

		Frequency	Percent
Table 13	0	21	70.0
	1	9	30.0
	Total	30	100.0

Table 14: Has VA Disability Rating

		Frequency	Percent
Table 14	0	13	43.3
	1	17	56.7
	Total	30	100.0

Data from pre and post survey results for anger, anxiety, depression, meaning and purpose (M&amp), post-traumatic stress (PTS), quality of life (QOL), pain, sleep disturbance (Sleep), and cognitive function (Cog) are presented in Table 15. Entries marked with a “1” indicate pre-intervention survey results whereas entries marked with a “2” indicate post-intervention survey results. Experimental group “NS” are those that underwent training without a support person and group “S” underwent training with a support person. The change in pre and post intervention results for each group is expressed in Table 16 as Delta(metric). Of note, lower scores for Anger, Anxiety, Depression, PTS, Pain, and Sleep are considered more favorable. Conversely, higher scores for M&amp, QOL, and Cog are considered more favorable. Both groups grossly improved from pre to post intervention results over each marker analyzed. As shown in Table 16, participants in the S category had overall more favorable changes in their pre to post intervention scores when compared to their counterparts in the NS group with the exception of change in cognitive function where the NS group (+11.29) slightly outperformed the S group (+10.07). When the favorable changes for each group were compared to one another, changes in Anger (p=0.047), and Sleep (p=0.039) were seen to be statistically significantly greater in the S group compared to NS group. Of note, there was one participant in the NS group where this set of metrics was not able to be collected, bringing our NS participant count to 14 for the following sets.

Table 15: Group Statistics 1

Experimental Group		N	Mean	Std. Deviation	Std. Error Mean	Two-Sided p
Anger 1	NS	14	11.57	3.756	1.004	0.023
	S	15	14.73	3.283	0.848	
Anger 2	NS	14	6.50	2.565	0.685	0.976
	S	15	6.47	3.248	0.839	
Anxiety 1	NS	14	7.57	2.174	0.581	0.261
	S	15	8.53	2.326	0.601	
Anxiety 2	NS	14	3.57	2.277	0.609	0.522
	S	15	3.07	1.907	0.492	
Depression 1	NS	14	8.93	4.233	1.131	0.411
	S	15	10.33	4.791	1.237	
Depression 2	NS	14	3.57	3.756	1.004	0.892
	S	15	3.73	2.520	0.651	
M&P1	NS	14	13.43	5.585	1.493	0.983
	S	15	13.47	3.642	0.940	
M&P2	NS	14	19.07	6.439	1.721	0.231
	S	15	21.73	5.244	1.354	
PTS1	NS	14	20.50	4.433	1.185	0.349
	S	15	21.87	3.226	0.833	
PTS2	NS	14	11.36	3.201	0.856	0.986
	S	15	11.33	4.047	1.045	
QOL1	NS	14	26.14	6.138	1.640	0.158
	S	15	23.13	4.998	1.291	
QOL2	NS	14	39.29	6.911	1.847	0.253
	S	15	41.87	4.868	1.257	
Pain1	NS	14	16.07	6.569	1.756	0.056
	S	15	20.80	6.178	1.595	
Pain2	NS	14	8.64	7.520	2.010	0.330
	S	15	10.93	4.667	1.205	
Sleep1	NS	14	11.57	3.390	0.906	0.220
	S	15	12.93	2.404	0.621	
Sleep2	NS	14	11.07	1.900	0.508	0.059
	S	15	9.73	1.751	0.452	
Cog1	NS	14	17.14	5.668	1.515	0.082
	S	15	20.00	2.236	0.577	
Cog2	NS	14	28.43	4.718	1.261	0.357
	S	15	30.07	4.698	1.213	

Table 16: Group Statistics 2

Experimental Group		N	Mean	Std. Deviation	Std. Error Mean	Two-Sided p
Delta Anger	NS	14	-5.07	4.066	1.087	0.047
	S	15	-8.27	4.200	1.084	
DeltaAnxiety	NS	14	-4.00	3.138	0.839	0.168
	S	15	-5.47	2.416	0.624	
DeltaDepression	NS	14	-5.36	4.413	1.180	0.502
	S	15	-6.60	5.343	1.379	
DeltaM&P	NS	14	5.64	5.759	1.539	0.216
	S	15	8.27	5.391	1.392	
DeltaPTS	NS	14	-9.14	4.865	1.300	0.402
	S	15	-10.53	3.907	1.009	
DeltaQOL	NS	14	13.14	7.294	1.950	0.051
	S	15	18.73	7.421	1.916	
DeltaPain	NS	14	-7.43	7.325	1.958	0.322
	S	15	-9.87	5.643	1.457	
DeltaSleep	NS	14	-0.50	4.034	1.078	0.039
	S	15	-3.20	2.541	0.656	
DeltaCog	NS	14	11.29	6.810	1.820	0.598
	S	15	10.07	5.457	1.409	

The data from Table 16 is reflected in Figure 1 and Figure 2. Figure 1 contains only metrics where a decrease score indicated an improvement from baseline and Figure 2 contains only metrics where an increase in score indicates an improvement from baseline.

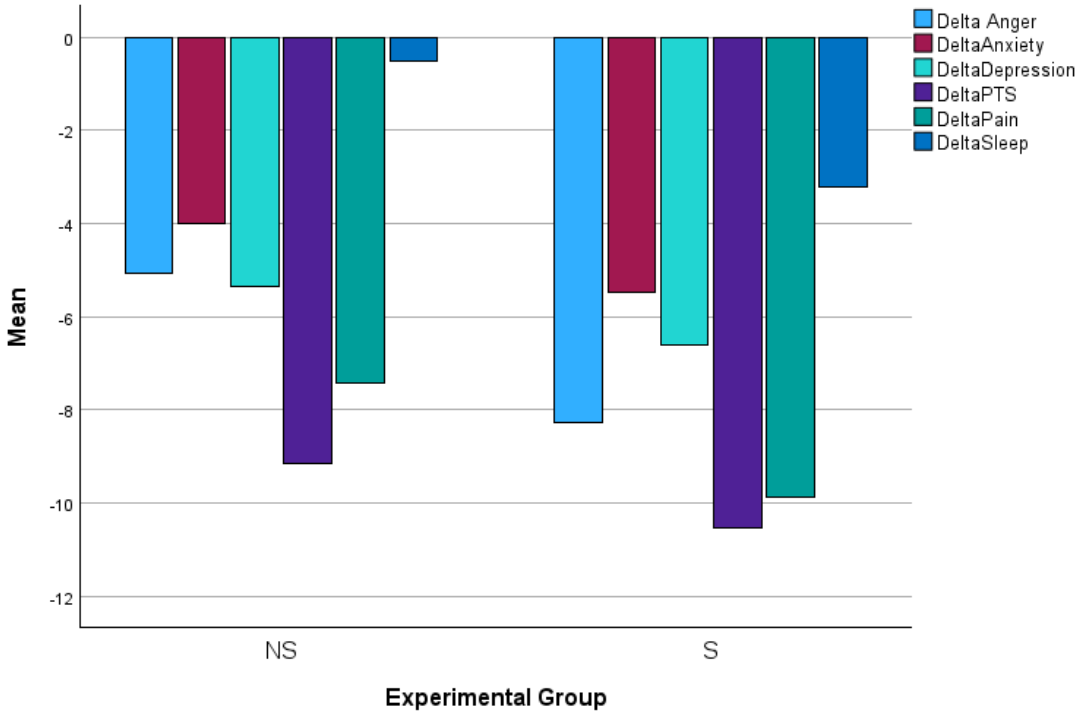

Figure 1. Changes in means of different markers where decreased score indicated improvement.

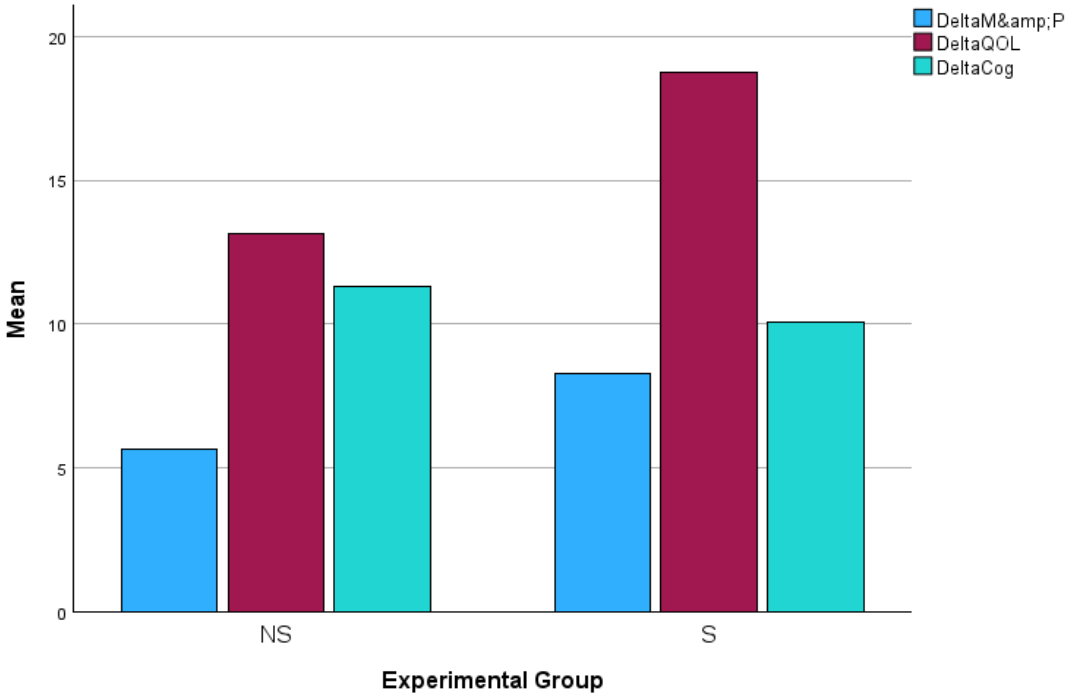

Figure 2. Changes in means of different markers where increased score indicated improvement.

The SWBA was also used as a major outcome measure for our study and is analyzed separately as detailed in the below section. This was due to the SWBA producing a variety of individual wellness scores across a variety of categories in contrast to the above metrics which each produced a single score for their respective measurement. The SWBA outcomes are presented in Table 17 are labeled 1 and 2 for pre and post survey results, respectively. The Life Changes metric is derived from a summation of point scores on the SWBA that correspond with participants' major turmoil or alternations in what they consider "normal life". The higher the score in Life Changes, the more prone to physical and psychological stress-related illness participants are than those that score lower. The Physical Stress Symptoms metric is derived from how participants answer questions about topics such as poor sleep, body aches, headaches, rapid heartbeats, fatigue and/or stomach ailments. A higher score in this category corresponds with greater stress. The other entries that involve "stress" or "distress" are calculated similarly for each respective type of stress. Additionally, high scores in the Response to Stress metric suggest that the person may not have a fully effective response to stress and thus stressful events are more likely to detract for their quality of life. The remaining metrics (Stress Management, Adaptability, Resilience, and Emotional Vitality) on the SWBA test are concerned with how well participants are able to respond and deal with adverse events. A higher score on these metrics is considered more favorable.

Table 18 takes the pre and post survey data expressed in Table 17 and presents it in terms of how much change occurred in each group after coaching was completed. Overall, the participants in the S group experienced greater decreases in the unfavorable metrics when compared to the NS group, apart from decreases in Work Stress being greater in the NS group. Of note, Life Changes and Social Stress increased overall in the NS group, indicating a worse status than baseline. Compared to one another, changes in Social Stress were statistically significant between the two groups ($p=0.008$) in favor of greater decreases in the S group. The results were similar when looking at the favorable metrics, with the S group experiencing greater increases in these metrics, with the exception of increases in Adaptability being slightly greater in the NS group. No difference in changes in favorable metrics achieved statistical significance.

Table 17: Group Statistics 3

Experimental Group		N	Mean	Std. Deviation	Std. Error Mean	Two-Sided p
Life Changes 1	NS	15	92.87	56.290	14.534	0.117
	S	15	123.27	46.052	11.891	
Life Changes 2	NS	15	105.13	81.632	21.077	0.613
	S	15	119.87	75.865	19.588	
Physical Stress Symptoms 1	NS	15	78.67	21.212	5.477	0.796
	S	15	80.53	17.728	4.577	
Physical Stress Symptoms 2	NS	15	61.87	34.251	8.844	0.937
	S	15	62.80	29.496	7.616	
Work Stress 1	NS	15	77.40	26.840	6.930	0.046
	S	15	51.33	40.343	10.416	
Work Stress 2	NS	15	66.00	29.864	7.711	0.214
	S	15	50.87	35.091	9.061	
Relationship Stress 1	NS	15	59.40	29.897	7.719	0.552
	S	15	65.40	24.462	6.316	
Relationship Stress 2	NS	15	48.53	31.904	8.237	0.471
	S	15	39.67	34.452	8.896	
Financial Stress 1	NS	15	55.73	37.351	9.644	0.858
	S	15	53.27	37.423	9.663	
Financial Stress 2	NS	15	50.33	39.518	10.203	0.604
	S	15	43.33	33.327	8.605	
Social Support Stress 1	NS	15	52.73	30.082	7.767	0.564
	S	15	58.93	28.083	7.251	
Social Support Stress 2	NS	15	57.53	32.359	8.355	0.123
	S	15	38.80	32.227	8.321	
Other Sources of Stress 1	NS	15	69.40	27.229	7.030	0.662
	S	15	65.07	26.467	6.834	
Other Sources of Stress 2	NS	15	57.93	36.096	9.320	0.693
	S	15	52.73	35.360	9.130	
Emotional Distress 1	NS	15	76.40	24.325	6.281	0.381
	S	15	67.73	28.816	7.440	
Emotional Distress 2	NS	15	64.67	32.880	8.490	0.309
	S	15	51.87	34.816	8.989	
Response to Stress 1	NS	15	76.60	21.152	5.461	0.604
	S	15	71.47	31.507	8.135	
Response to Stress 2	NS	15	68.07	32.635	8.426	0.538
	S	15	60.53	33.509	8.652	

Total Stress 1	NS	15	77.87	21.367	5.517	0.234
	S	15	66.60	28.822	7.442	
Total Stress 2	NS	15	68.73	29.824	7.701	0.236
	S	15	54.60	33.968	8.771	
Stress Management 1	NS	15	29.87	26.186	6.761	0.576
	S	15	24.40	26.795	6.918	
Stress Management 2	NS	15	42.27	31.336	8.091	0.550
	S	15	48.27	22.266	5.749	
Adaptability 1	NS	15	35.40	29.599	7.642	0.550
	S	15	28.87	29.500	7.617	
Adaptability 2	NS	15	51.60	30.004	7.747	0.507
	S	15	45.13	22.155	5.720	
Resilience 1	NS	15	31.47	22.548	5.822	0.962
	S	15	31.93	30.184	7.793	
Resilience 2	NS	15	45.87	24.489	6.323	0.789
	S	15	48.53	29.333	7.574	
Emotional Vitality 1	NS	15	32.33	25.068	6.472	0.676
	S	15	27.80	33.167	8.564	
Emotional Vitality 2	NS	15	37.00	29.914	7.724	0.558
	S	15	43.53	30.507	7.877	
Total Well Being 1	NS	15	26.87	21.679	5.598	0.945
	S	15	26.20	30.150	7.785	
Total Well Being 2	NS	15	41.27	33.103	8.547	0.843
	S	15	43.40	24.770	6.396	0.000

Table 18: Group Statistics 4

Experimental Group		N	Mean	Std. Deviation	Std. Error Mean	Two-Sided p
DeltaLife	NS	15	12.27	47.904	12.369	0.460
	S	15	-3.40	65.297	16.860	
DeltaPhysical	NS	15	-16.80	22.320	5.763	0.916
	S	15	-17.73	25.800	6.662	
DeltaWork	NS	15	-11.40	19.149	4.944	0.191
	S	15	-0.47	25.094	6.479	
DeltaRelationship	NS	15	-10.87	26.446	6.828	0.094
	S	15	-25.73	20.023	5.170	
DeltaFinancial	NS	15	-5.40	16.690	4.309	0.625
	S	15	-9.93	31.365	8.098	
DeltaSocial	NS	15	4.80	17.559	4.534	0.008
	S	15	-20.13	29.027	7.495	
DeltaOther	NS	15	-11.47	32.231	8.322	0.927
	S	15	-12.33	16.181	4.178	
DeltaEmotional	NS	15	-11.73	22.292	5.756	0.572
	S	15	-15.87	16.945	4.375	
DeltaResponse	NS	15	-8.53	19.917	5.143	0.757
	S	15	-10.93	22.031	5.688	
DeltaTotal	NS	15	-9.13	14.672	3.788	0.722
	S	15	-12.00	27.161	7.013	
DeltaStress	NS	15	12.40	14.131	3.649	0.154
	S	15	23.87	26.777	6.914	
DeltaAdaptability	NS	15	16.20	14.891	3.845	0.992
	S	15	16.27	20.261	5.231	
DeltaResilience	NS	15	14.40	17.162	4.431	0.728
	S	15	16.60	17.112	4.418	
DeltaEmotional	NS	15	4.67	15.601	4.028	0.107
	S	15	15.73	20.506	5.295	
DeltaTotalWellBeing	NS	15	14.40	14.411	3.721	0.693
	S	15	17.20	23.035	5.948	

The data from Table 18 is reflected in Figure 3 and Figure 4. Figure 3 contains only metrics where a decrease score indicated an improvement from baseline and Figure 4 contains only metrics where an increase in score indicates an improvement from baseline.

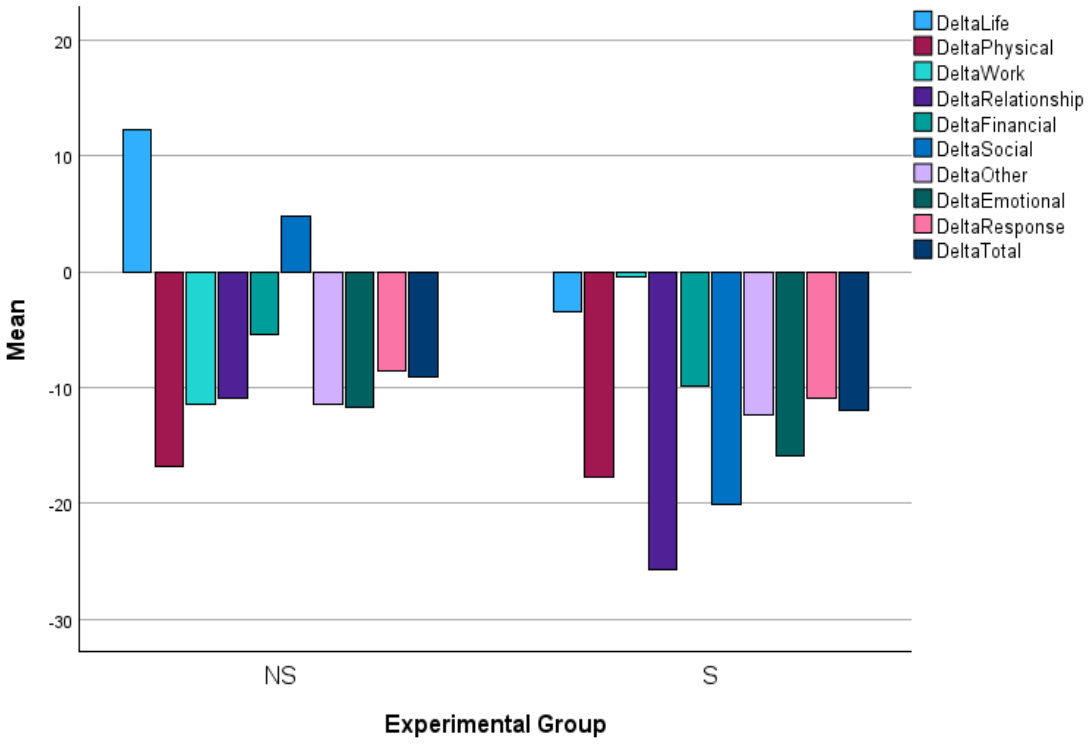

Figure 3. Changes in means of different markers where decreased score indicated improvement.

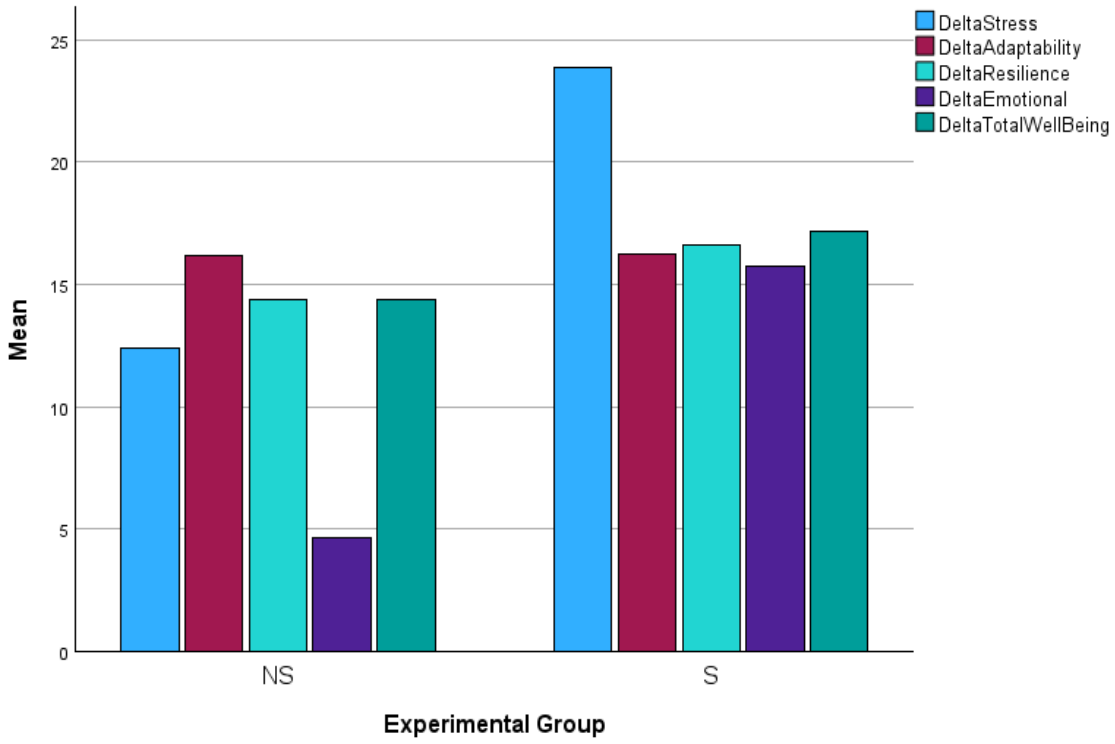

Figure 4. Changes in means of different markers where increased score indicated improvement.

An analysis of the data using the two coaches as experimental groups was performed to elucidate any difference present between outcomes that may be different according to the coach which the participants had. Table 19 shows how many participants from the S and NS group had either coach A or coach B for their sessions. Coach B coached 66% of the total participants, 80% of the NS group, and just over half (53.3%) of the S group.

Table 19: HRV Coach

Experimental Group			Frequency	Percent	Valid Percent
NS	Valid	A	3	20.0	20.0
		B	12	80.0	80.0
		Total	15	100.0	100.0
S	Valid	A	7	46.7	46.7
		B	8	53.3	53.3
		Total	15	100.0	100.0

Table 20 displays the results from analyzing the difference between pre and post survey results compared by coach. Nonparametric testing was performed to establish statistical significance for this analysis and it demonstrated that the following differences in pre and post survey

results had statistically significant differences between Coach A and Coach B: Delta Anger (p=0.035), Delta M&P (p=0.040), Delta PTS (p=0.006), Delta QOL (p=0.040), Delta Total (p=0.028), and Delta Social (p=0.013). Table 21 displays the difference between pre and post survey results compared by presence of TBI. Nonparametric testing was performed to establish statistical significance for this analysis, and it demonstrated that the following differences in pre and post survey results had statistically significant differences between subgroups with and without TBI: Delta Resilience (p=0.014) and Delta Total (p=0.048). Table 22 displays the difference between pre and post survey results compared by presence of PTSD. Nonparametric testing showed no statistically significant difference between the results of subgroups with and without PSTD. Table 23 displays the difference between pre and post survey results compared by presence of Chronic Pain. Nonparametric testing showed no statistically significant difference between the results of subgroups with and without Chronic Pain. Table 24 displays the difference between pre and post survey results compared by presence of Insomnia. Nonparametric testing was performed to establish statistical significance for this analysis and it demonstrated a statistically significant difference in Delta Pain (p=0.048) between subgroups with and without Insomnia. Table 25 displays the difference between pre and post survey results compared by positive history of Self Medication/Addiction. Nonparametric testing was performed to establish statistical significance for this analysis and it demonstrated a statistically significant difference in Delta Financial (p=0.032) between subgroups with and without history of Self Medication/Addiction. Table 26 displays the difference between pre and post survey results compared by presence of VA Disability Rating. Nonparametric testing was performed to establish statistical significance for this analysis and it demonstrated that the following differences in pre and post survey results had statistically significant differences between subgroups with and without VA Disability Rating: Delta QOL (p=0.003), Delta Total Well Being (p=0.048), Delta Stress Management (p=0.031), and Delta Social (p=0.039).

Table 27 specifically looks at mean differences for pre and post survey results of just participants in the S group coached by either Coach A or Coach B. This analysis was important in our case for root cause analysis of differences in outcomes between coaching groups.

Table 20: HRV Coach Analysis 1

HRVCoach			Delta Anger	Delta Anxiety	Delta Depression	Delta M&P	Delta PTS	Delta QOL	Delta Pain	Delta Sleep	Delta Cog	Delta Life	Delta Physical	Delta Work	Delta Relationship	Delta Financial	Delta Social	Delta Other	Delta Emotional Stress	Delta Response	Delta Total	Delta Stress Mangement	Delta Adaptability	Delta Resilience	Delta Emotional Vitality	DeltaTotal WellBeing
A	N	Valid	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
		Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean		-9.00	-6.00	-7.70	10.00	-12.80	19.50	-8.70	-2.20	10.90	-0.50	-26.20	2.70	-23.10	-15.50	-25.90	-14.40	-17.70	-17.50	-21.80	28.60	20.90	11.40	22.40	25.70
B	N	Valid	19	19	19	19	19	19	19	19	19	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
		Missing	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean		-5.53	-4.11	-5.11	5.42	-8.32	14.21	-8.68	-1.74	10.53	6.90	-12.80	-10.25	-15.90	-3.75	1.45	-10.65	-11.85	-5.85	-4.95	12.90	13.90	17.55	4.10	10.85

Table 20

Table 21: TBI Analysis

TBI			Delta Anger	Delta Anxiety	Delta Depression	Delta M&P	Delta PTS	Delta QOL	Delta Pain	Delta Sleep	Delta Cog	DeltaLife	Delta Physical	Delta Work	Delta Relationship	Delta Financial	Delta Social	Delta Other	Delta Emotional Stress	Delta Response	Delta Total	Delta Stress Mangement	Delta Adaptability	Delta Resilience	Delta Emotional Vitality	DeltaTotal WellBeing
No	N	Valid	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
		Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean		-4.57	-2.43	-4.29	4.86	-7.43	14.43	-9.14	-2.43	8.86	5.14	-5.00	-1.57	-6.57	1.57	-3.57	0.86	-6.86	3.00	-0.86	17.14	19.71	26.57	3.57	13.29
Yes	N	Valid	22	22	22	22	22	22	22	22	22	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
		Missing	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean		-7.41	-5.50	-6.55	7.68	-10.64	16.55	-8.55	-1.73	11.23	4.22	-21.00	-7.26	-21.87	-10.48	-8.91	-15.78	-15.91	-13.61	-13.52	18.43	15.17	12.13	12.22	16.57

Table 21

Table 22: PTSD Analysis

PTSD			Delta Anger	Delta Anxiety	Delta Depression	Delta M&P	Delta PTS	Delta QOL	Delta Pain	Delta Sleep	Delta Cog	Delta Life	Delta Physical	Delta Work	Delta Relationship	Delta Financial	Delta Social	Delta Other	Delta Emotional Stress	Delta Response	Delta Total	DeltaStress	Delta Adaptability	Delta Resilience	Delta Emotional Vitality	DeltaTotal WellBeing
No	N	Valid	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean		-6.67	-4.67	-8.00	5.33	-7.00	14.00	-12.00	-5.00	12.00	-37.67	-33.33	-20.67	-17.33	0.67	-21.33	-32.33	-15.33	-29.67	-28.67	9.00	23.33	9.33	6.33	12.33
Yes	N	Valid	26	26	26	26	26	26	26	26	26	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
		Missing	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean		-6.73	-4.77	-5.77	7.19	-10.19	16.27	-8.31	-1.54	10.50	9.11	-15.48	-4.30	-18.41	-8.59	-6.15	-9.63	-13.63	-7.52	-8.56	19.15	15.44	16.19	10.63	16.19

Table 22

Table 23: Chronic Pain Analysis

Chronic Pain			Delta Anger	Delta Anxiety	Delta Depression	Delta M&P	Delta PTS	Delta QOL	Delta Pain	Delta Sleep	Delta Cog	Delta Life	Delta Physical	Delta Work	Delta Relationship	Delta Financial	Delta Social	Delta Other	Delta Emotional Stress	Delta Response	Delta Total	DeltaStress	Delta Adaptability	Delta Resilience	Delta Emotional Vitality	DeltaTotal WellBeing
No	N	Valid	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
		Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean		-8.56	-5.22	-7.11	8.44	-9.56	18.89	-7.67	-2.78	12.33	-4.44	-26.11	-4.67	-16.33	-22.11	0.56	-8.33	-20.89	-11.56	-17.67	23.33	22.22	19.33	13.33	18.33
Yes	N	Valid	20	20	20	20	20	20	20	20	20	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
		Missing	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean		-5.90	-4.55	-5.50	6.35	-10.00	14.75	-9.15	-1.50	9.90	8.24	-13.48	-6.48	-19.14	-1.48	-11.19	-13.43	-10.76	-8.95	-7.52	15.90	13.67	13.86	8.86	14.71

Tabel 23

Table 24: Insomnia Analysis

Insomnia			Delta Anger	Delta Anxiety	Delta Depression	Delta M&P	Delta PTS	Delta QOL	Delta Pain	Delta Sleep	Delta Cog	Delta Life	Delta Physical	Delta Work	Delta Relationship	Delta Financial	Delta Social	Delta Other	Delta Emotional Stress	Delta Response	Delta Total	DeltaStress	Delta Adaptability	Delta Resilience	Delta Emotional Vitality	DeltaTotal WellBeing
No	N	Valid	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
		Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean		-6.58	-3.92	-5.17	7.08	-9.33	15.83	-6.00	-1.83	11.83	6.42	-20.08	-0.75	-11.25	-11.42	-11.00	-11.92	-16.17	-13.67	-15.42	27.92	23.67	19.25	14.08	19.17
Yes	N	Valid	17	17	17	17	17	17	17	17	17	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
		Missing	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean		-6.82	-5.35	-6.59	6.94	-10.24	16.18	-10.59	-1.94	9.82	3.11	-15.39	-9.39	-23.00	-5.17	-5.44	-11.89	-12.22	-7.11	-7.33	11.61	11.28	13.00	7.61	13.56

Table 24

Table 25: Self Medication/ Addiction Analysis

Self Medication/ Addiction			Delta Anger	Delta Anxiety	Delta Depression	Delta M&P	Delta PTS	Delta QOL	Delta Pain	Delta Sleep	Delta Cog	Delta Life	Delta Physical	Delta Work	Delta Relationship	Delta Financial	Delta Social	Delta Other	Delta Emotional Stress	Delta Response	Delta Total	DeltaStress	Delta Adaptability	Delta Resilience	Delta Emotional Vitality	DeltaTotal WellBeing
No	N	Valid	20	20	20	20	20	20	20	20	20	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
		Missing	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean		-6.35	-4.55	-5.25	7.40	-9.20	17.05	-8.20	-2.30	9.50	-6.29	-17.76	-4.71	-16.95	-3.38	-7.57	-9.67	-14.43	-9.62	-9.71	16.67	17.95	17.48	9.95	14.52
Yes	N	Valid	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
		Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean		-7.56	-5.22	-7.67	6.11	-11.33	13.78	-9.78	-1.00	13.22	29.44	-16.11	-8.78	-21.44	-17.67	-7.89	-17.11	-12.33	-10.00	-12.56	21.56	12.22	10.89	10.78	18.78

Table 25

Table 26: VA Disability Rating Analysis

Has VA Disability Rating			Delta Anger	Delta Anxiety	Delta Depression	Delta M&P	Delta PTS	Delta QOL	Delta Pain	Delta Sleep	Delta Cog	Delta Life	Delta Physical	Delta Work	Delta Relationship	Delta Financial	Delta Social	Delta Other	Delta Emotional Stress	Delta Response	Delta Total	DeltaStress	Delta Adaptability	Delta Resilience	Delta Emotional Vitality	DeltaTotal WellBeing
No	N	Valid	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
		Missing	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean		-8.17	-5.08	-7.75	9.17	-11.08	20.42	-9.17	-3.00	12.83	2.69	-20.00	-4.69	-17.23	-9.69	-19.62	-17.54	-20.77	-18.23	-15.62	29.46	19.54	13.00	20.23	24.62
Yes	N	Valid	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
		Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean		-5.71	-4.53	-4.76	5.47	-9.00	12.94	-8.35	-1.12	9.12	5.76	-15.18	-6.88	-19.12	-6.12	1.47	-7.59	-8.47	-3.24	-6.71	9.47	13.71	17.41	2.53	9.06

Table 26

Table 27: HRV Coach Analysis 2

HRVCoach		Delta Anger	Delta Anxiety	Delta Depression	Delta M&P	Delta PTS	Delta QOL	Delta Pain	Delta Sleep	Delta Cog	DeltaLife	Delta Physical	DeltaWork	Delta Relationship	Delta Financial	Delta Social	Delta Other	Delta Emotional Stress	Delta Response	Delta Total	Delta Stress	Delta Adaptability	Delta Resilience	Delta Emotional Vitality	DeltaTotal WellBeing
A	Mean	-9.14	-5.71	-7.14	11.43	-13.00	22.00	-6.57	-2.00	11.57	-0.14	-24.43	6.86	-23.71	-19.86	-38.14	-15.29	-20.29	-20.57	-23.14	40.43	25.29	12.71	27.14	29.57
	N	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Std. Deviation	3.579	2.059	5.305	1.902	2.887	2.309	4.826	1.414	4.541	83.758	27.048	31.201	12.579	28.014	20.748	12.284	19.687	23.071	20.788	28.547	20.670	18.910	19.274	23.064
B	Mean	-7.50	-5.25	-6.13	5.50	-8.38	15.88	-12.75	-4.25	8.75	-6.25	-11.88	-6.88	-27.50	-1.25	-4.38	-9.75	-12.00	-2.50	-2.25	9.38	8.38	20.00	5.75	6.38
	N	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	Std. Deviation	4.781	2.816	5.693	6.024	3.462	9.250	4.833	2.915	6.135	49.942	24.902	18.011	25.663	33.320	26.608	19.440	14.333	18.447	29.533	14.870	17.386	15.838	16.688	17.840
Total	Mean	-8.27	-5.47	-6.60	8.27	-10.53	18.73	-9.87	-3.20	10.07	-3.40	-17.73	-0.47	-25.73	-9.93	-20.13	-12.33	-15.87	-10.93	-12.00	23.87	16.27	16.60	15.73	17.20
	N	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
	Std. Deviation	4.200	2.416	5.343	5.391	3.907	7.421	5.643	2.541	5.457	65.297	25.800	25.094	20.023	31.365	29.027	16.181	16.945	22.031	27.161	26.777	20.261	17.112	20.506	23.035

Table 27

Discussion

While other studies exist illustrating the success of HRV training in veteran populations who are suffering from posttraumatic stress injuries and other invisible wounds of war abounds, no studies to date have explored the novel concept of utilizing HRV training in those close to the veteran to achieve even greater effects. The purpose of the current study is to contribute to both previous research on the utility of HRV training in wounded veteran populations and to compare outcomes between participants who underwent HRV coaching with a trusted companion and those that underwent training without a trusted companion. We hypothesized that both experimental groups will see great benefit from HRV training with the group that underwent training with a trusted companion experiencing overall greater increased in positive outcomes and greater decreases in negative outcomes than their counterparts.

There are four key findings to this paper. First, both groups were observed to have an overall increase from baseline in positive metrics and decrease from baseline in negative metrics, regardless of which group the participants belonged. Second, the group that had a trusted companion undergo training with them had overall superior metrics when compared to the group that had no trusted companion. Third, we observed significant differences in outcome measures based on which coach trained the participants. Finally, other demographic traits such as presence of TBI, insomnia, addiction, and VA disability status produced significant changes in the final comparative metrics between both groups. Overall, our study provides strong support to the practice of using HRV training to increase wellbeing and decrease psychological and physiological stressors in individuals with comorbid conditions such as PTS and TBI, especially those who are veterans of the United States Military. Further, this study provides a novel look into the benefits of utilizing coherence through the co-training of a trusted companion for individuals undergoing HRV training.

In almost every outcome we measured, both participants in the NS group and S group saw improvement from their baselines. This supports prior research that found similar benefits in overall increases in physical and emotional wellbeing through HRV training. Out of the 48 pre and post survey results analyzed (24 for each group), only 2 showed changes which were opposite what we expected. The first being the Life Changes metric measured as part of the SWBA for the NS group. Lower values for this metric are associated with greater stability in the participant's life, which can then be extrapolated to be associated with less risk of physical and phycological related illness. The NS group experiencing a mean increase in their life changes from the pre survey to post survey period is not necessarily indicative of a failure of HRV coaching but is more likely due to extenuating circumstances that were beyond the scope of our study to control. It is worth noting however, that having this increase in overall life changes could have been a confounder in the NS group not seeing the same levels of benefit as observed in the S group during the course of our study. The second outcome measure which behaved oppositely of what was expected was also seen in the NS group and was the change in social stress as part of the SWBA. The NS group experienced an increase in social stress which could have additionally contributed to other metrics not responding as positively to our intervention as was seen in the S group. High scores in this metric are thought to correlate with

a lack of adequate social support which may in part be due to the NS group not having had a trusted companion to undergo training with them. This could also be indicative of a larger social situation where there is an overall lack of support which might have manifested in not having anyone willing to go through training with these subjects. As seen in Figures 1 and 2, the greatest improvements in wellbeing and reductions in stress came in the change of quality of life and change in the effect of PTS, respectively. This is useful for future guidance of both coaches and their clients because our results suggest that the largest observed changes, regardless of coaching type, might be seen in areas related to quality of life and PTS.

As shown in Table 16, participants in the S category had overall more favorable changes in their pre to post intervention scores when compared to their counterparts in the NS group with the exception of the NS group (+11.29) slightly outperformed the S group (+10.07) in the change in cognitive function metric, however this difference was not statistically significant (p=0.598), indicating this observation could be due to chance. When the favorable changes for each group were compared to one another, changes in Anger (p=0.047), Sleep (p=0.039), and Social Stress (p=0.008) were seen to be statistically significant between the S group compared to NS group. While only 3 of the 24 metrics observed were seen to have statistically significant differences between the two groups, we believe the bigger take away is that in 23 out of the 24 measured metrics, the NS group outperformed the S group. It is likely that a greater number of statistically significant observations would have been seen if our sample size was larger because in our current study there were metrics such as QOL (p=0.051), that were very near achieving statistical significance. While both approaches to therapy are seen to be largely beneficial, based on the current study, coaches and providers should consider a trusted caregiver-based therapy model especially if the most debilitating areas of a client's life are related to anger, sleep disturbances, and social stressors as they will likely achieve more benefit over the same amount of time compared to if they had participated in coaching without a trusted companion.

In the analysis of differences in outcomes based on which coach participants had, it is important to note that nonparametric testing was used due to a sample size of less than 15 for Coach A. This is important because our data for this section is lower powered than if we had been able to use parametric t-tests. That being said, we did observe significant differences in outcomes based on which HRV Coach participants had. Participants of Coach A had consistently better results in almost all metrics, except for Delta Pain (A= -8.70, B= -8.68) and Delta Cog (A= 10.90, B= 10.53) where the results were mostly similar, and Delta Resilience (A=11.40, B=17.55) where the Coach B group saw better improvement, however this finding was not statistically significant (p=0.169). On the other hand, decreases seen in anger (p=0.035), PTS (p=0.006), total stress (p=0.028), social stress (0.013), and increases seen in meaning and purpose (p=0.040) and quality of life (p=0.040), were observed to be significantly greater in those coached by Coach A compared to the Coach B group. We anticipate these findings to be due to some combination of the following uncontrolled variables: differences in coaching style, the unequal split between S and NS group between each coach, and small sample size. In our current study, the first confounder, differences in coaching style, is not possible to control due to each coach having their preferred method of interacting with and guiding participants through the curriculum. Although the curriculum itself is standardized, each participant is a unique case and requires the coach to modify their approach as needed throughout the course

of their sessions. The second confounder, the unequal split between S and NS group members between each coach, is likely to have played a large role in the differences we observed when comparing the results achieved by each coach. 80% of our NS group was trained by coach B whereas group S was split near 50/50 between each coach. Because we know, based on our previous analysis, that group NS had lower overall improvements than S, it is possible that Coach B training a much larger volume of NS participants compared to Coach A skewed our outcome measures to be more favorable for those trained by Coach A, when it was really the underlying participant population that drove this difference. While is it admittedly difficult to tell if it was the majority of NS participants having Coach B that led to the difference we observed or the inherit difference between having a trusted companion and not having a trusted companion undergo training with the participant, we can look to the outcome measures in our S group for the answer. As seen in Table 27, when we just looked at outcomes for the S group according to which coach they had, the results are largely mixed with both groups performing similarly in 18 out of the 24 outcome measures according to the Mann-Whitney U Test. Of the 6 metrics where there were significant differences, changes in PTS, quality of life, social stress, stress response, and emotional resilience favored Coach A where changes in pain favored Coach B. Of these 6 differences, only changes in PTS, quality of life, and social stress were also seen between the coaching groups in our previous analysis of the NS and S groups. When comparing Table 20 data which included both group NS and group S to Table 27 which only included group S, there is a clear improvement in almost each metric. This leads us to conclude that while some differences between NS and S might be due to the assigned coach, it was not the only factor at play and there must also be a difference between the metrics due to the presence of the trust companion. Unfortunately, it is not possible to fully answer this question of confounding due to the increasingly small sample size the more our data is subgrouped. Future studies should attempt to have equal numbers of participants in each coached group or design a study just to look at metric differences based on coaching to better understand any potential differences coaching style may have on outcomes.

We also analyzed out outcomes through the lens of different preexisting conditions that our participants had going into their training and how these statuses or diagnoses might affect their coaching outcomes. When looking at participants through the lens of TBI, significant differences were observed between our resilience ($p=0.014$) and total stress metrics ($p=0.048$) as seen in Table 21. Participants without TBI benefitted from a greater increase in resilience from baseline whereas participants with TBI benefitted from a greater decrease in total stress as a result of their training. Based on this finding is that when coaching those with TBI, improving resilience in this population may take additional work or time when compared to coaching their peers that do not carry this diagnosis. Another interesting finding was observed when stratifying our groups by presence of insomnia. Table 24 shows that participants who suffered from insomnia saw a significantly greater improvement in their pain metrics ($p=0.048$) suggesting that HRV coaching can be particularly beneficial at reducing pain related symptoms in those that suffer from insomnia. Interestingly, while both those with and without insomnia experienced reductions in their sleep disturbance metric, the reduction was almost identical between the two. This suggests that HRV training will help limit sleep disturbances in those with insomnia and they can expect to experience a similar level of improvement to their peers from baseline.

Next, we looked at outcomes based on presence of self-medication or addiction. As seen in table 25, we found that those with history of addiction experienced a significantly lesser reduction (p=0.032) in their financial stress than their peer without addiction history. Among other detriments, addiction can place a serious financial strain on individuals and families, and it is possible that the resolution of these financial stressors was not able to be observed within the limited timeframe of our study. Next, we looked at outcomes based on VA Disability Rating status. As seen in Table 26, we found that those with a VA disability rating had significantly worse outcomes in in the following areas: quality of life (p=.003), stress management (p=0.031), social stress (p=0.039), and total well-being (p=0.048). We believe that the differences observed in outcomes between those participants with and without a VA Disability Rating is due to the overall increased severity of injury needed to gain an official disability rating. This metric can be thought of as a proxy for other comorbidities that our participants might have that we did not directly screen for. Thus, it is expected that those who are overall more severely injured would progress at a slower rate compared to their counterparts. HRV coaches working with veteran populations should take VA Disability Rating status into account when counseling their clients because it appears to be a strong indicator of delayed improvement compared to peer groups in a variety of significant areas of life. These participants might need additional sessions or targeted approaches, beyond what is already done, to see the same outcomes in the same amount of time as those without an official disability rating. It is also important to note that when we looked for differences in outcomes depending on PTSD and Chronic Pain status (Table 22 and Table 23), we found no significant differences between the groups. This might suggest that future coaches should expect similar results in participants with and without these preexisting conditions, negating any need for special approaches or additional sessions to achieve similar benefit to their peers.

Although our study is the first to analyze the effect of HRV training on veterans with and without trusted companion training, it is not without its limitations. First, our sample size was very small at only 15 participants in each experimental group for a total of 30. This made of analysis of both groups on the edge for the minimum sample size needed for parametric testing. This made our study low powered, especially when looking at subgroups within our data. A future study with more participants has the potential to reveal even more differences than the ones we observed here. Another limitation of our study was the lack of a control group. Because of the therapeutic nature of our intervention, it would not be ethical to have a control group. This makes it difficult to see if the benefits seen by our participants were entirely due to our interventions or other outside forces. We instead used the pre-intervention scores from each participant as the “control” when analyzing our data, which we believe is the best solution when producing a study that involves giving therapy to an in-need population. Another major limitation was that our participants were all clients of a non-profit and thus self-selected into either S or NS group depending on their life situation and preference. This could have possibly influenced outcomes in favor of the S group which was grossly seen in our study. Participants in the S group might have had more support and resources than those of the NS group due to the facts that they both had a trusted companion to undergo training with, and had enough outside support in their home and family life that both themselves and their trusted companion could afford to take the time to undergo training together. The final major

limitation in this study is that participant demographics were not able to be controlled for or stratified between groups, as seen with the majority of participants having served in the Navy or Army. This is because we were only able to collect data on current clients of Boot Campaign and did not do any specific recruiting to ensure that we had more equal representation across each demographic. Within this limitation also falls the unequal division of participants between our two coaches. Despite these limitations, our study provides strong support to the practice of using HRV training to increase wellbeing and decrease psychological and physiological stressors in individuals with comorbid conditions such as PTS and TBI, especially those who are veterans of the United States Military. Further, this study provides a novel look into the benefits of utilizing coherence through the co-training of a trusted companion for individuals undergoing HRV training.

Future Directions

While this research is potentially impactful for Boot Campaign and the veterans served by this organization and others like it, the implications of the results of our study extend much farther than veteran health. Similar “team-based” approaches may also be implemented in all aspects of HRV training for any population seeking to improve stress management and wellness promotion. Additionally, by showing the benefits of partner or team-based training, the utility of HRV training may gain traction for use with other professional teams, such as healthcare workers.

HRV training research is a rapidly progressing field of interest, and hopefully, this study will help this non-invasive, easily accessible, evidence-based, and cost-effective intervention gain more mainstream traction among counselors and healthcare providers.

Future studies should seek to address the limitations outlined above. While our study used a two person “team” model, other studies should seek to experiment with different team sizes for HRV training to analyze if there is an optimal group size for HRV training. Additionally, I believe it would be interesting to track HRV data in participants as they progress through training, along with analyzing the other metrics we studied. Other studies have tracked HRV change over time but doing it while implementing team approaches to coaching might reveal interesting information such as how differently HRV changes occur in each cohort.

Another study population which could greatly benefit from HRV training in pairs or teams and then analysis of the result in both wellness metrics but also performance metrics could be medical residents. The residents could take evaluation metrics before a certain rotation block of their curriculum and then undergo HRV training and monitoring throughout it and then look at post intervention data both in wellness and performance metrics after the block is over. Based on our preliminary results, residents would see boosts in not only wellbeing, but also performance in their duties during what is a very difficult and stressful part of their medical journey.

Conclusions

Providing veterans suffering from invisible wounds of war with tools to manage their overall stress is not only a benefit to the veterans and their families but our society in general. Many veterans enrolled in Boot Campaign's programs may be struggling to reenter the workforce, contribute meaningfully to those around them, or live a life free of psychological and physical pain due to visible and invisible injuries they suffered serving our country. Providing these men and women with relatively quick, efficient, and effective tools to improve well-being not only impacts them and their family unit, but also could provide the stepping-stone needed for some to utilize their leadership, discipline, and dedication to be able to go out and improve the world around them.

Our study provides strong support for the practice of using HRV training to increase wellbeing and decrease psychological and physiological stressors in individuals with comorbid conditions such as PTS and TBI, especially those who are veterans of the United States Military. Further, this study provides a novel look into the additional benefits of utilizing coherence through the co-training of a trusted companion for individuals undergoing HRV training. Each group that underwent HRV training improved vastly from baseline, with our group that underwent training with a trusted companion outperforming those who did not. This should be a signal to all interested in HRV training of the benefit of team-based therapy models and how they can "supercharge" an already very effective therapy modality.

Compliance

This study did not require TCU IRB approval. This study did not require any consideration or approval from IAUC. CITI training was completed by all investigators.

References

1. Cohen S, Janicki-Deverts D, Miller GE. Psychological Stress and Disease. *JAMA.* 2007;298(14):1685-1687.
2. Lazarus RS, Folkman S. *Stress, appraisal, and coping.* Springer publishing company; 1984.
3. Epel ES, Crosswell AD, Mayer SE, et al. More than a feeling: A unified view of stress measurement for population science. *Frontiers in neuroendocrinology.* 2018;49:146-169.
4. Mălina CR. Chronic occupational stress exposure may increase the vulnerability to acoustic trauma in military professionals. *Rev Med Chir Soc Med Nat Iasi.* 2015;119(1):51-54.
5. Maeng LY, Milad MR. Post-Traumatic Stress Disorder: The Relationship Between the Fear Response and Chronic Stress. *Chronic Stress.* 2017;1:2470547017713297.
6. Shalev A, Liberzon I, Marmar C. Post-Traumatic Stress Disorder. *N Engl J Med.* 2017;376(25):2459-2469.
7. Maren S, Phan KL, Liberzon I. The contextual brain: implications for fear conditioning, extinction and psychopathology. *Nature Reviews Neuroscience.* 2013;14(6):417-428.
8. Milad MR, Wright CI, Orr SP, Pitman RK, Quirk GJ, Rauch SL. Recall of fear extinction in humans activates the ventromedial prefrontal cortex and hippocampus in concert. *Biol Psychiatry.* 2007;62(5):446-454.
9. Beauchaine TP, Thayer JF. Heart rate variability as a transdiagnostic biomarker of psychopathology. *International journal of psychophysiology.* 2015;98(2):338-350.
10. Thompson M, Thompson L, Reid-Chung A. Chapter 8 - Combining LORETA Z-Score Neurofeedback with Heart Rate Variability Training. In: Thatcher RW, Lubar JF, eds. *Z Score Neurofeedback.* San Diego: Academic Press; 2015:159-188.
11. Thayer JF, Lane RD. Claude Bernard and the heart-brain connection: further elaboration of a model of neurovisceral integration. *Neurosci Biobehav Rev.* 2009;33(2):81-88.
12. Holzman JB, Bridgett DJ. Heart rate variability indices as bio-markers of top-down self-regulatory mechanisms: A meta-analytic review. *Neuroscience & Biobehavioral Reviews.* 2017;74:233-255.
13. Burch JB, Alexander M, Balte P, et al. Shift Work and Heart Rate Variability Coherence: Pilot Study Among Nurses. *Applied Psychophysiology & Biofeedback.* 2019;44(1):21-30.
14. Sloan RP, Schwarz E, McKinley PS, et al. Vagally-mediated heart rate variability and indices of well-being: Results of a nationally representative study. *Health Psychology.* 2017;36(1):73.
15. El-Sheikh M, Harger J, Whitson SM. Exposure to interparental conflict and children's adjustment and physical health: The moderating role of vagal tone. *Child development.* 2001;72(6):1617-1636.
16. Golosheykin S, Grant JD, Novak OV, Heath AC, Anokhin AP. Genetic influences on heart rate variability. *International journal of psychophysiology : official journal of the International Organization of Psychophysiology.* 2017;115:65-73.
17. Caldwell YT, Steffen PR. Adding HRV biofeedback to psychotherapy increases heart rate variability and improves the treatment of major depressive disorder. *Int J Psychophysiol.* 2018;131:96-101.
18. Goessl VC, Curtiss JE, Hofmann SG. The effect of heart rate variability biofeedback training on stress and anxiety: a meta-analysis. *Psychol Med.* 2017;47(15):2578-2586.
19. Ginsberg JP, Berry ME, Powell DA. Cardiac coherence and posttraumatic stress disorder in combat veterans. *Altern Ther Health Med.* 2010;16(4):52-60.
20. Steffen PR, Austin T, DeBarros A, Brown T. The Impact of Resonance Frequency Breathing on Measures of Heart Rate Variability, Blood Pressure, and Mood. *Front Public Health.* 2017;5:222.
21. Routledge FS, Campbell TS, McFetridge-Durdle JA, Bacon SL. Improvements in heart rate variability with exercise therapy. *Canadian Journal of Cardiology.* 2010;26(6):303-312.

22. McCraty R, Atkinson M, Tiller WA, Rein G, Watkins AD. The effects of emotions on short-term power spectrum analysis of heart rate variability. *The American Journal of Cardiology.* 1995;76(14):1089-1093.
23. Crocq MA, Crocq L. From shell shock and war neurosis to posttraumatic stress disorder: a history of psychotraumatology. *Dialogues Clin Neurosci.* 2000;2(1):47-55.
24. Eber S, Barth S, Kang H, Mahan C, Dursa E, Schneiderman A. The National Health Study for a New Generation of United States Veterans: methods for a large-scale study on the health of recent veterans. *Military medicine.* 2013;178(9):966-969.
25. Tan G, Dao TK, Farmer L, Sutherland RJ, Gevirtz R. Heart rate variability (HRV) and posttraumatic stress disorder (PTSD): a pilot study. *Appl Psychophysiol Biofeedback.* 2011;36(1):27-35.
26. Holt-Lunstad J, Smith TB, Layton JB. Social relationships and mortality risk: a meta-analytic review. *PLoS Med.* 2010;7(7):e1000316.
27. McCraty R, Childre D. Coherence: bridging personal, social, and global health. *Altern Ther Health Med.* 2010;16(4):10-24.
28. Proietti R, di Fronso S, Pereira LA, et al. Heart Rate Variability Discriminates Competitive Levels in Professional Soccer Players. *J Strength Cond Res.* 2017;31(6):1719-1725.
29. Morris SM. Achieving collective coherence: group effects on heart rate variability, coherence and heart rhythm synchronization. *Altern Ther Health Med.* 2010;16(4):62-72.
30. McCraty R. The Energetic Heart: Biolectromagnetic Interactions Within and Between People. *The Neuropsychotherapist.* 2003;6:22-43.
31. Wilson SJ, Bailey BE, Jaremka LM, et al. When couples' hearts beat together: Synchrony in heart rate variability during conflict predicts heightened inflammation throughout the day. *Psychoneuroendocrinology.* 2018;93:107-116.