THE EFFECTS OF AN AEROBIC-BASED CONDITIONING PROGRAM ON VETERANS WITH PTSD SYMPTOMS AND SLEEP DEFICIENCIES

by

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This research is dedicated to the men and women of the Armed Forces.

ABSTRACT

Veterans have been shown to have increased posttraumatic stress disorder (PTSD) symptoms and poorer sleep quality when compared to their civilian counterparts. The purpose of the first study was to evaluate the impact of aerobic exercise on sleep quality in veterans with PTSD ($N = 20$). The purpose of the second study was to evaluate the impact of aerobic exercise on PTSD symptoms in veterans with poor sleep quality ($N = 20$).

Study one measured sleep scores as measured by the Pittsburgh Sleep Quality Index (PSQI) at multiple time points during an aerobic training routine over an 8-week period. Within study one, there was a control group ($N = 10$) and an intervention group ($N = 10$). The difference between the control group's mid-test PSQI and the intervention group's mid-test PSQI when controlling for pre-test scores, was statistically significant $p = .028$. Additionally, the difference between the control group's post-test PSQI and the intervention group's post-test PSQI when controlling for pretest scores was statistically significant $p = .017$. The difference between the control group's post-test PSQI ($M = 13.84$, SD = 3.86) and the intervention group's post-test PSQI when controlling for mid-test scores was not statistically significant $p = .957$.

Study two measured PTSD symptoms as measured by the Posttraumatic Stress Disorder Checklist Version 5 at multiple time points during an aerobic training routine over an 8-week period. Within study, there was a control group ($N = 10$) and an intervention group ($N = 10$). The difference between the control group's mid-test PCL-5 ($M = 55.45$, $SD = 14.99$) and the intervention group's mid-test PCL-5 when controlling

for pre-test scores was statistically significant $p = .003$. Additionally, the difference between the control group's post-test PCL-5 and the intervention group's post-test PCL-5 when controlling for pre-test scores was statistically significant $p = .005$. The difference between the control group's post-test PCL-5 and the intervention group's post-test PCL-5 when controlling for mid-test scores, was not significant $p = .655$. Both of these studies highlight the application of aerobic exercise as a means to reduce PTSD and poor sleep quality in veterans.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF ABREVIATIONS

PTSD =	Posttraumatic Stress Disorder
US =	United States
VA =	Department of Veteran's Affairs
OSA =	Obstructive Sleep Apnea
PSQI =	Pittsburgh Sleep Quality Index
PCL-5 =	Posttraumatic Check List Version 5
CAPS-5 =	Clinician-Administered PTSD Scale
DSM-5 =	Diagnosis and Statistical Manual of Mental Disorders
PDS =	Posttraumatic Diagnostic Scale

CHAPTER I

DISSERTATION INTRODUCTION

The American Psychological Association (APA; 2018) has defined posttraumatic stress disorder (PTSD) as a psychiatric disorder that is the result of any traumatic event and/or experience. Posttraumatic stress disorder can be separated into two categories, short-term or long-term, based on the amount of time symptoms are experienced. Short-term PTSD includes individuals who have displayed symptoms for less than 12 months while long-term PTSD includes symptoms that exceed 12 months (Lurigio, 2018). An important factor with PTSD is that any symptomology left unchecked has the potential to increase in severity (Priebe et al., 2009).

Approximately 8.3% of the United States (US) population will experience some level of short-term or long-term PTSD within their lifetime (Kilpatrick et al., 2013). Regardless of military occupation, veterans tend to be twice as likely to exhibit PTSD symptoms when compared to civilian counterpart (Davidson, Babson, Bonn-Miller, Souter, & Vannoy, 2013). While the symptoms of PTSD can be debilitating, the comorbidities associated with PTSD can be of even greater concern. The risk of having cardiovascular, pulmonary, dermatological, and metabolic diseases is increased as levels of PTSD symptoms increase (Priebe et al., 2009).

A comorbidity of PTSD is decreased amount and quality of sleep. Approximately 44% of combat veterans with PTSD have issues with sleep quality (Neylan et al., 1998).

The Institute of Medicine Committee on Sleep Medicine and Research (2006) estimates approximately 50-70 million adults in the US suffer from the adverse effects of at least one sleep disorder. A unique dynamic between sleep and PTSD is that as sleep decreases, PTSD symptoms increase. This creates a negative feedback loop which has the potential to further increase comorbidities as well as increase suicidal ideations and attempts (Jakupcak et al., 2009; Pace-Schott, Germain, & Milad, 2015; Pietrzak et al., 2010; Priebe et al., 2009; Shankar, Symala, & Kalidindi, 2010; Thoresen & Mehlum, 2007).

From a study conducted by the Veteran's Affairs (VA) on a sample of nearly 1 million veterans with potential sleep disorders, it was estimated that approximately 73% of participants met the criteria for sleep apnea and insomnia (Alexander et al., 2016). Sleep apnea was the more prevalent issue of the two conditions. Obstructive sleep apnea (OSA) is the most common form of sleep apnea and has also been shown to have a direct relationship with PTSD symptoms in both civilian and veteran populations (Capaldi, Guerrero, & Killgore, 2011; Krakow et al., 2002). A separate study was conducted on OSA in a civilian population in order to see the effects of exercise on reducing the symptoms. The OSA symptoms were reduced through exercise and the improvement was independent of other variables that have been linked to OSA, such as weight loss (Schwartz et al., 1991).

Recently, exercise interventions have also been researched in a civilian population to improve PTSD symptoms. A study was conducted using moderate-intensity (40-59% HRmax [heart rate max]) jogging for approximately 30 minutes (Manger, & Motta, 2005). Posttraumatic stress disorder symptoms were not only reduced by clinically significant levels from pre- to post- test, but the positive effects of the protocol lingered 1-month post intervention. This is an important finding as exercise is easily administered to individuals regardless of financial and/or location limitations. In the past few years, the potential use of exercise to reduce sleep deficiencies as well as PTSD symptoms in a civilian based population has been researched, yet little is known regarding the effect of exercise and sleep in the veteran population. Therefore, it is warranted to study exercise as a potential avenue to improve sleep and PTSD in a veteran population.

Overall Summary

There are two studies within this dissertation that were designed to examine changes in veteran's sleep quality and PTSD symptoms in response to aerobic exercise. The first study measured and quantified veteran's sleep quality score based on the Pittsburgh Sleep Quality Index (PSQI) prior to the exercise intervention. After the intervention, the PSQI score was taken again to compare mid intervention group scores with mid control group scores while controlling for pre-test scores. The same method was done again to compare post intervention scores with post control scores while controlling for pre-test scores. Finally, a third analysis was done to compare post-test scores of the intervention group scores with the post-test scores of the control groups scores while controlling for mid-test scores. It was hypothesized that the veteran's PSQI score and subcategory scores would improve after completing the exercise intervention. The second study measured and quantified veteran's PTSD symptoms based on the Posttraumatic Check List Version 5 (PCL-5) prior to the exercise intervention. After the intervention, the PCL-5 score was taken again to compare mid intervention group scores with mid control group scores while controlling for pre-test scores. The same method was done again to compare post intervention scores with post control scores while controlling for pre-test scores. Finally, a third analysis was done to compare post-test scores of the intervention group scores with the post-test scores of the control groups scores while controlling for mid-test scores. It was hypothesized that the veteran's PCL-5 score would improve after completing the exercise intervention.

CHAPTER II

REVIEW OF THE LITERATURE

The beginning of the literature review contains information on PTSD as it relates to the general population and then includes a comparison between the general population and the veteran population. That section is followed by the comorbidities associated with PTSD and the issues that occur due to prolonged elevated levels of PTSD symptoms. The next section is on sleep, one of the comorbidities of PTSD, and the negative feedback loop associated with PTSD. Afterwards, there is a discussion on measurements of sleep and the applicability of particular methods to different settings. There is then a look into measures of PTSD as well as the applicability of these measures to certain populations. The next section is on interactions between sleep and PTSD. Lastly, information on exercise interventions and PTSD and sleep, respectively is presented.

PTSD

Posttraumatic Stress Disorder (PTSD), as defined by the American Psychological Association (APA; 2018), is a psychiatric disorder in response to any traumatic event or experience including: 1) directly experiencing, 2) witnessing firsthand, 3) becoming aware of an event happening to a relative, or someone close, or 4) experiencing the aftermath of traumatic events that had recently occurred (first responders and emergency personnel). Traumatic events include: 1) acts of terror, 2) mass shootings, 3) physical, psychological, or emotional abuse, 4) and combat exposure (Courtois et al., 2017). There are two categories of PTSD. Short term PTSD refers to any individual who has had symptoms for less than 12 months. Anything equal to or greater than 12 months is categorized as long-term PTSD (Lurigio, 2018). Regardless of classification, PTSD, if left unchecked, has the potential to increase exponentially in severity (Priebe et al., 2009). This is one of the driving factors in the importance of early diagnosis of PTSD.

Approximately 8.3% of the United States (US) population will experience an event that induces some level of PTSD in their lifetime (Kilpatrick et al., 2013). Unlike civilian counterparts, veterans, due to the nature of their workplace environment, tend to have increased exposure rates and an increased likelihood of severe PTSD symptoms. Generally, veterans, regardless of occupation, are approximately twice as likely as civilians to experience PTSD symptoms in their lifetime (Davidson, Babson, Bonn-Miller, Souter, & Vannoy, 2013). Though veteran PTSD rates range from 2%-17%, veterans with direct combat exposure for the Gulf wars have been shown to have PTSD rates as high as 44% (Jakupcak et al., 2009; Lapierre, Schwegler, & LaBauve, 2007; Richardson, Frueh, & Acierno, 2010).

In addition to direct exposure to traumatic events, another issue that compounds PTSD symptoms for combat veterans is the training routine outside of deployments that tends to be fast paced with little time off. This can discourage individuals from seeking help as it could negatively impact the unit’s combat readiness as well as have adverse effects on the veteran’s status within the unit. Though there are medical stand downs, or times for the battalion to attend medical appointments, these stand downs typically will be a week or less. It takes more time for a veteran to schedule, meet, and receive a proper diagnosis and treatment for PTSD than is provided in a typical stand down and the veteran must continue with training and deployments before resolution. The lifestyle during a combat veteran's active duty can lead to increased risk of the symptoms associated with PTSD (Jakupcak et al., 2009). As varying as the issues surrounding PTSD are, the methods and tools involved with diagnosing PTSD must be as numerous to be able to properly assess each individual with their unique PTSD symptoms.

Measures of PTSD

There are several different measurement scales for those with PTSD symptoms to properly assess different populations. It is necessary to have a wide range of measurement scales due to the type of event that has occurred, including harassment, sexual trauma, a loved one being deployed, and combat (National Center for PTSD, 2018). The clinician-administered PTSD scale (CAPS-5) for the diagnostic and statistical manual version 5 (DSM-V) is the gold standard for the assessment of PTSD (PTSD Assessment Instruments, 2018). This is a 30-item structured questionnaire which can assess short- or long-term PTSD symptoms. The CAPS-5, when properly administered by a clinician, accurately diagnoses PTSD and the severity of PTSD symptoms. While this is the preferred method for diagnosis, it is not practical for assessment of changes during or after an intervention protocol due to the subjective nature of the test.

Another accepted method of measurement for PTSD symptoms is the PTSD checklist for the DSM-V (PCL-5; (Bovin et al., 2016; PTSD Assessment Instruments, 2018). This is a more practical measurement when assessing changes following interventions. It is concise and there are also multiple versions to target specific issues related to PTSD (National Center for PTSD, 2018). The three versions in use today are the PCL-C (civilian version), PCL-S (specific events version), and the PCL-M (military version; Blevins, Weathers, Davis, Witte, & Domino, 2015). While the PCL-C and the PCL-S have validity in their own specific populations, the PCL-M is the primary self-reported survey in use for veterans (Wortmann et al., 2016). The PCL-M is a 17-item survey which has been modified from the original PCL-C version to reflect questions directly related to traumatic events causing PTSD for veterans (National Center for PTSD, 2018). The PCL-M has yet to be updated since the revisions to the DSM-IV in 2013 to the new DSM-V; however, the validity of the PCL-M has remained constant (Back; 2015; Decker, Deaver, Abbey, Campbell, & Turpin, 2018; Kip, Berumen, Zeidan, Hernandez, & Finnegan, 2019). The PCL-M can measure PTSD symptoms in a quantitative way and is ideal for measurements in a pre- and post-test environment. Along with the issues associated with PTSD, there are other comorbidities that can have adverse effects on the veteran.

Comorbidities of PTSD Among Veterans

Post-traumatic stress disorder can affect the brain and has several comorbidities. During high stress situations, such as combat, a biological stress response stimulates the production and the release of endogenous opioids from the brain. This response, thought to reduce the perception of pain, will also interfere with memory-protective processes, which may cause dissociation during the perceived threat (Olszewski & Varrasse, 2005). While this is an important response to imminent danger, individuals who are frequently experiencing the traumatic event associated with PTSD (such as combat veterans) are likely to reactivate this process which, in turn, maintains a high level of endogenous opioids within the body. Chronically elevated levels of endogenous opioids are a driving factor behind drug use and abuse with veterans who have PTSD (Dell & O'Neil, 2015).

Along with substance abuse and alcohol abuse, are a myriad of comorbidities involving the cardiovascular system that develop over the course of the veteran's life with PTSD. A study on aging veterans was conducted with the purpose of investigating groups with and without PTSD and the difference in risk of cardiovascular disease (Beristianos, Yaffe, Cohen, & Byers, 2016). The group with PTSD had a 45% increased risk for cerebrovascular disease, 26% increased risk for congestive heart failure, 49% increased risk for incidents involving myocardial infarction, and a 35% increased risk for peripheral vascular disease when compared to the group without PTSD.

In a study conducted in Croatia, researchers examined the comorbidities of veterans with PTSD 15 years after the Croatian war (Priebe et al., 2009). The authors concluded the veterans were at an increased risk for cardiovascular, pulmonary, dermatological, and metabolic diseases (Priebe et al., 2009). One predictor for these diseases was the total time spent within the warzone. As time increased, so did the risk of having one of these diseases. The veterans were also shown to be four times more likely to be diagnosed with a neurological disease than their civilian counterparts that had not participated in the war (Priebe et al., 2009).

Another facet of the combat veteran's health that is affected by PTSD is his or her quality and amount of sleep. Approximately 44% of combat veterans with PTSD have trouble falling asleep and staying asleep (Neylan et al., 1998). Even as the combat veteran's PTSD symptoms remain constant, his or her sleep can continually deteriorate. The sleep disruptions can further increase PTSD symptomology thereby increasing the likelihood of comorbidities including suicidal ideation and attempts (Jakupcak et al., 2009; Pace-Schott, Germain, & Milad, 2015; Pietrzak et al., 2010; Priebe et al., 2009; Shankar, Symala, & Kalidindi, 2010; Thoresen & Mehlum, 2007). This is an important factor to consider as this particular comorbidity produces a unique increase in the PTSD symptoms. The relationship between a veteran's PTSD symptomology and overall quality and quantity of sleep warrants further review in order to better understand the dynamics of this association.

Sleep Among Civilians and Veterans

Sleep, as defined from a scientific standpoint, can be separated by behavioral responses and physiological changes that are measured through electrical rhythm changes (Chokroverty, 2010). The behavioral responses are characterized by a gradual slowing of mobility, decreased eye movements, postural behavior related to sleep, decreased response time, and impaired cognitive function. The physiological criteria can be seen through an electroencephalogram (EEG), electro-oculography (EOG), and electromyography (EMG). Each of these measurement tools detect specific electrical stimulation that is produced by the body during specific states of sleep (Chokroverty, 2010).

Previously, sleep patterns were scored using the Rechtschaffen and Kales scoring manual, which divided sleep into seven stages (wake, stage 1, stage 2, stage 3, stage 4, stage REM [rapid eye movement], and movement time; Moser et al., 2009). In 2007, the

American Academy of Sleep Medicine (AASM) categorized sleep into four smaller stages (N1, N2, N3, and REM). The reason for this change was due to score reporting based on specific capabilities of polysomnography (Moser et al., 2009). The cycles and stages of sleep will continually repeat themselves until individuals are completely rested or are awoken by a separate stimulus. The first three stages are essentially the non-REM cycles preceding REM and can be further broken down by more specific characteristics.

The beginning stage of sleep where the individual is moving from wakefulness to sleep is N1. It is a relatively short period of time lasting only several minutes. It is characterized by light sleep and one's eye movements, breathing, and heartbeat begin to slow ("Brain Basics: Understanding Sleep," 2019). This can be seen through PSGs as brainwaves begin to slow from the previously awakened state. Ambient lighting has a significant impact during this stage due to light's effect on the natural circadian rhythm ("Brain Basics: Understanding Sleep," 2019).

The second stage of sleep, N2, makes up the vast majority of sleep time ("Brain Basics: Understanding Sleep," 2019). This period in the sleep cycle is characterized by slower brainwaves than the previous N1 stage and sudden bursts of electrical activity which can be monitored through the PSG. Another aspect related to this stage is a drop in core temperature and the cessation of eye movement ("Brain Basics: Understanding Sleep," 2019; Czeisler, Weitzman, Moore-Ede, Zimmerman, & Knauer, 1980). This is the stage immediately preceding deep sleep.

The final stage prior to entering REM sleep is N3. This stage is characterized by breathing and heart rates (HRs) at their lowest points during the overall sleep cycle

(“Brain Basics: Understanding Sleep,” 2019). This stage also has the slowest brain waves as detected by PSG. Additionally, muscles are at their most relaxed state during this time and it can be difficult to awaken individuals in N3. During the first half of the night, this stage is considerably longer than at the end of the night of sleep (“Brain Basics: Understanding Sleep,” 2019).

The last stage of the sleep cycle is REM sleep. This stage typically occurs in the first 90 minutes of sleep (“Brain Basics: Understanding Sleep,” 2019). As indicated in the name, individuals will experience rapid eye movements as well as a few other characteristics that appear during the wake cycle. Heart rate and blood pressure will be at or near levels of waking. Additionally, breathing patterns become rapid and irregular. Due to the production of the neurotransmitters gamma-aminobutyric acid (GABA) and glycine from the hypothalamus and the brain stem, the skeletal muscles become paralyzed which prevents individuals from acting out dreams and causing potential self-injury (“Brain Basics: Understanding Sleep,” 2019; Brooks & Peever, 2011).

The total amount of times that individuals repeat the sleep cycle depends on age. The AASM recommends that infants up to 1 year of age need 12-16 hours daily of sleep. Children ages 1 to 12 years require between 14-10 hours of sleep a day. Teenagers up to 18 years old need approximately 10 hours of sleep each day for optimal health (“Recharge with Sleep: Pediatric Sleep Recommendations Promoting Optimal Health,” 2016). For the adult population, the AASM’s and the Sleep Research Society (SRS)’s guidelines for sleep decrease further. In June of 2015, a yearlong research study by the AASM and SRS jointly indicated adults should sleep 7 or more hours each night to promote optimal health (Watson et al., 2015). Furthermore, those who chronically sleep less than 7 hours are at increased risk for weight gain, obesity, diabetes, hypertension, heart disease, stroke, and mental health disorders such as depression (Watson et al., 2015).

It is estimated that approximately 50 – 70 million adults in the US are experiencing the adverse effects of a sleep disorder (Institute of Medicine (US) Committee on Sleep Medicine and Research, 2006). Common sleep disorders include: 1) insomnia, 2) excessive daytime sleepiness, 3) obstructive sleep apnea, 4) narcolepsy, 5) periodic limb movements of sleep and 6) parasomnias (An Overview of Sleep Disorders, 2007). Of these, the most common with veterans are sleep apnea, insomnia, and periodic limb movement (Alexander et al., 2016). Each of these disorders may detract from a person's sleep quality and, many times, disorders will overlap, exponentially decreasing the quality of sleep. These negative effects can affect a wide range of physiological components such as: increased risk for hypertension, diabetes, obesity, depression, heart attack, and stroke (Alexander et al., 2016; Institute of Medicine [US] Committee on Sleep Medicine and Research, 2006). From the year 2000 to 2010, a study was conducted on sleep disorders in veterans that had been to the VA within that decade (Alexander et al., 2016). During this time, there was a three-fold increase in veterans receiving treatment for sleep disorders, likely due to the increased deployments to warzones, such as Iraq and Afghanistan (Capaldi, Guerrero, & Killgore, 2011). Recent research shows the importance of the quantity and quality of sleep and the potential issues that may occur when sleep is disrupted. The manner in which sleep is measured is an important component in order to fully understand and in order to implement be able to treat individuals who may be suffering from sleep ailments.

Measures of Sleep Quality

There are numerous methods to measure sleep, each with strengths and limitations. Polysomnography, the wrist worn Actigraph, and the self-administered sleep assessment Pittsburgh sleep quality index (PSQI) are all valid measurement tools related to sleep.

A clinical measure of sleep, considered the gold standard, is PSG (Marino et al., 2013). A PSG procedure typically takes place in a specialized sleep center or a hospital (Giorgi, 2017). An elastic belt is placed around the chest and stomach to allow measurements of breathing patterns and movement patterns. A clip is then placed on the finger for measurement of blood oxygen levels (Giorgi, 2017). Electrodes are the final measurement tools placed and are located on the scalp, temples, chest, and legs. All of these sensors are kept on during an individual's sleep to allow data to be collect throughout the various stages and cycles of sleep (Giorgi, 2017). The data collected allow for the measurement of numerous variables that allow for proper diagnosis of sleep disorders as well as sleep treatment plans. A brief list of variables measured includes blood oxygen levels, EEG, breathing rates and patterns, body position, eye movement, HR and rhythm, leg movements, sleep stages, excessive snoring and noises during sleep, and erratic movement patterns (Brooks, 2018). While this is the preferred method in a clinical setting, it is not as practical in an intervention study where multiple measurements throughout the course of a study are required. This is due to the cost and the requirement of a specific location for use as well as the invasiveness of implementing the measurement tools. Also, when dealing with special populations that have hyper arousal issues, such as people suffering from PTSD, the implementation of PSGs can greatly decrease a person's sleep quality, skewing the sleep data collected (Edinger et al., 1997; Edinger et al., 2001). Polysomnography, however, has had many validation studies compared to the Actigraph which is a more common and cost-effective instrument (Blackwell et al., 2008; Jean-Louis, Kripke, Cole, Assmus, & Langer, 2001; Kanady, Drummond, & Mednick, 2011; Kushida et al., 2001; Marino et al., 2013; Souza et al., 2003;).

There have been further studies into the Actigraph and its ability to estimate sleep patterns for civilians as well as veterans that have PTSD symptoms (Bertram et al., 2014; Dagan, Zinger, & Lavie, 1997; Khazaie, Ghadami, Nasoori, & Paveh, 2015). An additional benefit of using the Actigraph as opposed to the PSG is that the individual using the Actigraph is able to sleep in his or her own home where he or she is more comfortable and likely to have more normal sleep rhythms (Edinger et al., 1997; Edinger et al., 2001; Mendels, & Hawkins, 1967). The main issue with the Actigraph monitor is that it does not have an accurate overall measure of sleep. The Actigraph can quantify total sleep time (TST) accurately; however, it loses precision when accounting for wake after sleep onset (WASO) and total sleep efficiency (TSE; Lee, Byun, Keill, Dinkel, & Seo, 2018). In fact, many other activity and sleep monitors fall short when trying to account for all aspects of sleep. In terms of a complete measurement of sleep: TST, WASO, TSE, and time spent in bed, the Sensewear Armband, Fitbit Charge HR, Basis

Peak, Garmin Vivosmart, and Jawbone all fail to have complete and accurate measurements (Lee, Byun, Keill, Dinkel, & Seo, 2018).

A measurement tool considered to be an accurate measure of overall quality of sleep and a noninvasive measure is the PSQI (Grandner, Kripke, Yoon, & Youngstedt, 2006). The PSQI is a self-rated questionnaire which can be used to evaluate sleep disturbances and sleep quality over a 1-month period. It has 24 questions which generate a seven-component score which includes: Subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). The PSQI has been validated and used by various research populations including veterans who have PTSD (Babson et al., 2015; Lewis, Creamer, & Failla, 2009; Plumb, Peachey, & Zelman, 2014). The PSQI is the preferred method of measurement for quantity and quality of sleep due to its validity as well as its less invasive means of collecting data, especially among those such as veterans. It is important to understand PTSD and its measures as well as sleep and its measures; however, further review into the complexity of sleep as it relates to PTSD is necessary.

Sleep and PTSD

In a sample size of nearly 1 million veterans with potential sleep disorders, approximately 73% met the criteria for sleep apnea and insomnia (Alexander et al., 2016). Of the two disorders, sleep apnea was more prevalent in the veteran population than insomnia. Obstructive sleep apnea (OSA) is one of the most common form of sleep apnea and is characterized by a decrease or halt in breathing due to the relaxation of the throat muscles (Park, Ramar, & Olson, 2011). Obstructive sleep apnea has been shown to have a direct relationship with PTSD in both civilian and veteran populations (Capaldi, Guerrero, & Killgore, 2011; Krakow et al., 2002). In more recent studies, the use of continuous positive airway pressure (CPAP) has been shown to improve PTSD symptoms by reducing OSA severity (Orr et al., 2017). This finding strengthens the evidence of PTSD symptom reduction through the improvement of sleep quality.

Another potential avenue that has been explored recently is the use of exercise to reduce OSA severity. It was originally presumed that the benefits of physical activity in the reduction of OSA symptoms was primarily due to weight loss (Schwartz et al., 1991). More recent studies have shown that OSA symptom reduction through increased physical activity is independent of weight loss (Awad, Malhotra, Barnet, Quan, & Peppard, 2012; Quan, 2007). Whether the sleep disorder is OSA or another sleep disorder, increased physical activity and exercise have been shown to be beneficial in improving sleep (Awad, Malhotra, Barnet, Quan, & Peppard, 2012; Iftikhar, Kline, & Youngstedt, 2014; Kline et al., 2012; Quan, 2007).

Exercise

Exercise has been shown to be beneficial to numerous aspects of good health, including, increased HDL, decreased LDL, improved body composition, improved blood pressure, improved lipid profile. This is a short list of the physiologic improvements associated with exercise. When looking into the benefits of exercise, it becomes clear that its application can extend even farther. Improvement into ones sleep as well as mental health have been documented by many research studies to date.

Exercise and Sleep

Baekeland and Lasky (1966) investigated the relationship between exercise and sleep while it was still in its nascent stages. They began by looking at different time periods of exercise and their individual effects on the various stages of sleep. They had found that within the sample of 10 college students there were increased delta wave activity across the sample regardless of the timing (Baekeland, & Lasky, 1966). Since this time, numerous studies have emerged exploring the unique dynamic between different modes of exercise training and their effects on various stages of sleep.

Aerobic-based training has been led to improved quality of sleep (Brassington, & Hicks, 2019; Reid et al., 2010; Wang, & Youngstedt, 2014). A study assessing the effects of exercise on insomnia was conducted at Northwestern University in Chicago, IL. (Baron, Reid, & Zee, 2013). A sample of 11 female participants with insomnia (mean age of 61 years) exercised aerobically for 30 minutes a day, 3 times per week. The mode of exercise was treadmill-based using a percentage of the participant's Maximal Oxygen Uptake (VO_{2max}). The duration of the protocol was 16 weeks. Participants were assed using the Actigraph as well as the PSQI for sleep pre- and post- exercise protocol (Baron, Reid, & Zee, 2013). The results of this study showed evidence of improved TST, sleep efficiency (SE), and self-reported global sleep quality from the pre-protocol scores to post-protocol scores (Baron, Reid, & Zee, 2013).

Sleep quality improvement are not just limited to populations with sleep abnormalities. A separate study showed the effects of aerobic exercise on sleep quality in male participants (Kamrani, Shams, Dehkordi, & Mohajeri, 2014). Elderly men ($N = 45$)

with a mean age of 65 years participated in an aerobic based exercise protocol for 8 weeks. The dosage of exercise was determined by the individual's max heart rate (MaxHR). There were 2 groups, one doing moderate intensity walking (40-50% MaxHR) and the other doing moderate to slightly vigorous intensity walking (50-70% MaxHR; Kamrani et al., 2014). A third group was used as a control group where no exercise protocol was administered. For the 2 groups who completed exercise programs, each exercise sessions consisted of a 10-minute warm-up at 20-30% MaxHR, 35 minutes of low or moderate intensity aerobic exercise, and a 10 minute cool-down at 20-30% MaxHR (Kamrani et al., 2014). The PSQI was used to determine pre and post test scores for quality of sleep. Both groups showed improvements in the overall PSQI score when compared to the measures of the control group; however, the moderate intensity group had the greatest improvements in total PSQI score (Kamrani et al., 2014).

Exercise interventions are not restricted to treadmill-based protocols. At the University of Pittsburgh Medical Center, a study was conducted on 437 overweight/obese postmenopausal women using semi-recumbent cycle ergometry and treadmill-based exercise protocols (Kline et al., 2012). The participants were separated into 4 groups: one group was set as a control and no exercise was performed, the second group received 50% of the recommended dosage of exercise per week, the third group completed 100%, and the fourth completed 150% (Kline et al., 2012). The recommended dosage of exercise was prescribed by the National Institute of Health and Consensus Development Panel. The groups that were exercising maintained a moderate intensity of exercise (50% Peak Oxygen Uptake [VO_{2peak}]) throughout the program. Exercise groups alternated between cycle ergometry and treadmill-based exercise during the week (Kline et al., 2012). Each group performed the exercise protocol 4 times a week for 6 months. A pre-test and post-test analysis were conducted to measure total sleep quality using the Medical Outcomes Study and Sleep Problems Index. All groups that received the intervention had improvement in both measures. Furthermore, no groups had significant weight loss throughout the protocol, which is evidence that sleep improvement through exercise can be independent of weight loss (Kline et al., 2012). While it is shown that exercise is a potential intervention to improve sleep, it must be discussed further of exercises potential beneficial effect on PTSD symptoms.

Exercise and PTSD

While the body of knowledge within exercise and sleep is an expansive one, the current literature on exercise and PTSD is in an earlier stage of development by comparison. This research is in a particularly newer developmental stage when considering exercise's effect on veterans with PTSD related to their military experiences. However, the information provided by the following research articles undoubtedly points towards exercise as a potential intervention for veterans due to the wide range of individuals who have benefited previously from its effects.

Researchers at the University of Regina in Canada conducted a 2-week stationary bike intervention for 33 individuals with clinically significant levels of PTSD (Fetzner, & Asmundson, 2015). Posttraumatic stress disorder symptoms were quantified using the PCL-C. The individuals pedaled at a rate to maintain a HR between 60-80% of heart rate maximum (HRmax). A total of 6 sessions of 20 minutes each were required for completion of the study (no more than 4 sessions per week). Upon completion of the study, 89% of the participants exhibited a clinical change (10-point decrease) in PTSD symptoms as indicated by the PCL-C (Fetzner, & Asmundson, 2015). Though this sample was taken from a civilian population, this study indicates a potential avenue for aerobic-based conditioning interventions as a method of PTSD symptom reduction.

Diaz and Motta (2008) used a walking program in an attempt to reduce PTSD symptoms in 12 female adolescents. All participants had PTSD symptoms ranging from subclinical to clinical levels. The Child PTSD Symptom Scale (CPSS) was utilized to quantify PTSD severity. There were 15 sessions administered of moderate-intensity walking (40-59% HRmax). Post intervention testing, as well as 1 month post intervention testing, showed a reduction in PTSD severity (Diaz & Motta, 2008). This study not only shows a reduced intensity exercise protocol with as few as 15 sessions can be effective in reducing PTSD symptoms, but also that the effects of the protocol have a prolonged effect.

Another study was conducted by Manger and Motta in 2005 using a jogging protocol on a treadmill. A sample of 26 participants performed the intervention all with at least mild levels of PTSD as dictated by the Posttraumatic Diagnostic Scale (PDS). The protocol for the exercise intervention was a 5-minute self-selected intensity on a stationary bike followed by a 5-minute stretching protocol (Manger, & Motta, 2005). Afterwards, a 30-minute session of jogging at a moderate-intensity (40-59% HRmax) was conducted. A 10-minute walking cool down was administered immediately after. The participants completed 2-3 sessions per week for 10 weeks. Upon completion of this study, there was a significant reduction of PTSD symptoms between pre- and post-intervention scores. There was also a 1-month post intervention score that also indicated significantly lower levels of PTSD symptoms when compared to pre-intervention scores (Manger & Motta, 2005). This study not only shows the variability in types of exercise interventions that can be administered in order to reduce PTSD symptoms, but it also helps to confirm the prolonged effect of the intervention on the PTSD symptom reduction. Though these studies are beneficial for their respective population study groups, exercise as a means to reduce PTSD needs to be explored further within a veteran population.

Overall Summary

The veteran population tends to be at greater risk for PTSD symptoms. Though PTSD can be debilitating alone, the comorbidities associated with this mental health disorder can also have catastrophic consequences on an individual's health. A particular comorbidity associated with PTSD is a decrease in overall quality of sleep. This is of importance as sleep has its own myriad of comorbidities and can also increase PTSD symptoms. Due to the increased rates of PTSD with veterans when compared to civilians, there is a need for additional intervention methods to reduce PTSD symptoms. Exercise interventions have been shown to improve sleep and PTSD in a civilian population. Therefore, the purpose of these studies is to explore the association between exercise and PTSD as well as the association between exercise and sleep quality in veterans with PTSD.

CHAPTER III

PSQI CHANGES FOLLOWING AEROBIC BASED TRAINING IN VETERANS WITH POSTTRAUMATIC STRESS DISORDER SYMPTOMS

Introduction

To promote optimal health, it is recommended adults get 7 hours or more of sleep a night (Watson et al., 2015). Those who chronically sleep less than the recommended amount are at increased risk for weight gain, obesity, diabetes, hypertension, heart disease, stroke, and mental health disorders such as depression (Watson et al., 2015). An estimated 50-70 million adults within the United States (US) are suffering from the adverse effects of a sleep disorder (Institute of Medicine (US) Committee on Sleep Medicine and Research, 2006). A study by Alexander et al. (2016), conducted over 10 years, between 2000 and 2010, documented the number of veterans with sleep disorders. During this time, a 3-fold increase in veterans seeking help for these sleeping disorders within the VA was observed.

These disorders can affect a person’s sleep quality, quantity, and many times, individuals can have multiple disorders that will overlap and become difficult to distinguish (Institute of Medicine (US) Committee on Sleep Medicine and Research, 2006). Aerobic exercise has been researched and utilized in treatment for sleep disorders for several decades within civilian populations. Exercise intensities for aerobic-based conditionings programs to impact sleep have ranged from low (less than 40% of maximum heart rate [HR_{max}]) to vigorous (greater than 59% of HR_{max}; Kamrani et al., 2014; Kline et al., 2012). Improvements in sleep quality have been documented following 8 weeks (Kamrani et al., 2014) and 6 months (Kline et al., 2012) of aerobic activity with positive changes maintained 1-month post-intervention (Kamrani et al., 2014; Kline et al., 2012).

In the study by Alexander et al. (2016), approximately 73% of the 1 million veterans included, met the criteria for sleep apnea and insomnia. One of the most common sleep disorders among veterans is sleep apnea (Park, Ramar, & Olsen, 2011). Obstructive sleep apnea has been shown to have a direct relationship among veterans and the reduction of this condition has also been shown to improve the symptoms of PTSD (Capaldi, Guerrero, & Killgore, 2011; Krakow et al., 2002; Orr et al., 2017). Research on the impact of aerobic exercise on the overall quality of sleep of veterans who suffer from posttraumatic stress disorder (PTSD) is limited. Due to sleep issues perpetuating in the veteran population, it is important to explore additional avenues of treatment that are both simplistic to administer as well as cost efficient. Therefore, the purpose of this study was to evaluate the impact of aerobic exercise on sleep quality in veterans with PTSD. It was hypothesized that veterans who completed the 8-week self-selected aerobic-based conditioning program would demonstrate greater improvements in sleep quality than veterans in the non-exercise control group.

Methodology

Participants

Demographic information for participants can be found in Table 1. Participants in this study were military veterans (*n* = 16 males, *n* = 4 females). Veteran status was determined by individuals who had completed at least one military contract (active, reserve, or national guardsman). The mean age of participants was (*M* = 37, SD = 7.39). Participants were screened for inclusion criteria using the Pittsburgh Sleep Quality Index (PSQI) to determine the minimum score (5 or more) necessary to be considered to have a sleep deficiency (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). With respect to PTSD, either a clinical diagnosis or a score of 31 or higher on the Posttraumatic Stress Disorder Checklist Version 5 (PCL-5) (minimum PTSD threshold; Weathers et al., 2013) were necessary for inclusion. Participants were then screened using the American College of Sports Medicine (ACSM) preparticipation health screening algorithm to ensure no medical clearance was necessary. Participants were recruited via word of mouth and through Middle Tennessee State University's Charlie Daniel's Veteran Center. Prior to screening, participants completed an informed consent. This study was approved by the University Institutional Review Board.

Instrumentation

PTSD Checklist Version 5

The PCL-5 is a self-administered survey which determines the quantity of PTSD symptoms being experienced due to military service. The use of the PCL-5 with veterans in diagnosing PTSD symptoms has been validated (Blevins, Weathers, Davis, Witte, &

Table 1

PTSD Diagnosis and Military Descriptors History (N=20)

	Mean	*Frequency*
Army	-	11
Air Force	-	1
Navy	-	4
Marines	-	3
Coast Guard	-	1
Diagnosis PTSD	-	8
No Diagnosis	-	12
Combat Experience*	-	5

Note. * = Includes combat action ribbons and combat badges; PTSD = Posttraumatic stress disorder.

Domino, 2015). This questionnaire consisted of 20 items on a 5-point Likert scale ranging from 1 (*not at all*) to 5 (*extremely*). A total PTSD symptom score includes the

Demographic Questionnaire

The demographic questionnaire included questions on age, sex, branch of service, deployment history, clinical PTSD diagnosis, and whether or not the veteran received any combat badge/ribbon during his or her service. The demographic questions were screened by co-investigators, for readability and content. These data were used for descriptive purposes. This survey was also conducted on a secure website (Qualtrics, Provo, Utah).

Pittsburgh Sleep Quality Index

The PSQI is a self-administered survey on sleep that is used to estimate the quality of sleep over the past month (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). There are 19 questions and 7 components which generate a composite score ranging from 0-21. A lower score indicates better sleep while a higher score indicates poorer sleep. This survey was completed by participants on a secure website at the start of the intervention, at midpoint (4 weeks), and post intervention (Qualtrics, Provo, Utah).

Procedures

The protocol was an 8-week intervention comprised of 26 sessions**.** The first day was considered intake for each participant while the final day was the post-test session for the intervention. On the intake day, each participant completed the PCL-5, demographics and PSQI surveys prior to official admittance into the study. Participants also completed an ACSM Algorithm Screening to assure medical clearance was not needed. Once it was determined that the participant met the inclusion criteria. At this point, either participants were assigned to an intervention group, where they conducted the assigned exercise protocol, or they were assigned to the control group. The control group conducted the same pre, mid, and post training procedures as well as the survey but had no intervention assigned. At the midpoint, it was confirmed with participants that they had not change any treatment related to sleep quality.

For those who were assigned to the intervention group, a training schedule was set up for each individual. Each participant was required to complete 2-3 training sessions per week (no less than 2) with no less than 48 hours between each session. If the participant failed to meet the minimum days per week for the exercise protocol, their exercise protocol was extended until a total of 24 exercise session was completed. A mid-test assessment of the participants PSQI was conducted at the 4-week mark for both the intervention and control groups. If any participant missed two subsequent weeks, they were either be dropped from the study or he or she would repeat the study from the beginning.

The exercise protocol intensity was based on the individual's age estimated HR_{max}. The participant would wear a Polar HR monitor that was set to beep when the participant had a HR that was too low or too high. This allowed the participant to keep their HR within range. The protocol was designed to start at a low (< 40% HR_{max}) intensity. The participants worked at this intensity for the first week in order to allow the participants to familiarize themselves with the equipment as well as to ease into the training routine. Following this, the participants could self-select their own intensities of exercise within the moderate intensity range (40-59% HR_{max}) throughout the protocol.

Each exercise day began with a 5-minute warmup at a self-selected low intensity range. The exercise protocol was 30 minutes in length at the preselected intensity for that training session. The sessions could be any aerobic mode of training that the participant chose that the lab could accommodate, to include, but not limited to; rowing, treadmill based walking, and stationary bike. These sessions were conducted with only one participant training at a time and were to be conducted in the presence of the researcher. Once the session was completed, there was a subsequent 5-minute cooldown at a self-selected low intensity range in order to help transition the participant back to a resting state. Within 72 hours of completion of the exercise protocol, participants returned to the lab and completed the PSQI survey.

Statistical Analyses

The Statistical Package for the Social Sciences (SPSS) 26.0 (Chicago, IL) software program was used for statistical analysis. Descriptive statistics are reported as means ± standard deviation. A one-way between subjects analysis of covariance (ANCOVA) was calculated to examine the effect of an aerobic based exercise intervention on PSQI scores from pretest to posttest when compared to a nonintervention-based control group. Statistical significance was set at $p < .05$ for all analyses. See Appendix A for IRB approval.

Results

There were 22 volunteers participating in the research, 11 were assigned to the intervention group and 11 to the control group. Participants in the intervention group were monitored in order to ensure that the 26 training sessions were completed, which was the minimum requirement. Each group had attrition which resulted in 10 participants in each group. One Participant was removed from the training group due to noncompliance with the frequency of session requirements and a second participant withdrew from the control group due to conflicts with work schedules.

The mean values for PSQI pre-test, mid-test, and post-test can be found in Table 2. The difference between the control group's mid-test PSQI (*M* = 15.00, SD = 4.27) and the intervention group's mid-test PSQI (*M* = 13.10, *SD* = 3.21), when controlling for pre-test scores, was statistically significant *F* (1, 19) = 5.76, *p* = .028. Cohen's effect size value (*d* = .56) suggested a practical significance, which indicates there were meaningful differences between the intervention and control groups at mid-test when pre-test scores were controlled.

Additionally, the difference between the control group's post-test PSQI (*M* = 14.70, SD = 3.86) and the intervention group's post-test PSQI (*M* = 13.00, *SD* = 3.40), when controlling for pretest scores, was statistically significant *F* (1, 19) = 2.05, *p* = .017. Cohen's effect size value (*d* = .57) suggested practical significance, which indicates that there were meaningful differences between the intervention and control groups at post-test when pre-test scores were controlled.

The difference between the control group's post-test PSQI (*M* = 13.84, SD = 3.86) and the intervention group's post-test PSQI (*M* = 13.87, *SD* = 3.40), when controlling for mid-test scores, was not statistically significant *F* (1, 19) = .003, *p* = .957. Cohen's effect size value (*d* = .05) suggested a negligible practical significance This indicates that there were little to no meaningful differences between the intervention and control groups from mid-test to post-test.

Table 2

PSQI Scores (N=10)

	Mean	SD
(I) Pre-test PSQI	15.20	4.26
(C) Pre-test PSQI	15.20	3.88
(I) Mid-test PSQI	13.10_a	3.21
(C) Mid-test PSQI	15.00	4.27
(I) Post-test PSQI	13.00_a	3.40
(C) Post-test PSQI	14.70	3.86

Note. (I) = Intervention group, (C) = Control group; PSQI = Pittsburgh Sleep Quality Index; * = Reported in estimated marginal means.

Discussion

In this study there were two groups, one was a control while the other was the intervention-based group. Each group contained 10 participants that had a PSQI score greater than or equal to 5 as well as PTSD symptoms greater than or equal to 34 as measured on the PCL-5. They completed 26 low to moderate intensity aerobic walking sessions over the course of this study averaging 2-3 sessions per week. Each participants' intensity was kept between low to moderate for the entirety of the protocol. There were pre, mid, and post-tests performed taking measurements of the individuals' PSQI scores. The purpose of this study was to evaluate the impact of aerobic exercise on PTSD symptoms in veterans with poor sleep quality. It was hypothesized that veterans who completed the 8-week self-selected aerobic-based conditioning program would demonstrate greater decreases in PTSD symptomology than veterans in the non-exercise control group. The data collect within this research supported the hypothesis. The ANCOVA performed indicated a statistically significant difference between pre-test and mid-test as well as pre-test to post-test for the intervention group. These findings are in keeping with the results of previously conducted studies (Brassington, & Hicks, 2019; Reid et al., 2010; Wang, & Youngstedt, 2014). When looking into the mid- test to post-test results, the ANCOVA indicated that there was no statistical significance. This is indicative of little to no change from the initial drop in PSQI which is observed in the current study's pre-test and mid-test results. The ANCOVA conducted on the control group demonstrated no statistical difference between pre-test to mid-test, pre-test to post-test, nor mid-test to post-test. This indicated that the control had no change throughout the period of the protocol.

While the PSQI remaining relatively unchanged for the intervention group from mid-test to post-test was not an anticipated outcome, it indicates that the benefits gained from an aerobic exercise routine are acute and then sustained for the entirety of the training regimen. This has considerable implications and applications for veterans who are suffering from poor sleep. Many veterans struggle with poorer sleep when compared to their civilian counterparts and approximately 10 percent of all veterans seeking medical treatment through the VA have been diagnosed with a sleep disorder (Alexander et al., 2016). It has been shown by previous research that those who have less than 7 hours of sleep consistently are more likely to present with symptoms of mental health disorders, such as depression (Watson et al., 2015). It has also been shown that 10 percent of all veterans seeking medical treatment through the VA will have sleep disturbances (Alexander et al., 2016). This study presents a potential intervention that can be implemented on a wide scale and improve sleep quality in Veterans and thereby decrease mental health issues. While this is not the only method to improve veterans sleep quality, this study’s findings indicate an acute implementation for an aerobic training schedule could be a viable option to help curb poor sleep quality while additional treatments are implemented such as pharmaceutical interventions.

There are several studies which look at the effect of aerobic training and its unique effect on sleep (Kamrani et al., 2014; Kline et al., 2012; Reid et al., 2010). The current study has a significant strength as it develops the body of knowledge of sleep and aerobic exercise further with its implementation of aerobic training on veterans with sleep difficulties who are also suffering from PTSD. An additional strength to this study is that every participant included had moderate to severe levels of PTSD as measured by the PCL-5 and a score of PSQI of 5 or greater. Both criteria are difficult to meet as they are a challenge to find separately, let alone combined in a participant. This adds to the current body of knowledge of sleep and aerobic activity as this population of veterans with PTSD symptoms has limited research conducted at this time.

Sample size is always a difficulty with intervention studies, specifically with a population as finite as veterans suffering from both PTSD and sleep disorders symptoms. Nonetheless, the sample size for this intervention study is extremely limited and is taken from an even narrower subgroup of veterans currently employed with the federal service. This could potentially make the current study's sample group less representative of the overall veteran population in which this study is applicable. A separate limitation to this study is the lack of timepoints taken post intervention. While this study's findings support the use of aerobic-based exercise to reduce PSQI symptoms for veterans with PTSD, there is no indication as to how long these effects may linger.

The next potential avenue in which to direct research for exercise-based studies in improving sleep among veterans suffering from PTSD would be to investigate veterans with sleep disorders without PTSD symptoms. This could potentially aid in determining if the sleep variable is independent of the PTSD symptoms when exercise-based interventions are employed. A separate facet in which future research should expand upon is altering the exercise protocol's intensity for each session. Numerous studies, including this current study, have conducted low to moderate ranges of intensity for their exercise protocols (Diaz & Motta, 2008; Kamrani et al., 2014; Kline et al., 2012). Research into increasing the intensity of the exercise protocols is less developed as the very nature of these studies tend to have more limitations and restrictions for the safety of the participants. However, understanding the effects of low to vigorous intensity aerobic-based exercise interventions in veterans with sleep disorders and PTSD symptoms could help determine the appropriate types of protocols to implement.

While there are continual improvements in sleep disorder treatment through medications and varying therapies, additional interventions, such as this study, are necessary for the growing population of veterans returning home from the conflicts across the globe in the middle east. Since the beginning of the Iraq and Afghanistan wars, there has been a 3-fold increase in the number of veterans suffering from sleep disorders (Alexander et al., 2016). It cannot be overstated enough that the need for additional research is needed in order to help support and benefit the veterans that have given so much for this country.

CHAPTER III REFERENCES

Alexander, M., Ray, M. A., Hébert, J. R., Youngstedt, S. D., Zhang, H., Steck, S. E., Bogan, R. K., & Burch, J. B. (2016). The National Veteran Sleep Disorder Study: Descriptive Epidemiology and Secular Trends, 2000–2010. *Sleep*, *39*(7), 1399–1410. https://doi.org/10.5665/sleep.5972

American College of Sports Medicine (2017). *ACSM's guidelines for exercise testing and prescription*. Lippincott, Williams & Wilkins.

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research*, *28*(2), 193–213. https://doi.org/10.1016/0165-1781(89)90047-4

Blevins, C. A., Weathers, F. W., Davis, M. T., Witte, T. K., & Domino, J. L. (2015). The Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5): Development and Initial Psychometric Evaluation. *Journal of Traumatic Stress*, *28*(6), 489–498. https://doi.org/10.1002/jts.22059

Capaldi, V. F., Guerrero, M. L., & Killgore, W. D. S. (2011). Sleep disruptions among returning combat veterans from Iraq and Afghanistan. *Military Medicine*, *176*(8), 879–888. https://doi.org/10.7205/milmed-d-10-00440

Grandner, M. A., Kripke, D. F., Yoon, I. Y., & Youngstedt, S. D. (2006). Criterion validity of the Pittsburgh sleep quality index: Investigation in a non-clinical sample. *Sleep and Biological Rhythms*, (2), 129-139. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=edsgao&AN=edsgcl.158839540&site=eds-live&scope=site

Institute of Medicine (US) Committee on Sleep Medicine and Research. (2006, January 1). Sleep disorders and sleep deprivation: An unmet public health problem. Retrieved October 1, 2019, from https://www.ncbi.nlm.nih.gov/pubmed/20669438

Kamrani, A., Shams, A., Shamsipour Dehkordi, P., & Mohajeri, R. (2014, March). The effect of low and moderate intensity aerobic exercises on sleep quality in men older adults. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3999022/

Kline, C. E., Ewing, G. B., Burch, J. B., Blair, S. N., Durstine, J. L., Davis, J. M., Youngstedt, S. D. (2012). Exercise training improves selected aspects of daytime functioning in adults with obstructive sleep apnea. *Journal of Clinical Sleep Medicine*, *8(*4), 357-365.

Krakow, B., Melendrez, D., Warner, T. D., Dorin, R., Harper, R., & Hollifield, M. (2002). To breathe, perchance to sleep: Seep-disordered breathing and chronic insomnia among trauma survivors. *Sleep and Breathing, 06*(4), 189–202. https://doi.org/10.1055/s-2002-36593

Orr, J. E., Smales, C., Alexander, T. H., Stepnowsky, C., Pillar, G., Malhotra, A., & Sarmiento, K. F. (2017). Treatment of OSA with CPAP is associated with improvement in PTSD symptoms among veterans. *Journal of Clinical Sleep Medicine, 13*(1), 57–63. https://doi.org/10.5664/jcsm.6388

Park, J. G., Ramar, K., & Olson, E. J. (2011). Updates on definition, consequences, and management of obstructive sleep apnea. *Mayo Clinic Proceedings, 86*(6), 549–555. doi:10.4065/mcp.2010.0810

Reid, K. J., Baron, K. G., Lu, B., Naylor, E., Wolfe, L., & Zee, P. C. (2010). Aerobic exercise improves self-reported sleep and quality of life in older adults with insomnia. *Sleep Medicine*, *11*(9), 934–940. https://doi.org/10.1016/j.sleep.2010.04.014

Watson, N. F., Badr, M. S., Belenky, G., Bliwise, D. L., Buxton, O. M., Buysse, D., Dinges, D. F., Gangwisch, J., Grandner, M. A., Kushida, C., Malhotra, R. K., Martin, J. L., Patel, S. R., Quan, S., & Tasali, E. (2015). Recommended Amount of Sleep for a Healthy Adult: A Joint Consensus Statement of the American Academy of Sleep Medicine and Sleep Research Society. *SLEEP*. https://doi.org/10.5665/sleep.4716

Weathers, F.W., Litz, B.T., Keane, T.M., Palmieri, P.A., Marx, B.P., & Schnurr, P.P. (2013). The PTSD Checklist for *DSM-5* (PCL-5). www.ptsd.va.gov.

CHAPTER IV

CHANGES IN PTSD SYMPTOMOLOGY FOLLOWING AEROBIC TRAINING IN VETERANS SUFFERING FROM SLEEP DEFICIENCIES

Introduction

The American Psychiatric Association (APA) defines posttraumatic stress disorder (PTSD) as an anxiety disorder stemming from any traumatic event including: an accident, sexual assault, a natural disaster, or a combat related incident (Lurigio, 2018). A study conducted in 2015 demonstrated approximately 8.3% of the United States (US) population will experience PTSD symptoms within their lifetime (Kilpatrick et al., 2013). However, veterans are nearly twice as likely to experience PTSD symptoms (Davidson, Babson, Bonn-Miller, Souter, & Vannoy, 2013). Veteran PTSD rates have been shown to be, on average, between 2-17%; however, studies have shown that those veterans exposed to combat within the Gulf Wars have had PTSD rates as high as 44% (Jakupcak et al., 2009; Lapierre, Schwegler, & LaBauve, 2007; Richardson, Frueh, & Acierno, 2010).

Prolonged PTSD symptom exposure can lead to cardiovascular, pulmonary, dermatological, and metabolic diseases and an increased mortality risk, primarily as a result of suicide (Priebe et al., 2009). While there are pharmacological treatment modalities, aerobic exercise is being explored as a potential modality to address the symptoms and comorbidities of PTSD. While not yet well understood within the veteran population, exercise interventions have been successful at improving PTSD symptomology among other sub-populations of people with PTSD symptoms (Davidson et al., 2013; De Moor et al., 2006).

Diaz and Motta (2008) conducted an aerobic exercise intervention with 12 adolescent females with PTSD related to sexual trauma. The program was a moderate-intensity walking program which was 15 sessions in length. A total of 91% of the participants showed a reduction in PTSD symptoms as indicated by the Child PTSD Symptom Scale (Diaz & Motta, 2008). A post intervention test conducted one-month post intervention demonstrated a reduction in PTSD symptoms after one-month. This is an important aspect of the study as it shows the lasting positive effects of an exercise intervention for PTSD symptoms.

The increased rates of PTSD symptoms within the veteran population warrants the need to investigate if aerobic exercise, which is inexpensive and does not require medical intervention, can also successfully lower PTSD symptomology for these individuals. Therefore, the purpose of this study was to evaluate the impact of aerobic exercise on PTSD symptoms in veterans with poor sleep quality. It was hypothesized that veterans who completed the 8-week self-selected aerobic-based conditioning program would demonstrate greater decreases in PTSD symptomology than veterans in the non-exercise control group.

Methodology

Participants

Military veterans were recruited for this study (*n* = males = 16, *n* = females = 4). Active, reserve, and guardsman that had completed at least one contract were considered veteran status for this study. The mean age of participants was (*M* = 37, SD = 7.39). For inclusion in this study, the participants needed to have a minimum score of 31 on the Posttraumatic Stress Disorder Checklist Version 5 (PCL-5) (Weathers et al., 2013). If the participant failed to meet the minimum criteria necessary by the PCL-5 then the demographics section questions were reviewed to determine whether the participant had been clinically diagnosed with PTSD. Additionally, participants need to exhibit a "poor sleeper" status (5 points or more) as indicated by the Pittsburgh Quality Sleep Index (PSQI) prior to admittance into the study (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). Participants were recruited via through Middle Tennessee State University's Charlie Daniel's Veteran Center and through word of mouth. Participants completed an informed consent prior to participation. Participant were also screened by the American College of Sports Medicine (ACSM, 2017) preparticipation health screening questionnaire to ensure there was no medical clearance necessary. This study was approved by the University's Institutional Review Board.

Instrumentation

PTSD Checklist Version 5

The PCL-5 is a self-administered survey that indicates the amount of PTSD symptomology that is being exhibited by an individual due to their military experience. The PCL-5 has been used on a multitude of populations including veterans and has been validated (Blevins, Weathers, Davis, Witte, & Domino, 2015). This questionnaire included a Likert scale ranging from 1 (*not at all*) to 5 (*extremely*) and consisted of 20 questions total. The PTSD score was compiled by the sums of all questions (Blevins et al., 2015). A higher PCL-5 score was representative of higher PTSD symptoms while lower scores indicated lower PTSD symptoms. This survey was completed by participants on a secure website pre intervention, midpoint (4 weeks), and post intervention (Qualtrics, Provo, Utah).

Demographics Questionnaire

There were 6 questions in total for the demographics section which included: age, sex, branch of service, clinical PTSD diagnosis, and whether the veteran received any combat badge/ribbon during his or her service. Co-investigators screened the demographics section for content and readability. The demographics sections was used for descriptive purposes. This survey was conducted on a secure website (Qualtrics, Provo, Utah).

Pittsburgh Sleep Quality Index

The PSQI is a self-administered sleep survey which allows an individual to estimate their quality of sleep within the past month (Buysse, Reynolds, Monk, Berman,

& Kupfer, 1989). The questionnaire contains 19 questions in total comprised of 7 components on which to compile a score ranging from 0-21. A higher score indicated a poorer sleeper while a lower score indicated a better sleeper. This survey was completed on a secure website by participants (Qualtrics, Provo, Utah).

Procedures

An 8-week protocol comprised of 26 sessions was completed by each participant. The first session was considered the intake day where all the qualifying criteria for the study were gathered and the last day included the post-testing procedures. A mid-test assessment of the participants PCL-5 was conducted at the 4-week mark for both the intervention and control groups. The remaining sessions were considered the exercise protocol days. On the intake day, prior to admittance into the study, each participant completed a PCL-5 survey, demographics section, a PSQI survey, and the ACSM algorithm for assuring no medical clearance was necessary. After the participant had completed all surveys, questionnaires, and was admitted into the study. Once the test was completed and the individual had an estimated VO2max established, the first day was completed. Each participant was assigned to an intervention group, where they received the exercise protocol, or they were assigned to the control group. The control group completed the same pre, mid, and post testing as well as the survey, but they did not receive the exercise protocol. At the midpoint, it was confirmed with participants that they had not change any treatment related to PTSD.

Each week of training protocol consisted of 3 training protocol days. An individual was not allowed to have two training protocols within a 48-hour period. If a participant was unable to complete a training session that week, an additional session was added to the end of their training program. If 2 weeks were missed with no training, then the participant was either dropped from the study or had to begin from the beginning of the study.

The exercise protocols were based upon the participant's age estimated HR_{max}. The protocol intensities were designed to be low intensity (<40%HR_{max}) to moderate intensity (40-59% HR_{max}). The participant would wear a Polar HR monitor that was set to beep when the participant had a HR that was too low or too high. This allowed the participant to keep their HR within range. Only the first 2-3 training protocol days were kept at low intensities in order to allow the participant to become familiarized with the equipment as well as to ease the individual into the training protocol. The participant could self-select the intensity for each training protocol day as long as he or she kept the HR ranges within the designated ranges.

A warmup was administered prior to each training session for a total of 5 minutes in order to prepare the individual for the training protocol. The participant was allowed to self-select this intensity. The training sessions were 30 minutes in length and the intensity was kept between the predesignated HR_{max} intensity ranges. The sessions could be any aerobic mode of training that the participant chose that the lab could accommodate, to include, but not limited to; rowing, treadmill based walking, and stationary bike. These sessions were conducted with only one participant training at a time and were to be conducted in the presence of the researcher. Upon completion of each training session, the participant was allowed to cool down for 5 minutes at their own self-selected intensities in order to allow the body to return to a resting state. Following the completion of the 24 exercise sessions, the participant would return to the lab within one week and retake their PCL-5 survey.

Statistical analyses

The Statistical Package for the Social Sciences (SPSS) 26.0 (Chicago, IL) software program was used for statistical analysis. Descriptive statistics are reported as means standard deviation. A one-way between subjects analysis of covariance (ANCOVA) was calculated to examine the effect of an aerobic based exercise intervention on PCL-5 scores from pretest to midtest, pretest to posttest, and midtest to posttest when compared to a nonintervention-based control group. Statistical significance was set at $p < .05$ for all analyses. See Appendix A for IRB approval.

Results

Demographic information for participants can be found in Table 1. Of the 22 volunteers participating in the research, 11 were randomly assigned to the training group and 11 to the control group. Participants in the training group were monitored to determine that 26 training sessions, the minimum required, were completed. Attrition occurred in each group resulting in 10 participants in each group. One Participant was removed from the training group due to noncompliance with the frequency of session requirements and a second participant withdrew from the control group due to conflicts with work schedules.

The mean values for PCL-5 pre-test, mid-test, and post-test can be found in Table 2. The difference between the control group's mid-test PCL-5 ($M = 55.45$, $SD = 14.99$)

Table 1

PTSD Diagnosis and Military Descriptors History (N=20)

	Mean	*Frequency*
Army	-	11
Air Force	-	1
Navy	-	4
Marines	-	3
Coast Guard	-	1
Diagnosis PTSD	-	8
No Diagnosis	-	12
Combat Experience*	-	5

Note. * = Includes combat action ribbons and combat badges; PTSD = Posttraumatic stress disorder.

Table 2

PCL-5 Scores (N =20)

	Mean*	*SD*
(I) Pre-test PCL-5	55.45	14.99
(C) Pre-test PCL -5	55.45	12.37
(I) Mid-test PCL-5	51.64	15.51
(C) Mid-test PCL -5	55.26	11.43
(I) Post-test PCL-5	51.37	15.12
(C) Post-test PCL -5	55.63	11.98

Note. (I) = Intervention group, (C) = Control group; PCL-5 = Posttraumatic Stress Disorder Checklist Version 5; * = Reported in estimated marginal means.

and the intervention group's mid-test PCL-5 (*M* = 51.64, *SD* = 15.51), when controlling for pre-test scores, was statistically significant F (1, 19) = 10.35, p = .003. Cohen's effect size value (d = .25) suggested practical significance, which indicates there were meaningful differences between the intervention and control groups at mid-test when pre-test scores were controlled.

Additionally, the difference between the control group's post-test PCL-5 (*M* = 55.63, SD = 11.98) and the intervention group's post-test PCL-5 (*M* = 51.37, *SD* = 15.12), when controlling for pre-test scores, was statistically significant F (1, 19) = 12.38, p = .005. Cohen's effect size value (d = .27) suggested a practical significance, which indicates that there were meaningful differences between the intervention and control groups at post-test when pre-test scores were controlled.

The difference between the control group's post-test PCL-5 (*M* = 53.8, SD = 11.98) and the intervention group's post-test PCL-5 (*M* = 53.2, *SD* = 15.12), when controlling for mid-test scores, was not significant F (1, 19) = .21, p = .655. Cohen's effect size value (d = .02) suggested negligible practical significance. This indicates that there were little to no meaningful differences between the intervention and control groups from mid-test to post-test.

Discussion

The purpose of this study was to evaluate the impact of aerobic exercise on PTSD symptoms in veterans with poor sleep quality. It was hypothesized that veterans who completed an 8-week self-selected aerobic-based conditioning program would demonstrate greater decreases in PTSD symptomology than veterans in the non-exercise control group. The data collected within this research supported the hypothesis.

PCL-5 scores for the intervention group when compared to the control group PCL-5 scores when controlling for pre-test scores. These support results of previously conducted studies which indicated aerobic based training decreased PTSD symptoms in civilian populations of various trauma exposures (Diaz & Motta, 2008, Fetzner, & Asmundson, 2015, Manger, & Motta, 2005). However, the difference between post-test PCL-5 scores when comparing the intervention group to the control group while controlling mid-test scores was not statistically significant, indicating that the greatest impact occurred in the first 4 weeks of the study.

A critical finding within this study was the protocol's display of an acute intervention being a potential means for reducing PTSD symptoms in veterans. As stated previously, PTSD that left unchecked has the potential to increase in severity (Priebe et al., 2009). Many veterans will require some form of pharmacological intervention such as Zoloft or Paxil; however, these medications have not been approved by the FDA for use on combat veterans suffering from PTSD (Castro, 2014). A study such as this one, indicates that exercise could potentially counteract and even decrease PTSD symptoms specially for veterans rapidly while other medications and interventions with longer lasting effects can be implemented concurrently.

Another important finding within this study was the mid-test to post-test PCL-5 scores for the intervention group not being statistically different from the control group's PCL-5 scores when controlling for mid-test scores. While this was not an expected outcome, it indicates that the effects of an exercise program on veterans with PTSD symptoms are acute and can be sustained. A protocol, such as the one in this study, could be implemented for a short-term intervention while the veteran is able to find additional therapeutic and medicinal measures to help decrease PTSD symptoms even further.

A strength to this study was its novelty within the nascent field of reducing PTSD symptoms using exercise interventions. Since the Iraq and Afghanistan wars, there has been a growing concern for caring for veterans returning from these conflicts. However, there is still limited information readily available in intervention-based studies specific to veterans which utilize non-invasive protocols such as exercise. Another key strength to this study is the intensity used for the entirety of the protocol. A low to moderate exercise intervention is an important consideration for veterans who are suffering from a mental disorder (Bouchard et al., 2004). This level of intensity is also safe and easy to implement on a wider scale than other more strenuous exercise regiments that may require observation to ensure that the techniques and protocols are performed correctly.

A limitation to this study is the lack of time points for the PCL-5 measurements. Many times, veterans suffering from PTSD symptoms will have symptoms that wax and wane and there could be a day of decreased or increased symptoms experienced (Bremner et al., 1996). This could cause the data to not be entirely representative of everyone's individual PCL-5 score over time. An additional limitation to this study was the impact COVID-19 may have had on the individuals within the study. Although the protocol was able to be completed, the residuals of the global pandemic may have had unintended effects on the individuals' PCL-5 scores within this study as increased solitude and social distancing were mandated throughout the world.

Future research within the field of exercise-based interventions needs to be focusing on the intensities and modes of exercise. The variations within exercise modalities are crucial as the needs for individual veterans may be better suited with different types of exercises. Varying intensities could also be essential as not every veteran is comfortable, or even able, to sustain exercises at a moderate intensity. Furthermore, future research should begin to focus on the subgroups with the veteran population who experience PTSD. Veterans can be exposed to PTSD through several different incidents, whether it be combat, sexual trauma, natural disasters, etc. Being able to find if there are differences in the effects of exercise-based interventions within these groups is necessary in order to identify the best protocols for each veteran.

The wars within the Gulf War era have continued for over 30 years. The more recent wars, Iraq and Afghanistan, have yet to be concluded as they push past the 20-year mark. With every deployment that the men and women in the armed forces from around the globe conduct to the middle east, PTSD symptoms will likely increase, or at best, linger. Because of this, there is a growing need to care for those who return from these deployments and this study represents a small contribution to an even smaller field of research on a problem that is ever-expanding. It is imperative for the benefit of our armed forces that we continue to pursue improved means of treating those veterans who suffer from PTSD from these conflicts.

CHAPTER IV REFERENCES

American College of Sports Medicine (2017). *ACSM's guidelines for exercise testing and prescription.* Lippincott, Williams & Wilkins.

Blevins, C. A., Weathers, F. W., Davis, M. T., Witte, T. K., & Domino, J. L. (2015). The Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5): Development and Initial Psychometric Evaluation. *Journal of Traumatic Stress*, *28*(6), 489–498. https://doi.org/10.1002/jts.22059

Bouchard, S., Paquin, B., Payeur, R., Allard, M., Rivard, V., Fournier, T., Renaud, P., & Lapierre, J. (2004). Delivering Cognitive-Behavior Therapy for Panic Disorder with Agoraphobia in Videoconference. *Telemedicine Journal and e-Health, 10*(1), 13–25. https://doi.org/10.1089/153056204773644535

Bremner, D. J., Charney, D. S., Darnell, A., & Southwick, S. M. (1996). Chronic PTSD in Vietnam combat veterans: course of illness and substance abuse. *American Journal of Psychiatry, 153*(3), 369–375. https://doi.org/10.1176/ajp.153.3.369

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research, 28*(2), 193–213. https://doi.org/10.1016/0165-1781(89)90047-4

Castro, C.A. (2014). The US framework for understanding, preventing, and caring for the mental health needs of service members who served in combat in Afghanistan and Iraq: A brief review of the issues and the research. *European Journal of Psychotraumatology*, *5*, 1-12. https://doi.org/10.3402/ ejpt.v5.24713

Davidson, C. L., Babson, K. A., Bonn-Miller, M. O., Souter, T., & Vannoy, S. (2013). The impact of exercise on suicide risk: Examining pathways through depression, PTSD, and sleep in an inpatient sample of veterans. *Suicide and Life-Threatening Behavior*, *43*(3), 279-289. https://doi.org/10.1111/sltb.12014

De Moor, M. H., Beem, A. L., Stubbe, J. H., Boomsma, D. I., & De Geus, E. J. (2006). Regular exercise, anxiety, depression and personality: A population-based study. *Preventative Medicine*, *4*, 273.

Diaz, A., & Motta, R. (2008). The effects of an aerobic exercise program on posttraumatic stress disorder symptom severity in adolescents. *International Journal of Emergency Mental Health*, *1*, 49.

Jakupcak, M., Cook, J., Imel, Z., Fontana, A., Rosenheck, R., & McFall, M. (2009). Posttraumatic stress disorder as a risk factor for suicidal ideation in Iraq and Afghanistan war veterans. *Journal of Traumatic Stress*, *22*, 303–306.

Kilpatrick, D. G., Resnick, H. S., Milanak, M. E., Miller, M. W., Keyes, K. M. & Friedman, M. J. (2013). National estimates of exposure to traumatic events and PTSD prevalence using DSM-IV and DSM-V criteria. *Journal of Traumatic Stress*, *26*, 537–547. https://doi.org/10.1002/jts.21848

Lapierre, C. B., Schwegler, A. F., & LaBauve, B. J. (2007). Posttraumatic stress and depression symptoms in soldiers returning from combat operations in Iraq and Afghanistan. *Journal of Traumatic Stress*, *20*, 933–943. https://doi.org/10.1002/jts.20278

Lurigio, A. J. (2018). DSM-5. Salem press encyclopedia of health. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=ers&AN=115297534&se=eds-live&scope=site

Priebe, S., Matanov, A., Gavrilović, J. J., Mccrone, P., Ljubotina, D., Knežević, G., & Schützwohl, M. (2009). Consequences of untreated posttraumatic stress disorder following war in former Yugoslavia: Morbidity, subjective quality of life, and care costs. *Croatian Medical Journal*, *50(5)*, 465-475. https://doi.org/10.3325/cmj.2009.50.465

Richardson, L. K., Frueh, B. C., & Acierno, R. (2010). Prevalence estimates of combat-related post-traumatic stress disorder: Critical review. *Australian & New Zealand Journal of Psychiatry*, *44*(1), 4–19. https://doi.org/ezproxy.mtsu.edu/10.3109/00048670903393597

The National Institute of Mental Health. (2019, May). Post-traumatic stress disorder. Retrieved from https://www.nimh.nih.gov/health/topics/post-traumatic-stress-disorder-ptsd/index.shtml

Weathers, F.W., Litz, B.T., Keane, T.M., Palmieri, P.A., Marx, B.P., & Schnurr, P.P. (2013). The PTSD Checklist for *DSM-5* (PCL-5). Scale available from the National Center for PTSD at www.ptsd.va.gov.

CHAPTER V

CONCLUSION

Literature has shown throughout this dissertation that veterans tend to have a higher risk of developing PTSD symptoms than their civilian counterparts (Davidson, Babson, Bonn-Miller, Souter, & Vannoy, 2013). The comorbidities associated with chronic PTSD can many times be as debilitating or even worse than the PTSD symptoms themselves (Priebe et al., 2009). Poor sleep quality is a particular comorbidity that is consistently found with individuals who have PTSD (Neylan et al., 1998). Not only does poor sleep quality contribute to other ailments, it also has been shown to compound the symptoms of PTSD and creates a negative feedback loop thereby increasing both poor sleep and PTSD symptoms. (Priebe et al., 2009). Due to these reasons, it is becoming paramount to explore new methods of treating PTSD symptoms and improve sleep quality. The use of aerobic based exercise interventions has been shown to improve sleep quality and reduce PTSD symptoms in a civilian population (Diaz & Motta, 2008). Therefore, the purpose of these studies was to explore the association between exercise and PTSD and sleep quality in veterans.

The first study was designed to measure the impact of an aerobic exercise-based intervention on PSQI scores of veterans suffering from poor sleep quality who also had symptoms of PTSD. The second study measured the effects of an aerobic exercise-based intervention on PCL-5 scores in veterans with PTSD symptoms who also had poor sleep quality. There were two groups, intervention and control, which had measurements taken for both studies at the pre, mid, and post-test time points. When comparing the intervention group's PCL-5 scores for mid-test to the control group's PCL-5 scores for mid-test while controlling for pre-test scores, there was a statistically significant difference between the scores. The same is true when running the same analysis model for the PSQI scores. In addition, there was a statistically significant difference between post-test PCL-5 scores for the intervention group when compared to the control group's post-test PCL-5 scores when controlling for pre-test scores as well. The same was also true when the PSQI post-test scores were analyzed. Lastly, there was no statistically significant difference between post-test PCL-5 scores for the intervention group compared to the post-test PCL-5 scores for the control group when controlling for the mid-test scores and the same was true for the PSQI scores.

The most notable finding within both studies is that both the PCL-5 and PSQI scores follow the same pattern. For the experimental group, both the mid-test and post-test scores for the PCL-5 and PSQI demonstrated improvements when compared to the control when controlling for pre-test scores. While this is the finding was hypothesized, it was unexpected to observe no statistical difference in PSQI and PCL-5 between both group's post-test scores when controlling for mid-test scores. This finding suggests that the changes the veteran's received during the intervention were acute and sustained throughout the protocol. While it is uncertain if the poor sleep quality or the PTSD symptoms were affecting each other, it is clear from this study that the aerobic intervention administered reduced the symptoms and were able to maintain the reductions. Aerobic-based exercise interventions for veterans are in a nascent stage and exercise is an untapped resource from which our VA healthcare system could potentially use in an attempt to slow and eliminate symptoms of PTSD in veterans.

Over that last 100 years of warfare, the names used to describe mental illness related to combat have dramatically changed, such as: combat fatigue, shell shock, war neurosis, soldier's heart, and PTSD. Mental illness related to combat has also continually developed as we better understand the causes and effects of armed conflict on the human psyche. While we have cultivated our knowledge of this issue, our ability to curb its effects have progressed. Our research into pharmaceuticals and various styles of therapy have continued to advance. Unfortunately, our capabilities and determination to wage extended warfare have also developed as the United States nears the 20-year anniversary of the current war in Afghanistan. It goes without saying that if we are to continually send our nations men and women into armed conflict, it is our duty and the duty of our nation to offer every effort to help aid these individuals as they return from their duties.

DISSERTATION REFERENCES

Alexander, M., Ray, M. A., Hébert, J. R., Youngstedt, S. D., Zhang, H., Steck, S. E., Bogan, R. K., & Burch, J. B. (2016). The National Veteran Sleep Disorder Study: Descriptive Epidemiology and Secular Trends, 2000–2010. *Sleep*, *39*(7), 1399–1410. https://doi.org/10.5665/sleep.5972

American College of Sports Medicine (2017). *ACSM's guidelines for exercise testing and prescription*. Lippincott, Williams & Wilkins.

Andrade, F. M., & Pedrosa, R. P. (2016). The role of physical exercise in obstructive sleep apnea. *Jornal Brasileiro de Pneumologia: Publicacao Oficial da Sociedade Brasileira de Pneumologia e Tisilogia*, *42*(6), 457–464. https://doi.org/10.1590/S1806-37562016000000156

An overview of sleep disorders. (2007, December 18). Retrieved October 2, 2019, from http://healthysleep.med.harvard.edu/healthy/getting/treatment/an-overview-of-sleep-disorders

Andrade, F. M., & Pedrosa, R. P. (2016). The role of physical exercise in obstructive sleep apnea. *Jornal Brasileiro de Pneumologia: Publicacao Oficial da Sociedade Brasileira de Pneumologia e Tisilogia*, *42*(6), 457–464. https://doi.org/10.1590/S1806-37562016000000156

Awad, K. M., Malhotra, A., Barnet, J. H., Quan, S. F., & Peppard, P. E. (2012). Exercise is associated with a reduced incidence of sleep-disordered breathing. *The American Journal of Medicine, 125*(5), 485–490. https://doi.org/10.1016/j.amjmed. 2011.11.025

Babson, K. A., Heinz, A. J., Ramirez, G., Puckett, M., Irons, J. G., Bonn-Miller, M. O., & Woodward, S. H. (2015). The interactive role of exercise and sleep on veteran recovery from symptoms of PTSD. *Mental Health and Physical Activity, 8*, 15–20. https://doi.org/10.1016/j.mhpa.2014.12.002

Back, S. E., Foa, E. B., Killeen, T. K., Mills, K. L., Teesson, M., Cotton, B. D., Carroll, K. M., & Brady, K. T. (2015). Concurrent Treatment of PTSD and Substance Use Disorders Using Prolonged Exposure (COPE). *Oxford Clinical Psychology*. https://doi.org/10.1093/med:psych/9780199334537.001.0001

Baekeland, F., & Lasky, R. (1966). Exercise and Sleep Patterns in College Athletes. *Perceptual and Motor Skills, 23*, 1203–1207. https://doi.org/10.2466/ pms.1966.23.3f.1203

Baron, K. G., Reid, K. J., & Zee, P. C. (2013, August 15). Exercise to improve sleep in insomnia: Exploration of the bidirectional effects. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3716674/

Beristianos, M. H., Yaffe, K., Cohen, B., & Byers, A. L. (2016). PTSD and risk of incident cardiovascular disease in aging veterans. T*he American Journal of Geriatric Psychiatry*, *24*(3), 192–200. https://doi.org/10.1016/j.jagp.2014.12.003

Bertram, F., Jamison, A. L., Slightam, C., Kim, S., Roth, H. L., & Roth, W. T. (2014). Autonomic arousal during actigraphically estimated waking and sleep in male veterans with PTSD. *Journal of Traumatic Stress, 27*(5), 610–617. https://doi.org/10.1002/jts.21947

Blackwell, T., Redline, S., Ancoli-Israel, S., Schneider, J. L., Surovec, S., Johnson, N. L., Cauley, J. A., & Stone, K. L. (2008). Comparison of Sleep Parameters from Actigraphy and Polysomnography in Older Women: The SOF Study. *Sleep*, *31*(2), 283–291. https://doi.org/10.1093/sleep/31.2.283

Blevins, C. A., Weathers, F. W., Davis, M. T., Witte, T. K., & Domino, J. L. (2015). The Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5): Development and Initial Psychometric Evaluation. *Journal of Traumatic Stress*, *28*(6), 489–498. https://doi.org/10.1002/jts.22059

Bouchard, S., Paquin, B., Payeur, R., Allard, M., Rivard, V., Fournier, T., Renaud, P., & Lapierre, J. (2004). Delivering Cognitive-Behavior Therapy for Panic Disorder with Agoraphobia in Videoconference. *Telemedicine Journal and e-Health, 10*(1), 13–25. https://doi.org/10.1089/153056204773644535

Bovin, M. J., Marx, B. P., Weathers, F. W., Gallagher, M. W., Rodriguez, P., Schnurr, P. P., & Keane, T. M. (2016). Psychometric properties of the PTSD Checklist for Diagnostic and Statistical Manual of Mental Disorders–Fifth Edition (PCL-5) in veterans. *Psychological Assessment, 28*(11), 1379-1391.

Brain Basics: Understanding Sleep. (2019, August 13). Retrieved fromhttps://www.ninds.nih.gov/Disorders/Patient-Caregiver-Education/ Understanding-Sleep

Brassington, G. S., & Hicks, R. A. (2019). Aerobic exercise and self-reported sleep quality in elderly individuals: *Journal of Aging and Physical Activity, 3*(2).Retrieved from https://journals.humankinetics.com/view/journals/japa/3/2/article-p120.xml

Bremner, D. J., Charney, D. S., Darnell, A., & Southwick, S. M. (1996). Chronic PTSD in Vietnam combat veterans: course of illness and substance abuse. *American Journal of Psychiatry, 153*(3), 369–375. https://doi.org/10.1176/ajp.153.3.369

Brooks, P. L., & Peever, J. H. (2011). Impaired GABA and Glycine transmission triggers cardinal features of rapid eye movement sleep behavior disorder in mice. *Journal of Neuroscience, 31*(19), 7111–7121. https://doi.org/10.1523/jneurosci.0347-11.2011

Brooks, R. (2018, January 4). What Is polysomnography? Retrieved from https://www.aastweb.org/blog/what-is-polysomnography

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research, 28*(2), 193–213. https://doi.org/10.1016/0165-1781(89)90047-4

Capaldi, V. F., Guerrero, M. L., & Killgore, W. D. S. (2011). Sleep disruptions among returning combat veterans from Iraq and Afghanistan. *Military Medicine*, *176*(8), 879–888. https://doi.org/10.7205/milmed-d-10-00440

Castro, C.A. (2014). The US framework for understanding, preventing, and caring for the mental health needs of service members who served in combat in Afghanistan and Iraq: A brief review of the issues and the research. *European Journal of Psychotraumatology*, *5*, 1-12 https://doi.org/10.3402/ ejpt.v5.24713

Chokroverty, S. (2010). Overview of sleep & sleep disorders. *Indian Journal of Medical Research, (2)*, 126. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=edsgao&AN=edsgcl.229718082&site=eds-live&scope=site

Courtois, C. A., Sonis, J., Brown, L. S., Cook, J., Fairbank, J. A., Friedman, M., Schulz, P. (2017, February 24). Clinical practice guideline for the treatment of PTSD. Retrieved from https://www.apa.org/ptsd-guideline/

Dagan, Y., Zinger, Y., & Lavie, P. (1997). Actigraphic sleep monitoring in posttraumatic stress disorder (PTSD) patients. *Journal of Psychosomatic Research, 42*(6), 577–581. https://doi.org/10.1016/s0022-3999(97)00013-5

Davidson, C. L., Babson, K. A., Bonn-Miller, M. O., Souter, T., & Vannoy, S. (2013). The impact of exercise on suicide risk: Examining pathways through depression, PTSD, and sleep in an inpatient sample of veterans. *Suicide and Life-Threatening Behavior*, *43*(3), 279-289. https://doi.org/10.1111/sltb.12014

Decker, K. P., Deaver, S. P., Abbey, V., Campbell, M., & Turpin, C. (2018). Quantitatively improved treatment outcomes for combat-associated PTSD with adjunctive art therapy: Randomized controlled trial. *Art Therapy*, *35*(4), 184–194. https://doi.org/10.1080/07421656.2018.1540822

Dell, P. F., & O'Neil, J. A. (2015). Dissociation and the dissociative disorders: DSM-V and beyond. Routledge.

De Moor, M. H., Beem, A. L., Stubbe, J. H., Boomsma, D. I., & De Geus, E. J. (2006). Regular exercise, anxiety, depression and personality: A population-based study. *Preventative Medicine*, *4*, 273.

Diaz, A., & Motta, R. (2008). The effects of an aerobic exercise program on posttraumatic stress disorder symptom severity in adolescents. *International Journal of Emergency Mental Health*, *1*, 49.

Edinger, J. D., Glenn, D. M., Bastian, L. A., Marsh, G. R., Daile, D., Hope, T. V., Young, M., Shaw, E., & Meeks, G. (2001). Sleep in the Laboratory and Sleep at Home II: Comparisons of Middle-Aged Insomnia Sufferers and Normal Sleepers. *Sleep*, *24*(7), 761–770. https://doi.org/10.1093/sleep/24.7.761

Edinger, J. D., Fins, A. I., Sullivan, R. J., Marsh, G. R., Dailey, D. S., Hope, T. V., Young, M., Shaw, E., Carlson, D., & Vasilas, D. (1997). Sleep in the Laboratory and Sleep at Home: Comparisons of Older Insomniacs and Normal Sleepers. *Sleep*, *20*(12), 1119–1126. https://doi.org/10.1093/sleep/20.12.1119

Fetzner, M. G., & Asmundson, G. J. G. (2015). Aerobic exercise reduces symptoms of posttraumatic stress disorder: A randomized controlled trial. *Cognitive Behaviour Therapy, 44*(4), 301–313. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2015-26836-007&site=eds-live&scope=site

Giorgi, A. (2017, March 31). Polysomnography: Purpose, procedure & risks. Retrieved from https://www.healthline.com/health/polysomnography#procedure

Grandner, M. A., Kripke, D. F., Yoon, I. Y., & Youngstedt, S. D. (2006). Criterion validity of the Pittsburgh sleep quality index: Investigation in a non-clinical sample. *Sleep and Biological Rhythms*, *2*, 129-139. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=edsgao&AN=edsgcl.158839540&site=eds-live&scope=site

Iftikhar, I. H., Kline, C. E., & Youngstedt, S. D. (2014, February). Effects of exercise training on sleep apnea: A meta-analysis. Retrieved fromhttps://www.ncbi.nlm.nih.gov/pmc/articles/PMC4216726/

Institute of Medicine (US) Committee on Sleep Medicine and Research. (2006, January 1). Sleep disorders and sleep deprivation: An unmet public health problem. Retrieved October 1, 2019, from https://www.ncbi.nlm.nih.gov/pubmed/20669438

Jakupcak, M., Cook, J., Imel, Z., Fontana, A., Rosenheck, R., & McFall, M. (2009). Posttraumatic stress disorder as a risk factor for suicidal ideation in Iraq and Afghanistan war veterans. *Journal of Traumatic Stress*, *22*, 303–306.

Jean-Louis, G., Kripke, D. F., Cole, R. J., Assmus, J. D., & Langer, R. D. (2001). Sleep detection with an accelerometer actigraph: Comparisons with polysomnography. *Physiology & Behavior, 72*(1-2), 21–28. https://doi.org/10.1016/s0031-9384(00)00355-3

Kamrani, A., Shams, A., Shamsipour Dehkordi, P., & Mohajeri, R. (2014, March). The effect of low and moderate intensity aerobic exercises on sleep quality in men older adults. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3999022/

Kanady, J. C., Drummond, S. P. A., & Mednick, S. C. (2011). Actigraphic assessment of a polysomnographic-recorded nap: A validation study. *Journal of Sleep Research, 20*(1pt2), 214–222. https://doi.org/10.1111/j.1365-2869.2010.00858.x

Khazaie, H., Ghadami, M., Nasoori, M., & Paveh, B. K. (2015). PTSD-related paradoxical insomnia: An actigraphic study. *Sleep Medicine, 16*. https://doi.org/10.1016/j.sleep.2015.02.124

Kip, K. E., Berumen, J., Zeidan, A. R., Hernandez, D. F., & Finnegan, A. P. (2019). The emergence of accelerated resolution therapy for treatment of post□traumatic stress disorder: A review and new subgroup analyses. *Counselling and Psychotherapy Research, 19*(2), 117–129. https://doi.org/10.1002/capr.12210

Kilpatrick, D. G., Resnick, H. S., Milanak, M. E., Miller, M. W., Keyes, K. M. & Friedman, M. J. (2013). National estimates of exposure to traumatic events and PTSD prevalence using DSM-IV and DSM-V criteria. *Journal of Traumatic Stress*, *26*, 537–547. https://doi.org/10.1002/jts.21848

Kline, C. E., Ewing, G. B., Burch, J. B., Blair, S. N., Durstine, J. L., Davis, J. M., Youngstedt, S. D. (2012). Exercise training improves selected aspects of daytime functioning in adults with obstructive sleep apnea. *Journal of Clinical Sleep Medicine*, *8(*4), 357-365.

Kline, C. E., Sui, X., Hall, M. H., Youngstedt, S. D., Blair, S. N., Earnest, C. P., & Church, T. S. (2012). Dose–response effects of exercise training on the subjective sleep quality of postmenopausal women: exploratory analyses of a randomised controlled trial. *BMJ Open*, *2*(4). https://doi.org/10.1136/bmjopen-2012-001044

Krakow, B., Melendrez, D., Warner, T. D., Dorin, R., Harper, R., & Hollifield, M. (2002). To breathe, perchance to sleep: Seep-disordered breathing and chronic insomnia among trauma survivors. *Sleep and Breathing, 6*(4), 189–202. https://doi.org/10.1055/s-2002-36593

Kushida, C. A., Chang, A., Gadkary, C., Guilleminault, C., Carrillo, O., & Dement, W. C. (2001). Comparison of actigraphic, polysomnographic, and subjective assessment of sleep parameters in sleep-disordered patients. *Sleep Medicine, 2*(5), 389–396. https://doi.org/10.1016/s1389-9457(00)00098-8

Lapierre, C. B., Schwegler, A. F., & LaBauve, B. J. (2007). Posttraumatic stress and depression symptoms in soldiers returning from combat operations in Iraq and Afghanistan. *Journal of Traumatic Stress*, *20*, 933–943. https://doi.org/10.1002/jts.20278

Lee, J.-M., Byun, W., Keill, A., Dinkel, D., & Seo, Y. (2018). Comparison of wearable trackers' ability to estimate sleep. *International Journal of Environmental Research and Public Health, 15*(6), 1265. https://doi.org/10.3390/ijerph15061265

Lewis, V., Creamer, M., & Failla, S. (2009). Is poor sleep in veterans a function of post-traumatic stress disorder? *Military Medicine, 174*(9), 948–951. https://doi.org/10.7205/ milmed-d-04-0208

Lurigio, A. J. (2018). DSM-5. Salem press encyclopedia of health. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=ers&AN=115297534&se=eds-live&scope=site

Lynn F. Bufka Raquel Halfond Howard KurtzmanGuideline Development Panel for the Treatment of Posttraumatic Stress Disorder in Adults. (2017). Clinical practice guidelines for the treatment of PTSD [PDF File].

Manger, T. A., & Motta, R. W. (2005). The impact of an exercise program on posttraumatic stress disorder, anxiety, and depression. *International Journal of Emergency Mental Health*, *7*(1), 49-57.

Marino, M., Li, Y., Rueschman, M. N., Winkelman, J. W., Ellenbogen, J. M., Solet, J. M., Dulin, H., Berkman, L. F., & Buxton, O. M. (2013). Measuring Sleep: Accuracy, Sensitivity, and Specificity of Wrist Actigraphy Compared to Polysomnography. *Sleep*, *36*(11), 1747–1755. https://doi.org/10.5665/sleep.3142

Mendels, J., & Hawkins, D. R. (1967). Sleep laboratory adaptation in normal subjects and depressed patients ("first night effect"). *Electroencephalography and Clinical Neurophysiology, 22*(6), 556–558. https://doi.org/10.1016/0013-4694(67)90063-6

Moser, D., Anderer, P., Gruber, G., Parapatics, S., Loretz, E., Boeck, M., Dorffner, G. (2009). Sleep classification according to AASM and Rechtschaffen & Kales: effects on sleep scoring parameters. *Sleep, 32*(2), 139–149. https://doi.org/10.1093/sleep/32.2.139

National Center for PTSD. (2018, September 24). Retrieved from https://www.ptsd.va.gov/professional/assessment/adult-sr/ptsd-checklist.asp.

National Center for PTSD. (2018, September 24). Retrieved from https://www.ptsd.va.gov/professional/assessment/list_measures.asp.

Neylan, T. C., Marmar, C. R., Metzler, T. J., Weiss, D. S., Zatzick, D. F., Delucchi, K. L., Wu, R. M., & Schoenfeld, F. B. (1998). Sleep Disturbances in the Vietnam Generation: Findings From a Nationally Representative Sample of Male Vietnam Veterans. *American Journal of Psychiatry*, *155*(7), 929–933. https://doi.org/10.1176/ajp.155.7.929

Olszewski, T. M, & Varrasse, J. F. (2005). The neurobiology of PTSD: Implications for nurses. *Journal of Psychosocial Nursing & Mental Health Services, 43*(6), 40-7. Retrieved from https://ezproxy.mtsu.edu/login?url=https://search.proquest.com/docview/225547471?accountid=4886

Orr, J. E., Smales, C., Alexander, T. H., Stepnowsky, C., Pillar, G., Malhotra, A., & Sarmiento, K. F. (2017). Treatment of OSA with CPAP is associated with improvement in PTSD symptoms among veterans. *Journal of Clinical Sleep Medicine, 13*(1), 57–63. https://doi.org/10.5664/jcsm.6388

Pace-Schott, E. F., Germain, A., & Milad, M. R. (aasm). Sleep and REM sleep disturbance in the pathophysiology of PTSD: The role of extinction memory. *Biology of Mood & Anxiety Disorders*, *5*(1). https://doi.org/10.1186/s13587-015-0018-9

Parekh, R. (2017, January 1). What is posttraumatic stress disorder? Retrieved October 1, 2019, from https://www.psychiatry.org/patients-families/ptsd/what-is-ptsd

Park, J. G., Ramar, K., & Olson, E. J. (2011). Updates on definition, consequences, and management of obstructive sleep apnea. *Mayo Clinic Proceedings, 86*(6), 549–555. https://doi.org/10.4065/mcp.2010.0810

Pietrzak, R. H., Goldstein, M. B., Malley, J. C., Rivers, A. J., Johnson, D. C., & Southwick, S. M. (2010). Risk and protective factors associated with suicidal ideation in veterans of Operations Enduring Freedom and Iraqi Freedom. *PsycEXTRA Dataset*. https://doi.org/10.1037/e717682011-004

Plumb, T. R., Peachey, J. T., & Zelman, D. C. (2014). Sleep disturbance is common among service members and veterans of Operations Enduring Freedom and Iraqi Freedom. *Psychological Services, 11*(2), 209-219.

Priebe, S., Matanov, A., Gavrilović, J. J., Mccrone, P., Ljubotina, D., Knežević, G., & Schützwohl, M. (2009). Consequences of untreated posttraumatic stress disorder following war in former Yugoslavia: Morbidity, subjective quality of life, and care costs. *Croatian Medical Journal*, *50(5)*, 465-475. https://doi.org/10.3325/cmj.2009.50.465

PTSD Assessment Instruments. (2018, September 26). Retrieved from https://www.apa.org/ptsd-guideline/assessment/.

Quan, S. F., O'Connor, G. T., Quan, J. S., Redline, S., Resnick, H. E., Shahar, E., Siscovick, D., & Sherrill, D. L. (2007). Association of physical activity with sleep-disordered breathing. *Sleep and Breathing*, *11*(3), 149–157. https://doi.org/10.1007/s11325-006-0095-5

Recharge with sleep: Pediatric sleep recommendations promoting optimal health. (2016, June 13). Retrieved from https://aasm.org/recharge-with-sleep-pediatric-sleep-recommendations-promoting-optimal-health/

Reid, K. J., Baron, K. G., Lu, B., Naylor, E., Wolfe, L., & Zee, P. C. (2010). Aerobic exercise improves self-reported sleep and quality of life in older adults with insomnia. *Sleep Medicine*, *11*(9), 934–940. https://doi.org/10.1016/j.sleep.2010.04.014

Richardson, L. K., Frueh, B. C., & Acierno, R. (2010). Prevalence estimates of combat-related post-traumatic stress disorder: Critical review. *Australian & New Zealand Journal of Psychiatry*, *44*(1), 4–19. https://doi.org/ezproxy.mtsu.edu/10.3109/00048670903393597

Ryan, N., Borg, D., Fowler, P., Osborne, J., Stewart, I., Pavey, T., & Minett, G. (2019). Inter-device reliability of a wrist actigraph device in classifying sleep characteristics. *Journal of Science and Medicine in Sport, 22.* https://doi.org/10.1016/j.jsams.2019.08.142

Shankar, A., Syamala, S., & Kalidindi, S. (2010). Insufficient rest or sleep and its relation to cardiovascular disease, diabetes and obesity in a national, multiethnic sample. *PLoS ONE*, *5*(11). https://doi.org/10.1371/journal.pone.0014189

Schwartz, A. R., Gold, A. R., Schubert, N., Stryzak, A., Wise, R. A., Permutt, S., & Smith, P. L. (1991). Effect of weight loss on upper airway collapsibility in obstructive sleep apnea. *American Review of Respiratory Disease, 144*(3-pt-1), 494–498. https://doi.org/10.1164/ajrccm/144.3_pt_1.494

Souza, L. D., Benedito-Silva, A. A., Pires, M. L. N., Poyares, D., Tufik, S., & Calil, H. M. (2003). Further validation of actigraphy for sleep studies. *Sleep, 26*(1), 81–85. https://doi.org/10.1093/sleep/26.1.81

The National Institute of Mental Health. (2019, May). Post-traumatic stress disorder. Retrieved from https://www.nimh.nih.gov/health/topics/post-traumatic-stress-disorder-ptsd/index.shtml

Thoresen, S., & Mehlum, L. (2007). Traumatic stress and suicidal ideation in male peacekeepers. *PsycEXTRA* Dataset. https://doi.org/10.1037/e517322011-280

Wang, X., Youngstedt, S. (2014, January 10). Sleep quality improved following a single session of moderate-intensity aerobic exercise in older women: Results from a pilot study. Retrieved from https://www.sciencedirect.com/science/article /pii/S2095254614000039

Watson, N. F., Badr, M. S., Belenky, G., Bliwise, D. L., Buxton, O. M., Buysse, D., . . . Tasali, E. (2015). Recommended amount of sleep for a healthy adult: a joint consensus statement of the american academy of sleep medicine and sleep research society. *Sleep, 38*(6), 843–844. https://doi.org/10.5665/sleep.4716

Weathers, F.W., Litz, B.T., Keane, T.M., Palmieri, P.A., Marx, B.P., & Schnurr, P.P. (2013). The PTSD Checklist for *DSM-5* (PCL-5). Scale available from the National Center for PTSD at www.ptsd.va.gov.

Wortmann, J. H., Jordan, A. H., Weathers, F. W., Resick, P. A., Dondanville, K. A., Hall-Clark, B., Foa, E. B., Young-McCaughan, S., Yarvis, J. S., Hembree, E. A., Mintz, J., Peterson, A. L., & Litz, B. T. (2016). Psychometric analysis of the PTSD Checklist-5 (PCL-5) among treatment-seeking military service members. *Psychological Assessment*, *28*(11), 1392–1403. https://doi.org/10.1037/pas0000260

APPENDIX

Appendix A

IRB Approval Form

IRB
INSTITUTIONAL REVIEW BOARD
Office of Research Compliance,
01OA Sam Ingram Building,
2269 Middle Tennessee Blvd
Murfreesboro, TN 37129
FWA: 00005331//RB Regn. 0003571

MIDDLE TENNESSEE STATE UNIVERSITY

IRBN00l - EXPEDITED PROTOCOL APPROVAL NOTICE

Tuesday, October 13, 2020

Title	***The Effects of an Aerobic-Based Conditioning Program on Veterans with PTSD Symptoms and Sleep Deficiencies***
ID	**21-2036 4i7q**
PI	**Robert C. Huseth**
Advisor	Jenn Caputo
Co-Investigators	Sandra Stevens and Eric Oslund
Email(s)	*rch4t@mtmail. mtsu.edu; Jenn.caputo@mtsu.edu*
Department	Health and Human Performance (CBHS)
Funding	**NONE**

Dear Investigator(s),

The above identified research proposal has been reviewed by the MTSU IRB through the **EXPEDITED** mechanism under 45 CFR 46.110 and 21 CFR 56.110 within a PRIMARY category *(4) Collection of data through noninvasive procedures* and a SECONDARY category *(7) Research on individual or group characteristics or behavior.* A summary of the IRB action on this protocol is given below:

/RB Action	**APPROVED for ONE YEAR**
Date of Expiration	1013112021 I *Date of Approval:* 10/13/20 *Recent Amendment:* NONE
Sample Size	FIFTY (50)
Participant Pool	*Target Population:* Primary Classification: **Adults (18 or older)** Specific Classification: **US Veterans with PTSD symptoms and sleep disturbances**
Type of Interaction	[8J Virtual/Remote/Online interaction [8J **In person or physical interaction - Mandatory COVID-19 Management**
Exceptions	1. Permitted to obtain participants' full name for coordinating the interventions. 2. Qualtrics informed consent is aooroved for both types of interactions
Restrictions	**1. Mandatory ACTIVE Informed Consent.** **2. Other than the exceptions above, identifiable data/artifacts, such as, audio/video data, photographs, handwriting samples, personal address, driving records, social security number, and etc., MUST NOT be collected.** **3. Mandatory Final report (refer last page).** **4. CDC Quidelines and MTSU safe practice must be followed**
Approved Templates	*/RB Templates:* Informed Consent Templates *Non-MTSU Templates:* Verbal recruitment script
Research Inducement	**NONE**

Post-approval Requirements

The PI and FA must read and abide by the post-approval conditions (Refer *"Quick Links"* in the bottom):

- ***Reporting Adverse Events:*** The PI must report research-related adversities suffered by the participants, deviations from the protocol, misconduct, and etc., within 48 hours from when they were discovered.
- ***Final Report:*** The FA is responsible for submitting a final report to close-out this protocol before **10/31/2021** **(Refer to the Continuing Review section below)**; REMINDERS WILLNOT BE SENT. **Failure to close-out or request for a continuing review may result in penalties** including cancellation of the data collected using this protocol and/or withholding student diploma.
- ***Protocol Amendments:*** An IRB approval must be obtained for all types of amendments , such as: addition/removal of subject population or investigating team; sample size increases; changes to the research sites (appropriate permission letter(s) may be needed); alternation to funding; and etc. The proposed amendments must be requested by the FA in an addendum request form. The proposed changes must be consistent with the approval category and they must comply with expedited review requirements
- ***Research Participant Compensation:*** Compensation for research participation must be awarded as proposed in Chapter 6 of the Expedited protocol. The documentation of the monetary compensation must Appendix J and MUST NOT include protocol details when reporting to the MTSU Business Office.
- ***COVID-19:*** Regardless whether this study poses a threat to the participants or not, refer to the COVID-19 Management section for important information for the FA.

Continuing Review (The PI has requested early termination)

Although this protocol can be continued for up to THREE years, The PI has opted to end the study by **10/31/2021** **The PI must close-out this protocol by submitting a final report before 10/31/2021 Failure to close-out may result in penalties that include cancellation of the data collected using this protocol and delays in graduation of the student PI.**

Post-approval Protocol Amendments:

The current MTSU IRB policies allow the investigators to implement minor and significant amendments that would fit within this approval category. ***Only TWO procedural amendments will be entertained per year*** *(changes like addition/removal of research personnel are not restricted by this rule).*

Date	Amendment(s)	IRB Comments
NONE	NONE.	NONE

Other Post-approval Actions:

The following actions are done subsequent to the approval of this protocol on request by the PI/FA or on recommendation by the IRB or by both.

Date	IRB Action(s)	IRB Comments
NONE	NONE	NONE

The data must be stored for at least three (3) years after the study is closed. Additional Tennessee State data retention requirement may apply *(refer "Quick Links" for MTSU policy 129 below).* The data may be destroyed in a manner that maintains confidentiality and anonymity of the research subjects.

The MTSU IRB reserves the right to modify/update the approval criteria or change/cancel the terms listed in this letter without prior notice. Be advised that IRB also reserves the right to inspect or audit your records if needed.

Sincerely,

Institutional Review Board
Middle Tennessee State University

Quick Links:

- Post-approval Responsibilities: http://www.mtsu.edu/irb/FAQ/PostApprovalResponsibilities. php
- Expedited Procedures: https://mtsu.edu/irb/ExpeditedProcedures.php
- MTSU Policy 129: Records retention & Disposal: https://www.mtsu.edu/policies /general/129.php