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TISSUES AND TRAUMA: PAIN NEUROSCIENCE EDUCATION FOR VETERANS WITH
POST-TRAUMATIC STRESS AND LOW BACK PAIN

DISSERTATION

A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in the
College of Health Sciences at the University of Kentucky

By
Timothy Mark Benedict

Lexington, Kentucky

Director: Dr. Arthur Nitz, Professor of Physical Therapy

Lexington, Kentucky

2018

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ABSTRACT OF DISSERTATION

TISSUES AND TRAUMA: PAIN NEUROSCIENCE EDUCATION FOR VETERANS WITH POST-TRAUMATIC STRESS AND LOW BACK PAIN

Low back pain (LBP) is the top reason for Soldiers to seek medical care and one of the top reasons to be medically discharged. Mental health problems and psychosocial stressors have been increasing in Soldiers and are also top causes for medical discharge. Dysregulated stress has contributed to many Soldiers and Veterans to develop chronic LBP as well as mental health disorders like post-traumatic stress disorder (PTSD). Research suggests that psychosocial characteristics, as opposed to physical factors or tissue health, contribute to chronic pain the most. Focusing entirely on tissues for individuals seeking care for LBP can increase disability and vulnerability. Attributing physical pain to mental health concerns, however, risks stigmatizing patients or making them feel dismissed. The purpose of this dissertation was to develop a pain neuroscience education (PNE) program for Veterans and Soldiers with LBP and stress and determine if PNE is more effective in improving disability, PTSD symptoms, and beliefs about pain compared to traditional education about back pain and stress.

This dissertation demonstrated that Veterans with PTSD can comprehend the neuroscience of pain and PTSD at a comparable level to a highly educated Veteran and medical panel without PTSD when adjusting for education. Since a proportion of participants were concerned that using military examples in PNE might increase PTSD symptoms, however, results from pilot testing suggested that the PNE materials developed for this dissertation should be tested in a clinical trial to ensure they do not increase PTSD symptoms.

A systematic review and meta-analysis demonstrated that Veterans with PTSD have higher depression and pain-catastrophizing beliefs for a large effect size compared to Veterans without PTSD. Furthermore, Veterans with PTSD have significantly lower pain self-efficacy with a large effect size. Compared to Veterans without PTSD, Veterans with PTSD have higher pain and disability. These results, however, were not confirmed in Veterans presenting to a Physical Therapy clinic. In fact, this dissertation revealed that many of the negative outcomes previously attributed to PTSD in the literature may be due to the correlation between PTSD symptoms and pain-catastrophizing beliefs rather than from trauma. Furthermore, Veterans with chronic LBP do not appear to have different sensitivity levels to pressure based on PTSD symptoms.

Finally, the results from a randomized controlled trial provide evidence that PNE greatly improves the confidence of Veterans and Soldiers to increase participation in social, work, and life roles despite the pain as measured by the pain self-efficacy questionnaire. Participants in the experimental group were more likely to achieve a meaningful reduction in disability at the 8-

week follow-up compared to the control group. Furthermore, Veterans and Soldiers with LBP were more satisfied with how PNE explains pain and believed the PNE curriculum connected with their military experiences better than traditional psychosocial education about stress. Participants in the experimental arm were less likely to believe that exercise is harmful compared to traditional education. Finally, PNE improved PTSD symptoms beyond the clinically meaningful threshold in the experimental arm. In conclusion, PNE appears to be an effective treatment for PTSD, disability, and pain-related beliefs in Veterans and Soldiers with chronic LBP. These results should be replicated in a larger sample to ensure generalizability beyond the current study.

KEY WORDS: Low Back Pain, Post-Traumatic Stress Disorder, Stress, Pain Neuroscience
Education

Timothy Mark Benedict
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June 5, 2018
Date

TISSUES AND TRAUMA: PAIN NEUROSCIENCE EDUCATION FOR VETERANS WITH
POST-TRAUMATIC STRESS AND LOW BACK PAIN

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DEDICATION:

To my Grandfather, COL (ret) William Benedict (1926-2015): a true hero who volunteered to serve in the Army during World War II and had combat tours in the Korean and Vietnam Wars. Because of your service, you taught three generations the meaning of sacrifice, honor, and grit. Thank you for leaving a legacy that still lives today. Thank you to my parents for your hard work and example of service as well.

To all the Veterans and families who have served in the Armed Forces: Thank you for your service! My hope is that this work will in some way contribute to the good fight.

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Chapter 1: Introduction

Background

Low back pain (LBP) has been called a “Twentieth Century Health Care Enigma.”¹ Well in to the 21st Century, LBP continues to be an enigma despite advances in treatments and diagnostic imaging². The global point prevalence of LBP ranges from 11.9-23.2%, incurring substantial societal and individual burden³. In the U.S. alone, LBP costs surpass more than \$100 billion annually⁴. LBP is the most common pain condition reported by adults in the U.S.⁵ and a top reason for an individual to visit a physician⁶. In the U.S. military, LBP matches the general population as the top reason to seek healthcare treatment⁷ and is the leading cause of disability in the U.S. Army⁸.

Given the demanding nature of the mission of the U.S. Army, it is not surprising that Service Members experience high levels of stress⁹, defined as disruptions in neurophysiological homeostasis due to environment or psychosocial situations¹⁰. Approximately one-third of military members experience high levels of occupational stress⁹. Soldiers who have deployed to a combat location report even higher levels of stress¹¹. Although stress is ubiquitous to all individuals^{10,12}, Veterans with previous military experience display greater stress dysregulation compared to matched civilians without military experience¹³. Higher levels of stress contribute to greater mental health needs within the military⁹.

As occupational stressors and combat deployments have increased over the past two decades, mental health disorders have risen as the top reason for a Service Member to be hospitalized⁷. A specific mental health disorder that is particularly problematic for the military is post-traumatic stress disorder (PTSD). PTSD is diagnosed after exposure to a stressful, traumatic event and experiencing the cluster of symptoms of hyper-arousal, re-experiencing traumatic memories, avoidance, and negative cognitions for at least 30 days beyond trauma exposure¹⁴. Although up to 83% of Americans report lifetime prevalence of trauma exposure,¹⁵ only 7.8% develop persistent PTSD symptoms¹⁶. Therefore, development of PTSD may indicate an inability

to appropriately regulate stress responses following trauma¹². Understanding some of the differences between individuals who develop PTSD and those who do not may contribute to developing specific therapies tailored to an individual's ability to regulate stress.

Independently, PTSD and LBP cause significant disability in the U.S. military. Almost one-half of all medical discharges from the U.S. Army can be attributed to PTSD or LBP⁸. The impact of co-morbid PTSD and LBP, however, is not as well reported among Active Duty Soldiers as in Veteran populations¹⁷. Although at face value PTSD and LBP have different etiologies, these two conditions are highly co-prevalent in Veterans with military service. 66% of Veterans with PTSD have chronic pain¹⁸, with LBP as the most common condition^{18,19}. On the other hand, 7-51% of individuals who have chronic LBP have PTSD symptoms^{20,21}. In fact, chronic LBP and PTSD share many underlying neurobiological characteristics²². Chronic LBP, like PTSD, may be the result of a hypervigilant nervous system²³ and dysregulated stress response²⁴.

Not only do PTSD and LBP mutually increase the risk for each other²⁵⁻²⁷, when PTSD and pain are co-morbid, it amplifies negative symptoms and beliefs which are known to lead to greater disability^{28,29}. For example, compared to Veterans with chronic pain only, Veterans who also have co-morbid PTSD have significantly higher pain^{19,30-33}, pain catastrophizing beliefs³⁰⁻³², and disability^{19,30,31}. On the other hand, Veterans with PTSD and chronic pain have lower self-efficacy³⁰⁻³² and lower function^{30,33} compared to Veterans with pain only. Traditional biomedical education about LBP, which focuses on pathology and anatomy, is not only ineffective in Veterans with LBP and PTSD³⁴, but might even increase disability and catastrophizing by magnifying the threat of their condition³⁵.

Attributing physical pain to a mental health disorder, on the other hand, may lead patients to feel they are being dismissed³⁶ and contribute to providers making broad, premature judgments about patients with PTSD and pain^{37,38}. Individuals in chronic pain likely desire a biological

explanation for their pain, not just a psychological approach for bodily pain³⁹. Many healthcare providers, however, lack confidence examining patients with physical symptoms in the presence of mental health disorders⁴⁰. Many Physical Therapists do not feel equipped to appropriately manage the psychosocial symptoms that contribute to LBP⁴¹. These reasons could contribute to feelings of stigma in patients with PTSD⁴² and LBP⁴¹. The disconnect between explanations for physical and mental health disorders may help explain why many patients with PTSD have difficulty engaging in cognitive-based or counter-intuitive therapies for their pain^{39,43}.

Pain neuroscience education (PNE) represents a novel therapy to help both clinicians and patients understand the link between mental health—ultimately driven by the central nervous system—and bodily pain⁴⁴. Instead of focusing on anatomy and injured tissues, which typically heal in 3-6 months⁴⁵, PNE helps patients understand that on-going pain is the result of a hypervigilant and sensitive nervous system⁴⁴. PNE uses metaphors and stories to relate complex neurobiological principles about pain⁴⁶. Two systematic reviews have found PNE effective in improving pain, disability, and maladaptive beliefs about pain^{47,48}. Since pain represents bodily *danger* as perceived by the central nervous system, as opposed to actual tissue damage⁴⁹, PNE is proposed to decrease the threat of on-going pain, resulting in a top-down reduction of the pain experience⁵⁰.

Some of the patient populations that have benefited from PNE include fibromyalgia, chronic fatigue syndrome, and chronic LBP. These conditions are noteworthy for both dysregulated stress systems^{24,51,52} as well as a hypervigilant nervous system characterized by central sensitization⁵³. Central sensitization is defined as upregulation of pro-nociceptive neuronal messages and impaired endogenous inhibition of nociceptive signaling⁵³. If an individual believes that on-going pain is the result of damaged tissues that have failed to heal properly, then it makes sense (common sense model⁵⁴) that this individual's nervous system would continue to facilitate sensory information which may communicate danger to the tissues.

According to a modern neuroscience definition of pain⁴⁹, this will result in greater pain and avoidance of activities like exercise that could promote tissue health and function^{29,55}. Therefore, since PNE has helped decrease the threat of pain in other patient populations with hypervigilance, military Veterans and Soldiers with high levels of stressors and PTSD stand to greatly benefit from PNE.

A key question among healthcare providers is whether patients in chronic pain, however, can comprehend and understand the neuroscience of pain⁵⁶. Research has shown that patients, in fact, are able to comprehend PNE to a greater degree than predicted by medical providers⁵⁶. PNE comprehension has not, however, been tested in Veterans. Furthermore, Veterans with PTSD have neurocognitive deficits⁵⁷ which may limit their comprehension of PNE. Therefore, although PNE appears to be a logical intervention that could validate both psychosocial and physical symptoms in Veterans with PTSD, a first step is determining if Veterans can comprehend PNE materials. The purpose of this dissertation is to develop a PNE curriculum for Veterans with pain and PTSD or stress and test its effectiveness compared to traditional education about pain and stress. The following aims support this overall purpose:

Specific Aims

1. Develop a PNE curriculum for Veterans with PTSD and pain and determine if Veterans can comprehend PNE materials (Chapter 3).
2. Determine if co-morbid PTSD and chronic LBP increases disability in Active Duty Soldiers compared to chronic LBP alone (Chapter 4).
3. Determine if Veterans and Soldiers with PTSD and LBP have poorer health outcomes compared to Veterans and Soldiers without PTSD (Chapters 2 and 5).
4. Determine the effectiveness of PNE for Veterans and Soldiers with LBP (Chapter 6).

Operational definitions

Stress: Environmental, psychosocial, and physical disruptions to an individual's homeostasis¹⁰.

Stress can promote adaptive or maladaptive behaviors; stress can be classified as "good", "tolerable", or "toxic"⁵⁸. Throughout this dissertation and when communicating with research participants, maladaptive or negative stress was primarily considered.

Post-traumatic stress (PTS): Following a life-threatening traumatic event, it is normal to experience an acute disruption in an individual's homeostasis. An individual may also experience chronic physiologic adaptations following trauma. The difference between PTS and PTSD, however, is that an individual may continue to experience stressors following trauma but achieve a level of adaptation that prevents psychosocial disability.

Post-traumatic stress disorder (PTSD): Following a life-threatening traumatic event, an individual exhibits the following symptom clusters: hypervigilance, intrusions from traumatic experience, negative cognitions, and avoidance of trauma reminders. These symptoms persist for longer than 30 days following the trauma and interfere with an individual's functioning¹⁴.

Veteran: An individual who previously served in the United States Armed Forces. A combat deployment is not required to obtain Veteran status.

Soldier: A current member of the Armed Forces Army branch.

Active Duty: A uniformed individual employed full-time by the United States Armed Forces.

Service Member (SM): Sometimes used interchangeably for Veterans and Active Duty military personnel, a SM is a member of the Armed Forces to include all five branches of the military: Army, Air Force, Navy, Marines, and Coast Guard.

Service Connection: Upon separation from the U.S. Armed Forces, a SM may receive a rating of service connected disability. The Veteran's Administration uses the service connected rating to administratively classify Veterans and the service connected disability also serves as a compensation for service-related injuries incurred while in the Armed Forces. The compensation

is typically in the amount of a percentage (from 0-100%) of the individual's base pay prior to separation from the military.

Medical Evaluation Board (MEB): If a Soldier's supervisor or medical physician believes the Soldier may not have the medical capability of continuing to serve in the Soldier's current occupation, the Soldier may be evaluated for medical disability retirement.

Assumptions

Chapter 3: Participants fully read all the materials they rated.

Chapter 4: Although the study discussed the implications of a Soldier having a history of both PTSD and chronic LBP independently, co-morbid PTSD and chronic pain is frequently discussed as overlapping during a common time-frame. To continue the discussion with other research, participants in the Chapter 4 cohort study may be assumed to have co-morbid PTSD and chronic LBP, although the study methods were not able to definitively identify the temporal relationship between those with both PTSD and chronic LBP.

Chapter 5: Pain pressure threshold and self-report outcomes accurately represent the baseline and pre-treatment condition of participants.

Chapter 6: Participants will provide accurate self-report information at all time-points.

Limitations:

Chapter 2: The articles in the systematic review have not yet been graded for quality by a secondary assessor. Many studies dichotomized participants into PTSD/no PTSD only by using a cut-off score in PTSD symptomology.

Chapter 3: This study used a convenience sample and the study participants may not reflect the general opinion of Veterans with chronic pain and PTSD.

Chapter 4: This study relied on secondary analysis from a medical database.

Chapter 5: This study had a small sample size which potentially limited its ability to detect differences in some of the psychosocial outcomes that have been reported in the literature. This

study did not use a dynamic measure of quantitative sensory testing and did not use a remote, pain-free testing site to assess for characteristics of central sensitization.

Chapter 6: Only a small percentage of participants returned their activity and reading log. For some variables, this study lacked statistical power to confidently conclude the results were not due to chance, likely due to a relatively small sample size. Finally, the study included in this dissertation only has a short-term follow-up period of 4 and 8 weeks and will require 6-month long-term follow-up of healthcare utilization to be calculated and added to the final results.

Delimitations

Chapter 2: Study populations included in the systematic review required at least 30% of participants to have pain. Although this improved study homogeneity, it also excluded many studies that highlight important differences and outcomes in Veterans with PTSD compared to Veterans without PTSD.

Chapter 3: Veterans who reviewed the PNE materials must have previously served in the U.S. Armed Forces.

Chapters 5 and 6: Participants were Veterans or Soldiers ages 18-65.

Participants had chronic LBP.

Participants did not have schizophrenia, bi-polar disorder, or personality disorder.

Participants did not have a substance use disorder in the previous 6 months.

Soldiers were not undergoing Medical Evaluation Board.

Chapter 2: Post-Traumatic Stress Disorder (PTSD) Symptoms Contribute to Worse Pain and Health Outcomes in Veterans with PTSD Compared to those Without: A Systematic Review with Meta-Analysis.

Introduction

The “healthy warrior effect”⁵⁹ does not appear to protect Service Members and Veterans from chronic pain. Similar to the high prevalence of pain in the U.S. population⁶⁰, chronic pain is the number one reason for a Service Member to seek healthcare⁷. Musculoskeletal pain is also the number one reason for a Service Member to be medically discharged from the military⁸. Veterans from recent conflicts are estimated to cost the nation between \$300-\$700 billion over the course of their lifetime in medical expenses and disability compensation⁶¹. Although the modern era Service Member has a greater chance of combat survival than any other period in the history of warfare due to increased body armor⁶² and medical evacuation capabilities⁶³, not all wounds are visible or result in a purely physical injury⁶⁴.

One of the “wounds” that often accompanies combat trauma is post-traumatic stress disorder (PTSD), with a prevalence of approximately 10-17%^{65,66}. PTSD is diagnosed following exposure to life-threatening trauma and the presence of intrusive symptoms, avoidance, negative cognitions, and hyperarousal. These symptoms persist for at least 1 month following trauma exposure and impairs the individual’s function¹⁴. As the Department of Defense has prioritized identifying PTSD and other neurocognitive disorders within Active Duty and Veteran populations⁶⁷, it is evident that PTSD is not an isolated entity⁶⁸. Among one sample of treatment seeking Veterans with PTSD, 66% of them also had chronic pain¹⁸. The phenomenon of co-morbid pain and PTSD is not unique to the Veteran population, as meta-analysis has indicated PTSD as a significant risk factor for developing chronic, widespread pain²⁷. In Afari 2014, individuals with a history of combat PTSD incurred the highest odds of developing chronic, widespread pain with a pooled odds-ratio of 3.06. Furthermore, increased baseline pain predicts the development of PTSD longitudinally⁶⁹.

The bi-directional risk for pain and PTSD in the literature appears to support some of the theories offered to explain the co-morbidity of these two conditions. One theory is that individuals possess a shared vulnerability⁷⁰; faced with a traumatic event or injury, some individuals have a higher risk for developing disability compared to a resilient individual. Another explanation involves mutual maintenance²⁵ in which PTSD and pain reinforce the chronicity of each other whereby hypervigilance in someone with PTSD elevates potential threats and pain serves as an on-going threat which elevates hypervigilance in a continual cycle. Finally, altered central nervous system sensitivity due to PTSD symptoms could increase nociceptive signaling and amplify the subjective pain experience⁷¹. While the exact mechanism for the relationship between chronic pain and PTSD may be lacking⁷², evidence certainly supports many common neurobiological processes and neuroanatomic structures between pain and PTSD²².

Just as there are several theories that postulate mechanisms for the co-occurrence of chronic pain and PTSD, several narrative reviews have also offered potential treatment strategies for the co-morbid Veteran population^{73,74}. Initial treatment programs specifically directed at Veterans with PTSD and pain, however, have yielded nearly 50% drop-out rates^{17,75}. As integrated treatment programs have emerged for the Veteran population with chronic pain⁵⁵, the high drop-out rate for Veterans with co-morbid PTSD highlights the need to further understand this group. Identifying the profile and impairments of a Veteran with co-morbid pain and PTSD is a first step in developing targeted interventions. The purpose of this study, therefore, was to systematically review the literature and quantify disability, function, and pain-related beliefs and outcomes (O: Outcomes) in Veterans with PTSD (P: Patient) compared to Veterans without PTSD (C: Comparison).

Methods

Article Selection

The primary author (TMB) performed an electronic search of CINAHL, Medline, and PsychINFO according to the strategy in Table 2.1, resulting in 193 articles. During this initial

stage, exact duplicates, books, dissertations, and titles that clearly did not meet inclusion criteria were removed. The author next reviewed abstracts and full-text of 163 publications.

To be included in the systematic review and meta-analysis, the following Inclusion Criteria was applied:

- Articles available in English.
- Participants were U.S. Active Duty Military or Veterans. Since population cohorts indicate pain prevalence of approximately 30-40%^{76,77}, this study required at least 30% of participants to have pain to maintain study homogeneity.
- The authors examined pain, disability, beliefs, or other health related outcome.
- The authors compared groups with and without PTSD.
- The authors presented group means with standard deviation, Risk/Odds-Ratio with confidence interval, or other descriptive measure between groups with and without PTSD.

Articles were excluded if they did not meet this inclusion criteria, or if the primary study population was traumatic amputee, burn injury, spinal cord injury, inpatient, sexual trauma, or headache pain. The populations in the exclusion criteria would likely add too much variability in patient characteristics and outcomes.

After applying inclusion/exclusion criteria, 18 articles were identified for systematic review and meta-analysis. The primary author also searched the reference list for all included articles for relevant publications, identifying two additional articles which met established inclusion criteria. This resulted in 20 articles which were included in the systematic review and meta-analysis (see Figure 2.1). Next, the primary author reviewed all articles and graded them for methodological quality and risk for bias. Since the majority of articles included in the review were observational, the primary author graded these articles with the Newcastle-Ottawa Quality Assessment Scale for Cohort Studies⁷⁸ (NOS). The NOS is the preferred observational quality

assessment tool for observational studies as recommended by the Cochrane group⁷⁹. The NOS assesses potential bias related to selection, comparability, and outcomes (Table 2.2). A maximum of 9 stars or points is possible for each study, representing higher quality. For comparability, studies are awarded up to two stars depending on how they control for potential confounding variables. For this review, depression was selected as one covariate and a study could earn an additional star for controlling for a separate characteristic. For outcome, the follow-up period varied between 3-12 months, depending on the outcome assessed.

Data extraction

The principle aim of this systematic review was to describe pain-related outcomes between Veterans with and without PTSD. The broad categories evaluated in the included studies measured pain, disability, function, cognitive beliefs, and other health outcomes to include sleep, healthcare utilization, medication use, and suicide related behavior. The results among these domains were summarized in tabular form for each article. When possible, the primary author extracted the group means with number of subjects per group and respective standard deviation and entered these values into the Comprehensive Meta-Analysis Software (version 2.2.064; BioStat, Englewood, NJ, USA) for meta-analysis for health outcomes in which more than one study measured a similar outcome. Since many of the studies utilized questionnaires and measures with different psychometric properties, the outcome measure most consistently used or most similar across studies was selected for meta-analysis and computation of the standardized mean difference (SMD). Although all these studies were within Veterans and Service Members, the type of pain condition, population characteristics, and outcome measures varied among studies. Therefore, a random effects model was utilized in CMA except for two studies which used identical patient populations and outcome measures^{30,31}. Furthermore, as the majority of these studies were observational, bias was assessed through methodological quality assessment rather than through publication bias or funnel plot assessment.

Results

PTSD Diagnosis

Table 2.3 summarizes outcomes for all studies included in the systematic review. The most common method to assess PTSD exposure was through International Classification of Diseases (ICD-9) classification via electronic chart review^{33,76,77,80-86}. Only one study⁸⁷ specifically referenced using the Clinician Administered PTSD Scale (CAPS)⁸⁸—considered the gold standard in diagnosing PTSD—to generate the PTSD ICD-9 diagnosis. It was not possible to identify exactly how clinicians diagnosed participants with PTSD, although some studies mentioned clinical interview^{80,84} while another the Primary Care PTSD Screen (PC-PTSD)⁸³. The next most common tool to assess PTSD symptomology was the PTSD Checklist (PCL). The PCL consists of a military and civilian version. Both tests have good validity, reliability, and excellent internal consistency⁸⁹. Cut-off scores for PTSD vary between 30-60⁸⁹. In this systematic review, 5 studies used a PCL cut-off score of ≥ 50 ^{19,32,90-92} and 2 used a cut-off score of ≥ 41 in combination with the PC-PTSD^{30,31}. Other methods of determining PTSD exposure included the Davidson Trauma Scale ≥ 40 ⁹³ and the Mini-International Neuropsychiatric Interview (MINI)⁹⁴.

Quality Assessment

Quality assessment is summarized in Table 2.2. Many of the studies were population-based^{76,77,81-83,85,86}, limiting selection bias. Others, however, consisted of Veterans presenting for treatment at interdisciplinary pain specialty clinics^{19,30-33,90}. Veterans referred to pain specialty clinics might differ in prognosis and characteristics compared to the average Veteran. Adjusting for confounding factors is also important to limit potential study bias. Although most studies attempted to control for appropriate characteristics, many studies did not control for depression, which could inflate the contribution of PTSD symptoms if the PTSD group had disproportionate rates of depression. Finally, the cross-sectional design of many of the studies prevents

determining the temporal relationship between PTSD symptomology and health outcomes as they were measured at the same time.

Pain and Depression

Of the 7 studies that compared pain between Veterans with and without PTSD symptomology, 5 were included in meta-analysis^{19,30-32,92}. Meta-analysis determined that Veterans with PTSD had significantly higher self-reported pain for a pooled standardized mean difference of SMD=0.58 (95% CI .28-.89), indicating a medium effect size.

Most of the studies included in the meta-analysis for pain severity did not control for major depression. One study which did adjust for major depression determined that Veterans with and without PTSD did not statistically differ in pain severity¹⁹. Another study, however, found significant and independent associations for pain severity between both PTSD and depression even when adjusting for each condition³⁰. Three studies^{30,31,92} were possible to pool depressive symptoms in meta-analysis and determined that Veterans with PTSD have significantly higher depressive symptoms than Veterans without PTSD (SMD=1.40, 95% CI 1.2-1.6), large effect.

Furthermore, another study determined that Veterans with chronic, widespread pain (defined as pain in all four quadrants of a body pain chart) have 2.54 odds of being diagnosed with PTSD compared to those without chronic, widespread pain ($\chi^2=17.89$, $p<.001$)⁹⁵. Additionally, Veterans with PTSD were less likely to achieve a clinically meaningful reduction in pain compared to individuals without PTSD in Veterans receiving opioid-agonist treatment⁸⁶. This relationship persisted when adjusting for depression and other characteristics. Finally, Veterans with PTSD were less likely to achieve a reduction in pain severity after completing a multi-disciplinary and integrated healthcare program for pain³³.

Disability and Function

For the studies that analyzed disability, a higher score indicates more disability. Three studies were included for meta-analysis^{19,30,31}. Veterans with PTSD and pain had higher disability than Veterans with pain only (SMD=.52, 95% CI .33-.71, Figure 2.2). For function, on the other hand, a higher score indicates greater participation in physical and occupational roles. Two studies^{30,33} were analyzed for meta-analysis and found lower function in Veterans with PTSD and pain (SMD=.41, 95% CI .25-.56). Furthermore, one study found that Veterans with PTSD and pain were much more likely to score lower than the median for physical function ($\chi^2=73.09$, $p<.001$)⁹⁵. Finally, Nunnink 2012⁹³ reported that Veterans with PTSD scored significantly lower in physical function than Veterans without PTSD; however, this relationship did not maintain significance after adjusting for other covariates.

Cognitive Beliefs

Measures of pain catastrophizing and self-efficacy were included in meta-analysis. Pain catastrophizing measures increased negative appraisals towards pain⁹⁶ and was measured by three studies in this review³⁰⁻³². Compared to Veterans without PTSD, Veterans with PTSD report higher pain catastrophizing for a large effect size of .95 (95% CI .69-1.2). On the other hand, two studies^{30,31} determined that Veterans with PTSD and pain had lower self-efficacy as measured by the Arthritis Self-Efficacy Scale (ASES) compared to Veterans with pain only. The standardized mean difference between the two groups was SMD=.77 (95% CI .55-.99), reflecting a large effect size. These two studies indicate that Veterans with PTSD and pain have decreased confidence to personally cope with their pain condition compared to Veterans without PTSD.

In Outcalt et al³¹, 2014, Veterans with co-morbid PTSD and pain were more likely to rate their pain as central to their identity as measured by the Centrality of Pain Scale⁹⁷. Another study captured a similar higher focus on physical pain despite co-morbid mental health disability³²; Alschuler 2012 found that Veterans with PTSD and pain were more likely to believe pain is a sign of physical damage as measured by the Survey of Pain Attitudes (SOPA), Harm subscale⁹⁸:

2.41 (\pm .89) for PTSD versus 2.03(\pm .90) without PTSD, $p=.01$. The SOPA⁹⁹ is measured on a scale from 0-4 with 0 indicating “very untrue” and 4 “very true.” This difference, however, did not remain statistically significant after Bonferroni correction.

Other maladaptive cognitions associated with PTSD symptoms include more negative affect strategies¹⁹ and decreased mental health confidence⁹⁴. Finally, individuals with PTSD and pain were more likely to rate the spouse’s response to the Veteran’s pain as punishing⁹⁰, indicating that Veterans with PTSD and pain perceive their spouse responds to their pain in a negative manner¹⁰⁰.

Other Health Outcomes

Two studies reported higher healthcare utilization and costs associated with PTSD and pain compared to pain only^{76,83}. However, Veterans with PTSD were less likely than Veterans without PTSD to achieve optimal attendance of weight-management therapy sessions⁸¹. Additionally, Veterans with PTSD and pain were more likely to be prescribed opiates for their pain^{84,85}. Compared to Veterans without PTSD, this resulted in a greater number of adverse events to include opioid-related overdose and accidents, and self-inflicted or violent accidents⁸⁵. Similarly, Veterans with PTSD and pain performed suicide-related behavior at a significantly higher rate than those with pain only⁷⁷. In one cohort, PTSD increased the odds-ratio of suicide by 4.02 (95% CI 1.95-8.29)⁸⁷. Finally, two studies determined that Veterans with PTSD had higher sleep disturbance than Veterans without PTSD^{30,80}. The relationship between PTSD and sleep disturbance remained significant above and beyond pain interference⁸⁰. These two studies were able to be included in meta-analysis and indicated a SMD of .80 (95% CI .57-1.02) for a large effect size.

Discussion

The articles included in this systematic review and meta-analysis offer empirical support for the growing call to research and develop treatments specific to Veterans with co-morbid pain and PTSD^{71,73,74,101}. Although many previous reviews exist based on clinical experiences,

conceptual models^{25,70}, and a few original research publications in the Veteran population, this is the first study to systematically review the literature and synthesize the magnitude of health outcomes when pain and PTSD are co-morbid compared to Veterans without PTSD. Many Veterans with pain hold maladaptive beliefs about pain regardless of PTSD diagnosis⁵⁵. The results from this review indicate, however, that when PTSD symptomology is layered into the pain experience, Veterans report significantly worse health outcomes to include higher pain intensity, pain catastrophizing, and disability with lower function and self-efficacy. Furthermore, Veterans with pain and PTSD consume greater healthcare utilization, are more likely to be prescribed opioids resulting in adverse effects, and are more likely to engage in suicide-related behavior compared to Veterans without PTSD.

The results of this review support the Fear Avoidance Model²⁹ in which individuals with a negative appraisal view an injury and pain as a threat that should be avoided. This leads to disuse, depression, and disability, which then leads to a greater pain experience. A higher pain experience then reinforces catastrophic beliefs about pain, and the fear avoidance cycle continues. The results from this meta-analysis revealed a large standardized mean difference for pain catastrophizing, which could at least partially explain the increased disability and pain in Veterans with PTSD and pain. It is notable that Veterans with PTSD had an average score of disability greater than 15 as measured by the Roland Morris Disability Questionnaire (RMDQ, 0-24)¹⁰²; this score is considered at risk of poorer outcomes compared to a score of 10 or less¹⁰³. Furthermore, a Pain Catastrophizing Scale (PCS) score of ≥ 16 has been proposed as an elevated score, increasing the risk of poor post-operative outcomes. According to one study reviewed³¹, both Veterans with PTSD (PCS score of 28.59 ± 12.20) and without PTSD (PCS score 18.90 ± 11.24) have elevated pain catastrophizing scores. Although such elevated pain catastrophizing should be confirmed with further studies, it appears that Veterans with PTSD and pain score well above recommended cut-off scores for pain catastrophizing.

Although the timing and order about the Fear Avoidance Model has been questioned, there is empirical evidence to support the construct^{104,105}. In a sample who had lower back pain following a traumatic event, avoidant beliefs and behavior contributed to greater disability¹⁰⁶. Avoidance is a common impairment in individuals with PTSD, so the construct of avoiding potentially painful activities has face validity in Veterans with PTSD.

In addition to fear avoidance characteristics, Veterans with PTSD and pain demonstrated a large effect size of lower pain self-efficacy. Pain self-efficacy is the confidence to personally and actively cope with pain and is inversely related to fear of movement in patients with lower back pain¹⁰⁷. According to meta-analysis, self-efficacy is a top mediator for pain and disability above and beyond pain catastrophizing²⁸. Self-efficacy is one of most transcendent constructs in behavior change theories¹⁰⁸. Since this characteristic is significantly lacking in Veterans with PTSD and pain and plays such an important role for health outcomes, improving self-efficacy is likely an important target for treatment.

Another cognitive target for therapy is pain acceptance. Cook, et al., determined that pain acceptance was negatively correlated with both disability as well as PTSD symptoms¹⁰⁹. Acceptance Commitment Therapy (ACT) may be an appropriate therapy to address this finding. ACT is currently under trial in a Veteran population¹¹⁰ and the results from this systematic review warrant further investigation in Veterans with pain and PTSD as results are promising in civilian populations for chronic pain^{111,112}.

Although cognitive treatments certainly have evidence for treating chronic pain, the risk for drop-out is high^{39,43}. One review postulated this is because patients perceive their mental health providers are not considering the biological components of their pain experience but rather focus only on psychological contributions³⁹. It may seem counter-intuitive that patients with comorbid psychological disorders would focus more on their physical symptoms, but the evidence from this review suggests that patients with PTSD and pain consider their physical symptoms to be more concerning³² and more central to their identity than Veterans with pain only³¹. Since

patients want to know more about their pain⁴⁸, Veterans with PTSD and pain may be a prime population to present Pain Neuroscience Education (PNE), which aims to decrease the threat of pain⁴⁷. Patients with PTSD demonstrate enhanced sensitivity to threat as evidenced by increased amygdala plasticity^{113,114}, which may lead to heightened attention to pain and pain catastrophizing. PNE can decrease pain catastrophizing⁴⁸, which is one of the highest impairments in Veterans with PTSD and pain. PNE may also increase patient satisfaction with biopsychosocial interventions, since patients with pain want a biological explanation for their pain³⁹ and frequently feel stigmatized when providers attribute mental health problems to physical pain³⁶.

Limitations

There are some limitations to this review and the articles analyzed. First, the design for most of the articles preclude inferring that PTSD caused the negative health outcomes observed in these studies. Longitudinal prospective cohorts that measure PTSD symptomology as well as trauma exposure throughout military service and before chronic pain symptoms appear would be most ideal to ascertain the relationship of causation versus association. Second, there was a significant correlation between PTSD symptoms and depression in all studies that measured both conditions. In the studies that controlled for depression, the effects of PTSD symptoms on health outcomes were slightly diminished^{19,30,31}, but nonetheless an independent effect for PTSD could be determined^{30,90}. Third, there was variability among how the studies included in this review diagnosed PTSD. Only one study¹⁰⁹ utilized the CAPS, which is considered the gold standard for diagnosing PTSD⁸⁸. Therefore, the most accurate description for participants included in this review is Veterans with PTSD symptomology. This is not a significant limitation, however, as the diagnosis of PTSD is based on a set of symptoms following trauma exposure¹⁴. Finally, many cohorts did not specify how many participants were eligible for their study but declined to participate. This could potentially introduce selection bias if for some reason Veterans with more

severe symptomology and health outcomes participated more in these research studies than Veterans with milder PTSD symptoms.

Conclusion

In conclusion, this is the first systematic review with meta-analysis to capture the breadth of adverse health outcomes that are associated with PTSD and pain in Veterans. Although this review is unable to clarify the evidence regarding PTSD's role in the causation of negative health outcomes, this paper synthesizes and quantifies significant health effects that appear to be worse in Veterans with PTSD compared to those without PTSD or with pain only. As none of the pooled effect sizes crossed 0 in meta-analyses, the effects observed in the studies indicate that health outcomes are consistently worse for Veterans with PTSD. Many of these effects remained even after controlling for depression and ranged from medium to large effect sizes. Clinicians should consider PTSD symptomology when treating Veterans for pain as this review indicates a Veteran with PTSD has higher pain, disability, and pain catastrophizing than Veterans without PTSD. Furthermore, Veterans with PTSD have lower self-efficacy and function. Research should continue to test and develop effective treatment strategies for Veterans who have comorbid PTSD and pain.

Table 2. 1 Search Strategy

Search Number	Search Term	Results
S28	S23 NOT S27	184
S27	S24 OR S25 OR S26	(198,860)
S26	headache	(103,043)
S25	SCI	(41,690)
S24	amput*	(54,359)
S23	S6 AND S11 AND S15 AND S22	(233)
S22	S16 OR S17 OR S18 OR S19 OR S20 OR S21	(4,810,269)
S21	function	(2,161,994)
S20	prognosis	(627,049)
S19	belief	(162,357)
S18	health outcome	(155,163)
S17	outcome	(1,975,080)
S16	disability	(378,730)
S15	S12 OR S13 OR S14	(785,379)
S14	chronic pain	(86,033)
S13	persistent pain	(11,238)
S12	pain	(785,379)
S11	S7 OR S8 OR S9 OR S10	(232,730)
S10	"Service Member"	(429)
S9	Veteran	(57,981)
S8	Soldier	(10,348)
S7	military	(185,823)
S6	S1 or S2 or S3 or S4 or S5	(77,237)
S5	post-traumatic stress disorder	(25,003)
S4	posttraumatic stress disorder	(45,302)
S3	post traumatic stress*	(46,195)
S2	post traumatic stress disorder	(25,011)
S1	PTSD	(44,916)

*Truncation used to identify all possible term endings.

Table 2. 2 Methodological Quality using the New-Castle Ottawa Quality Assessment Scale

Study	Selection (Out of 4 ★s)	Comparability (Out of 2 ★s)	Outcome (Out of 3 ★s)	Total (Out of 9)
Alschuler 2012	★★	★		3/9
Alschuler 2013	★★	★★		4/9
Becker 2015	★★★★	★★	★★	8/9
Finley 2015	★★★	★★	★★	7/9
Helmer 2009	★★	★★		4/9
Lew 2010	★★★★	★		4/9
Magruder 2012	★★★★	★★	★★	7/9
Maguen 2016	★★★★★	★★	★★	8/9
McAndrew 2016	★	★	★	3/9
Morasco 2013	★★	★		3/9
Morasco 2016	★★★★	★	★★	6/9
Nunnink 2012	★★	★★		4/9
Otis 2010	★★	★★		4/9
Outcalt 2014a	★★	★		3/9
Outcalt 2014b	★★★★	★★	★★	7/9
Outcalt 2015	★★	★★		4/9
Rozet 2014	★★★★★	★	★★★★	8/9
Seal 2012	★★★★	★	★★	6/9
Smeeding 2010	★★★★★	★	★★	7/9
Taylor 2012	★★★★		★★	5/9

Figure 2. 1 Study Selection Diagram

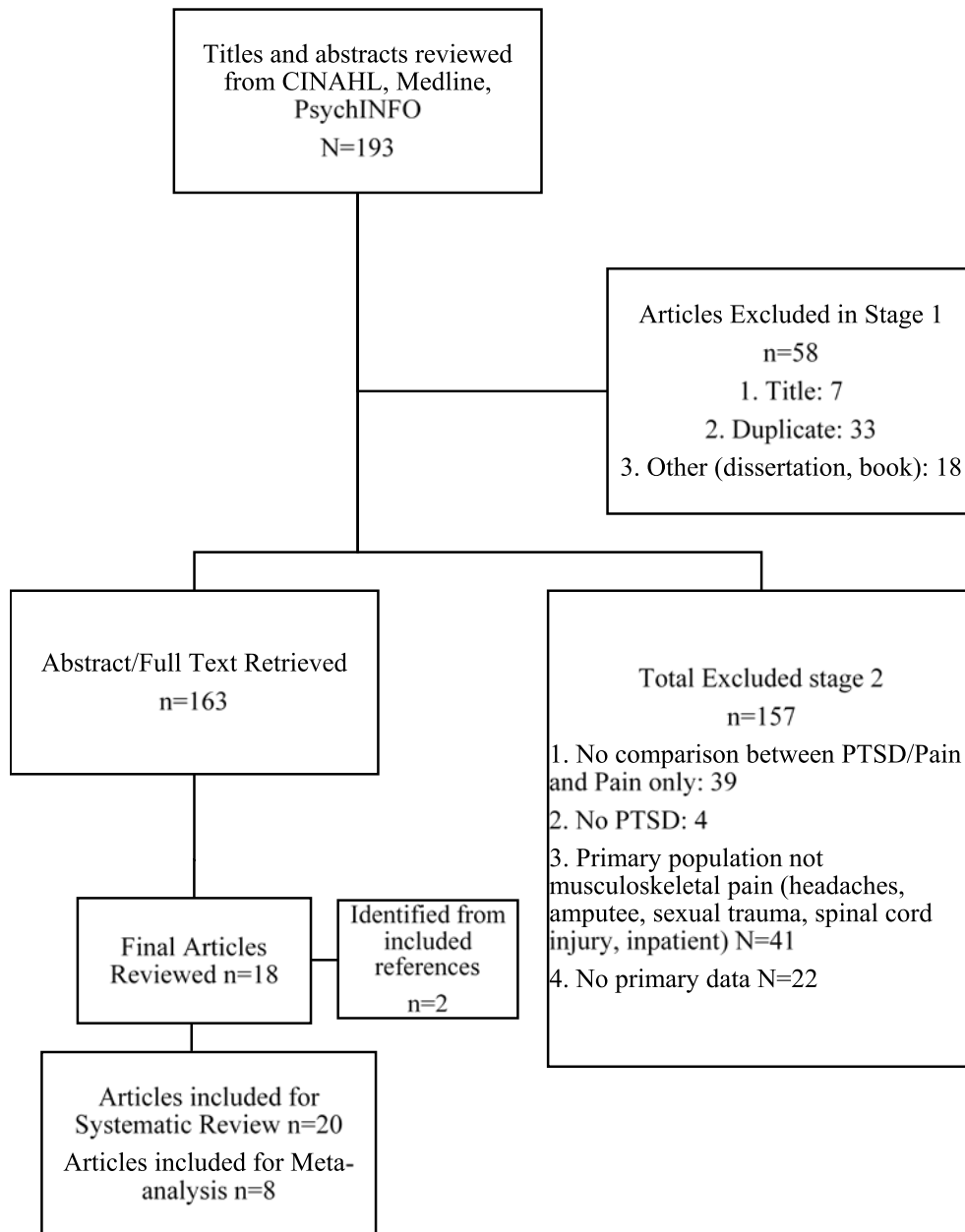


Table 2. 3 Summary of Research

Study	Study Type	Health Outcomes	Analytic Method	Results
Alschuler 2013 ⁹⁰ PTSD Diagnosed: PCL ≥ 50	Cross-sectional Retrospective Cohort, PTSD n=84, No PTSD n=100 Setting: Psychology Pain Management Program	Cognitive beliefs: Spouse response to Veteran’s pain, West Haven-Yale Multidimensional Pain Inventory (MPI)	Multivariate Analysis of Covariance (MANCOVA)	PTSD ↑ rating significant others others with “punishing” response to their pain, p<.001
Alschuler 2012 ³² , PTSD Diagnosed: PCL ≥ 50	Cross-sectional, Retrospective Cohort, PTSD n=91, No PTSD n=103 Setting: Psychology Pain Management Program	Pain: McGill Pain Questionnaire (MPQ) Disability: Survey of Pain Attitudes (SOPA- Disability) Cognitive beliefs: Pain control (SOPA- control), catastrophizing, Coping Strategies Questionnaire (CSQ)	Independent t- test MANCOVA	No difference in pain between groups. No difference in disability between groups PTSD ↓ control of pain experience PTSD ↑ pain catastrophizing p<.001
Becker 2015 ⁸⁶ PTSD Diagnosed: International Classification of Diseases (ICD)-9	Retrospective Cohort PTSD n=348, No PTSD n=823 Setting: Veteran’s Health Administration (VHA) Population Electronic Chart Review, 2003- 2010	Health Outcome: Odds of achieving clinical improvement in pain	Mixed-effects modeling, adjusting for all variables tested	PTSD ↓ odds by 32% of achieving clinical improvement in pain ≥2 numeric pain rating scale p=.01

Table 2.3, continued

Study	Study Type	Health Outcomes	Analytic Method	Results
Finley 2015 ⁷⁷ PTSD Diagnosed: ICD-9	Retrospective Cohort, PTSD n=14,018, No PTSD n=38,426 Setting: Population-based analysis of all OIF/OEF Veterans enrolled in VHA, 2009-2011	Health Outcome: Suicide ideation, suicide attempt.	Multinomial logistic regression	PTSD ↑ odds of suicide ideation, Odds Ratio (OR) 2.3 (2.0, 2.6)
Helmer 2009 ⁹⁵ PTSD Diagnosed: PC-PTSD ≥ 3	Retrospective Cross-sectional, PTSD n=220, No PTSD n=200 Setting: Post-deployment clinic	Pain: Chronic, widespread pain	Chi-square, frequency analysis	PTSD ↑ frequency for chronic widespread pain ($\chi^2=17.89$, $p<.001$).
Lew 2010 ⁸⁰ PTSD Diagnosed: ICD-9, clinical interview	Retrospective Cross-sectional, PTSD n=136, No PTSD n=64 Setting: Single VA Polytrauma Outpatient Clinic	Health Outcome: Sleep disturbance severity (0-4, 0=no disturbance, 4=severe disturbance)	Analysis of Variance (ANOVA)	PTSD ↑ sleep disturbance $p<.0001$
Magruder 2012 ⁸⁷ PTSD Diagnosed: CAPS	Retrospective Cohort, PTSD n=98, No PTSD n=718 Setting: Random sample of primary care patients from 4 VAMC in southeast	Health Outcome: Odds of suicidality	Multivariate logistic regression	PTSD ↑ odds of suicidality by 4.02 (1.95, 8.29).

OIF/OEF: Operation Iraqi Freedom/Operation Enduring Freedom

Table 2.3, continued

Study	Study Type	Health Outcomes	Analytic Method	Results
Maguen 2016 ⁸¹ PTSD Diagnosed: ICD-9	Retrospective Cohort PTSD n=11,417 No PTSD n=13,482 Setting: Population-level OIF/OEF Veterans with at least 1 MOVE! visit across VHA, 2008-2013	Health Outcome: VHA MOVE! weight management program participation	Multivariate logistic regression	PTSD ↓ likelihood to achieve optimal participation (≥12 visits over 12 months) in MOVE! Program
McAndrew 2016 ⁹¹ PTSD Diagnosed: PCL ≥ 50	Prospective Cohort PTSD n=24 No PTSD n=295 Setting: Army National Guard and Reserve enlisted Soldiers attending pre- and post-deployment medical processing, 2005-2011	Health Outcome: Chronic multi-symptom illness (CMI)	Analysis of frequency.	PTSD ↑ frequency of CMI (86% vs 52% without PTSD)
Morasco 2016 ⁸² PTSD Diagnosed: ICD-9	Retrospective Cohort, PTSD n=3593 No PTSD n=19,053 Setting: Population-level analysis of all Veterans receiving chronic opiod therapy (≥90 days), 2011	Health Outcome: Risk of urine drug testing (UDT) for chronic opiod therapy (COT)	Binomial regression	PTSD ↑ risk by 19% to receive UDT Relative Risk (RR) 1.19 (1.11-1.27), p<.0001

Table 2.3, continued

Study	Study Type	Health Outcomes	Analytic Method	Results
<p>Morasco 2013⁹²</p> <p>PTSD Diagnosed: PCL ≥ 50</p>	<p>Cross-sectional, PTSD n=65, No PTSD n=136</p> <p>Setting: Part of a larger study evaluating hepatitis C and substance abuse</p>	<p>Pain: interference and severity, Brief Pain Inventory (BPI)</p> <p>Cognitive Beliefs: Pain coping</p>	<p>Independent t- tests</p>	<p>PTSD ↑ pain severity and interference p<.001</p> <p>PTSD ↑ illness and wellness coping strategies (5/7 strategies, p<.048)</p>
<p>Nunnink 2012⁹³</p> <p>PTSD Diagnosed: Davidson Trauma Scale ≥ 40</p>	<p>Retrospective Cross-sectional, PTSD n=138, No PTSD n=250</p> <p>Setting: OIF/OEF Veterans newly enrolling at VAMC member services</p>	<p>Function: physical and mental health functioning (SF-36)</p>	<p>Independent t- tests, multivariate linear regression</p>	<p>PTSD ↓ physical and mental component score p<.001</p> <p>However, once adjusted for all variables, PTSD was no longer significant for physical function (p=.08)</p>
<p>Otis 2010¹⁹</p> <p>PTSD Diagnosed: PCL ≥ 50</p>	<p>Retrospective Cross-sectional, PTSD n=69, No PTSD n=73</p> <p>Setting: Psychology Pain Management Program</p>	<p>Pain, MPQ</p> <p>Disability, Roland Morris Disability Questionnaire (RMDQ)</p> <p>Cognitive beliefs: Negative affect, West Haven Yale Multidimensional Pain Inventory- Affective Distress (WHYMPI-AD) Subscale</p>	<p>MANCOVA, controlled for depression</p>	<p>No difference in pain between groups. However, PTSD predicted Veteran experience of pain, p<.01</p> <p>No difference in disability</p> <p>PTSD ↑ anger, irritability, and negative mood, p<.001</p>

Table 2.3, continued

Study	Study Type	Health Outcomes	Analytic Method	Results
<p>Outcalt 2015³⁰ PTSD Diagnosed: PCL \geq 41 and PC-PTSD \geq 1</p>	<p>Cross-Sectional baseline data, PTSD n=43, No PTSD n=207 Setting: Primary Care, Veterans with moderate-severe chronic pain.</p>	<p>Pain: severity and interference (BPI)</p> <p>Function/Disability: SF-12 Physical Component, Days/month of disability</p> <p>Cognitive Beliefs: Pain catastrophizing (CSQ), pain self-efficacy (Arthritis Self-Efficacy Scale, ASES, adapted)</p>	<p>Independent t-tests.</p>	<p>PTSD \uparrow pain severity and interference, medium to large effect size $p < .001$</p> <p>PTSD \downarrow function (effect size .36, $p = .028$)</p> <p>PTSD \uparrow disability (effect size .59, $p = .0004$)</p> <p>PTSD \uparrow pain catastrophizing</p> <p>PTSD \downarrow self-efficacy</p> <p>$p < .0001$, large effect size</p> <p>Significant effects still present but reduced after controlling for depression</p>
<p>Outcalt 2014a³¹ PTSD Diagnosed: PCL \geq 41 and PC-PTSD \geq 1</p>	<p>Cross-sectional baseline data, PTSD n=68, No PTSD n=173 Setting: Primary Care, Veterans with moderate-severe chronic pain.</p>	<p>Pain: Pain severity (Graded Chronic Pain Scale)</p> <p>Pain interference (BPI)</p> <p>Disability, (RMDQ)</p> <p>Cognitive beliefs: Pain identity, Pain Catastrophizing Scale, self-efficacy (ASES)</p>	<p>Independent t-test.</p>	<p>PTSD \uparrow pain severity and interference $p < .001$</p> <p>PTSD \uparrow disability $p < .001$</p> <p>PTSD \uparrow pain as central to identity PTSD \uparrow pain catastrophizing PTSD \downarrow self-efficacy ($p < .001$)</p>

Table 2.3, continued

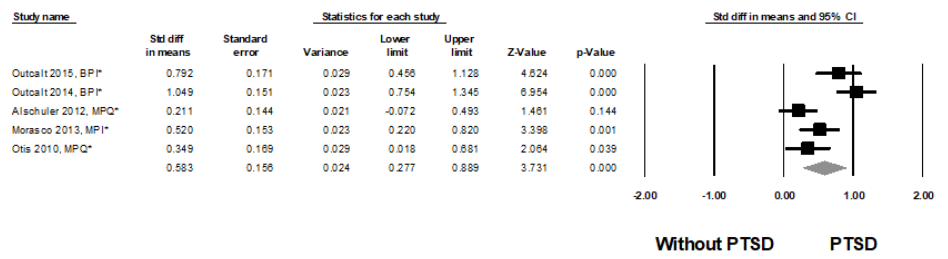
Study	Study Type	Health Outcomes	Analytic Method	Results
Outcalt 2014b ⁸³ PTSD Diagnosed: ICD-9 or PC-PTSD ≥ 3	Retrospective Cohort, PTSD n=5874, No PTSD n=33,281 Setting: All Veterans enrolled in mid-west Veterans Integrated Service Network, 2002-2007	Health Outcome: Healthcare utilization to include primary care visits, prescriptions, specialty visits.	Negative binomial	PTSD ↑ healthcare visits and medication utilization p<.0001
Rozet 2014 ⁸⁴ PTSD Diagnosed: ICD-9, clinical interview	Retrospective Cohort, PTSD n=47, No PTSD n=97 Setting: All Veterans in a large northwest VAMC receiving knee arthroscopy 2007-2010	Health Outcome: Odds of chronic post-operative (>30 days) pain and opiod prescription	Univariable frequency	PTSD ↑ odds of receiving opiod prescription >30 days post-operative, OR 10.3 (1.9, 54.8) p<.001
Seal 2012 ⁸⁵ PTSD Diagnosed: ICD-9	Retrospective Longitudinal Cohort PTSD n=44,983 No PTSD n=96,046 Setting: Population-based analysis of all OIEF/OEF Veterans enrolled in VHA 2005-2008	Health Outcome: Relative Risk (RR) of Opiod prescription RR of Opiod-related adverse event	Poisson regression	PTSD ↑ RR of opiod prescription by 4.32 (4.17-4.49) PTSD ↑ RR of multiple adverse events: wounds, self-inflicted injuries, overdose. p<.001

Table 2.3, continued

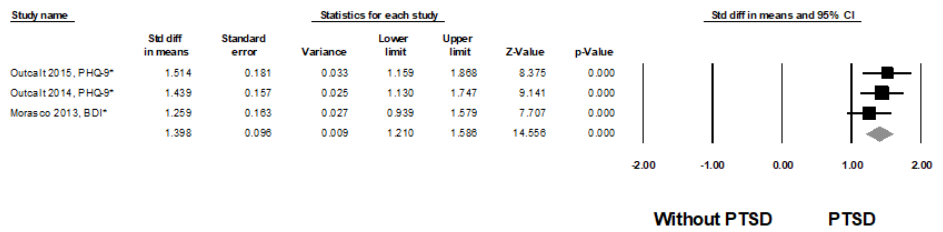
Study	Study Type	Health Outcomes	Analytic Method	Results
Smeeding 2010 ³³ PTSD Diagnosed: Electronic Health Record, PTSD service-connected disability rating	Retrospective Cohort, PTSD n=63, No PTSD n=102 Setting: All patients with chronic pain attending an Integrated Health Clinic, 2001-2007	Function: SF-36	Independent t-tests	PTSD ↓ function across all domains
Taylor 2012 ⁷⁶ PTSD Diagnosed: ICD-9	Retrospective Cohort, PTSD n=34,375, No PTSD n=58,602 Setting: Population-based analysis of all OIEF/OEF Veterans enrolled in VHA 2008-2009	Health Outcome: Healthcare utilization, annual median cost	Descriptive, median value (Interquartile Range).	PTSD ↑ annual median healthcare costs \$4978 (\$2655–\$9283) vs \$1974 (\$953–\$3890) without PTSD

Figure 2. 2 Meta-analysis of Studies

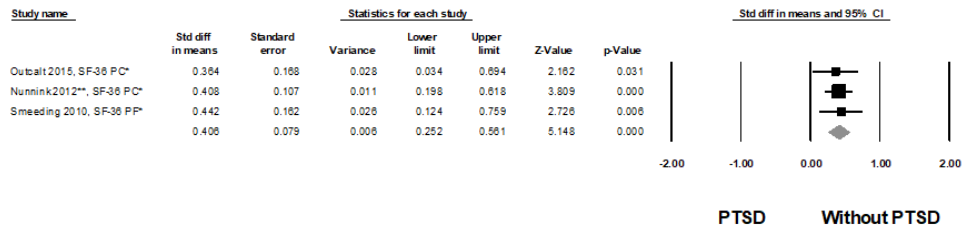
A: Pain



B: Depression



C: Function



D: Disability

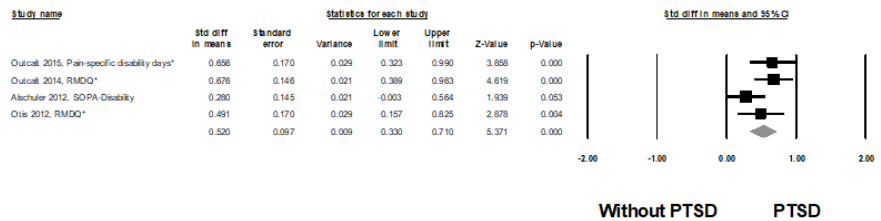


Figure 2.2, continued

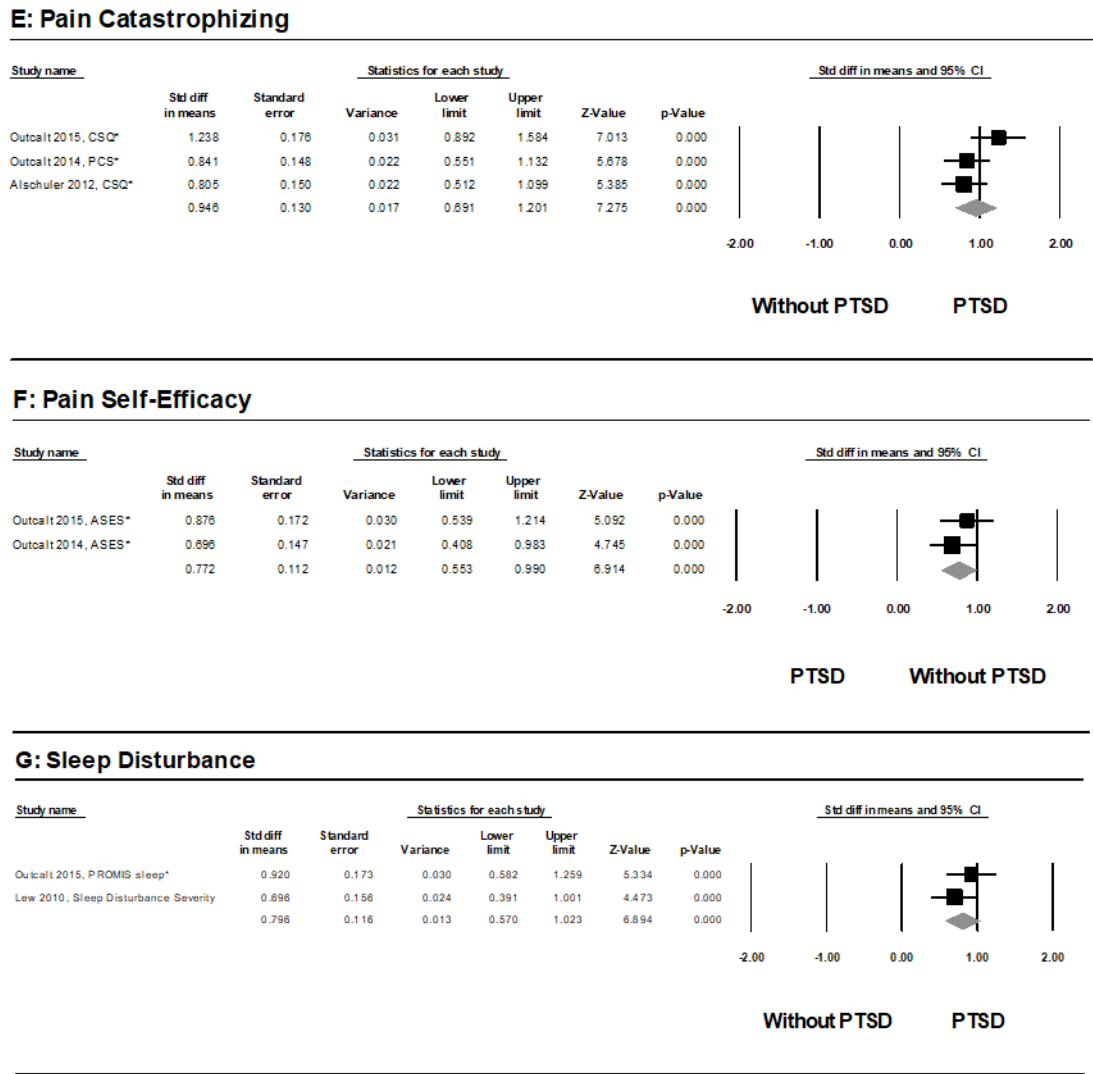


Figure 2 Legend: ASES: Arthritis self-efficacy scale; BDI: Beck depression index; BPI: Brief pain inventory; CSQ: Coping strategies questionnaire; MPQ: McGill pain questionnaire; MPI: Multidimensional pain inventory; PC: Physical component, PCS: Pain catastrophizing scale; PF: Physical function; PHQ: Patient health questionnaire; PROMIS: Patient reported outcome measurement information system; PTSD: Post-traumatic stress disorder; RMDQ: Roland Morris disability questionnaire, SOPA: Survey of Pain Attitudes.

Chapter 3: Development of a Pain Neuroscience Education Program for Veterans with Post-Traumatic Stress Disorder and Pain.

Introduction

Medical providers treating patients with post-traumatic stress disorder (PTSD) for co-morbid physical pain face a challenge in educating patients about their pain while attempting to reconcile mental and physical health concerns³⁷. Attributing physical symptoms to psychological distress can be dismissive³⁶ or stigmatizing^{42,115} to an individual with PTSD. Yet, patients with PTSD have more influential psychological characteristics—for example, higher pain catastrophizing³⁰⁻³² and lower self-efficacy^{30,31}—which contribute to higher pain and disability^{19,30,31}. Since PTSD appears to play a central role in the chronic pain experience³¹, it could be just as problematic to ignore mental health as it is to assume psychosomatic symptoms in an individual with co-morbid pain and PTSD by failing to address psychosocial characteristics that greatly influence health outcomes. Developing interventions that address both PTSD and pain is an important target for Veteran healthcare¹⁷.

PTSD is diagnosed after exposure to a traumatic event and experiencing the cluster of symptoms of hyper-arousal, re-experiencing, avoidance, and negative cognitions for at least 30 days beyond trauma exposure¹⁴. In one of the largest studies of disabled Veterans, participants revealed they wanted more education and classes for “emotional and physical pain”¹¹⁶. Several educational programs have successfully helped individuals with PTSD learn about their symptoms and have improved satisfaction with treatment¹¹⁷⁻¹¹⁹. However, when compared to a wait-list control, effect sizes of these programs are generally modest^{120,121}. Furthermore, none of these programs directly addressed physical pain, which is a highly prevalent co-morbidity in Veterans with PTSD¹⁸.

Pain Neuroscience Education (PNE) may be a valuable educational strategy that can address the symptoms of both PTSD and chronic pain. PNE uses metaphors and stories to help individuals understand the neurophysiology of pain⁴⁶. If an individual believes that pain indicates

current tissue damage, it makes sense that the individual would avoid activities that might cause pain and, thus, potentially harm body tissues⁵⁴. Modern neuroscience⁴⁹, however, demonstrates that on-going, chronic pain, poorly correlates with actual tissue health¹²². PNE, on the other hand, helps patients understand the role the nervous system plays in on-going pain. PNE communicates the phenomenon of increased nervous system sensitivity due to neuroplasticity resulting in maladaptive pain⁵³. PNE has shown to decrease pain, disability, and pain catastrophizing beliefs in patients with fibromyalgia, chronic low back pain, chronic fatigue syndrome, and other chronic pain conditions where hypervigilance and fear avoidance are common⁴⁷. Since pain is a protective response to potential tissue danger, PNE may be a top-down approach to decrease the threat of pain and enhance endogenous inhibition in individuals with chronic pain⁵⁰.

To date, no PNE curriculum specific to Veterans with PTSD and co-morbid pain has been developed or tested. Since culture-specific considerations are crucial to pain education¹²³⁻¹²⁵, research personnel developed a PNE program written for Veterans with PTSD and chronic pain using military stories and analogies to educate the neurophysiology of pain from a Veteran perspective. The curriculum was designed to relate and connect with the experiences of Veterans⁴² in efforts to increase the credibility of the materials.

A PNE curriculum specific to Veterans with PTSD and pain presents several challenges. First, healthcare providers typically underestimate a patient's ability to understand pain neurophysiology⁵⁶. Second, patients with PTSD exhibit generalized neurocognitive deficits⁵⁷ that may complicate the delivery and understanding of PNE. Furthermore, although the purpose of using military examples is intended to connect with Veterans, it is possible using military examples could trigger PTSD symptoms. Finally, given some skepticism about psychotherapy and high drop-out rates for counter-intuitive therapies in individuals with PTSD¹⁷, it is important to evaluate the credibility of a PNE program delivered to Veterans with PTSD and pain. The

purpose of this study was, therefore, to develop a PNE program for Veterans based on the best evidence of the neurophysiology of PTSD and pain. Secondary aims included determining if Veterans could comprehend the materials, find the program credible, and determine the impact of using military examples on PTSD symptoms.

Methods

This study followed the methods that have been reported in the literature to develop a population-specific PNE booklet¹²⁶. After reviewing the literature for the neurophysiology of PTSD and pain, a booklet was adapted for this research following the format *Why do I Hurt*^{127,128}. The neuroscience content was based on recommendations from two systematic reviews on PNE^{47,48}. The PNE booklet included neuroscience education specific to PTSD to demonstrate how trauma can make the nervous system more sensitive and thus susceptible to chronic pain^{22,24,37,114,129-131}. The main goal of the PNE booklet was to help Veterans who have PTSD and pain understand how the nervous system up-regulates threatening information after trauma. With a sensitive nervous system, the threshold for triggering pain and stress is lower. If Veterans can view pain and stress resulting from a sensitive nervous system, as opposed to tissue damage⁴⁹ or pathological physiology¹³², then Veterans may be more willing to pursue active therapies that they frequently avoid^{43,55,133}.

The booklet was divided into six sections: (1) introduction to the nervous system using military examples; (2) sensitization of the nervous system⁴⁴; (3) hypervigilance from stress hormones^{24,134,135}; (4) re-experiencing trauma and pain memories from a neuromatrix perspective⁴⁹; (5) how avoidance keeps the nervous system sensitive^{29,106}; (6) practical tips to recovery. All research procedures were approved by the Institutional Review Board at a Southeast University and Veterans Affairs Medical Center (VAMC).

Medical Panel

After developing an initial draft, the research team presented an electronic version of the booklet to a medical panel consisting of PNE researchers and instructors, physical therapists, psychologists, pain physicians, primary care physicians, occupational therapists, and interdisciplinary researchers. The first version of the booklet included images created from an electronic presentation software program and images available from the copyright free domain on the internet. A feedback questionnaire based on previous research¹²⁶ and a comprehension questionnaire to determine the ability of individuals to read and understand the PNE booklet were adapted and developed for this study. The feedback questionnaire addressed clarity, credibility, helpfulness, length, and other questions to determine the utility of the PNE booklet. Participants were also given open-ended questions to identify the main messages or individual feedback for the PNE booklet. The comprehension questionnaire was a combination of identifying specific content of the booklet as well as to assess understanding of the neuroscience of pain and PTSD. The expert panel was given 40 days to read and review the booklet and complete the questionnaires anonymously online. The survey software sent weekly email reminders to participants to review and complete the questionnaires.

PTSD Panel

Based on initial feedback from the medical panel, professional images were added and, after making minor revisions, the booklets were printed. The final booklet was 39 pages and 8,381 words with a 5.9 Fleish-Kincaid reading level. The books were 8.5×11” with a font size of 12 and contained approximately 1.2 images per page to maximize readability. The printed booklets were presented to a panel of Veteran patients with PTSD and pain at a PTSD Clinic in a Southeastern VAMC. The Veteran patients at this VAMC were diagnosed with PTSD with the Clinician Administered PTSD Scale⁸⁸. Participants were recruited from group therapy sessions. After obtaining informed consent, participants were given two weeks to read the booklet. Participants returned to the VAMC to complete feedback and comprehension questionnaires.

Additionally, some participants elected to give written and oral feedback based on their impression of the PNE booklet.

Veteran Panel

To maximize potential representation across Veteran eras, a convenience sample of Veterans irrespective of PTSD or pain was also recruited. Like the medical panel, the Veteran sample received an electronic version of the PNE booklet and had three weeks to read and complete the same questionnaires as the Veterans with PTSD and pain. A demographic questionnaire asked Veterans to report chronic pain¹³⁶ or self-report PTSD.

Adherence

Veterans with PTSD were directly asked if they read the PNE booklet. In addition, one question from the comprehension questionnaire asked participants to identify the primary example that was utilized throughout the PNE booklet and served as a proxy to determine if participants read the materials.

Statistical Analysis

Demographic characteristics among the 3 different panels were compared with independent t-tests and frequency analysis utilized Fisher's exact tests. To compare comprehension scores, a one-way analysis of covariance (ANCOVA) while controlling for number of years of education was utilized. Finally, feedback questionnaire ratings among the 3 groups were compared to determine how Veterans with PTSD perceived the PNE booklet compared to other Veterans and medical personnel with Fisher's exact tests. To control for multiple comparisons, a Benjamini-Hochberg¹³⁷ adjustment was applied to test p-values.

Results

Demographic characteristics of the medical panel are reported in Table 3.1. Overall, 89% of participants recommended the PNE booklet and 90% thought the PNE curriculum would help Veterans with PTSD and pain. The response rate for the medical panel was 46.7%. Most

medical respondents were physical therapists (72.4%, Table 3.1) and regularly use PNE in clinical practice or research (71.4%, data not shown). The entire panel believed the PNE booklet would help Veterans with PTSD and pain and believed the content of the booklet. Additionally, 100% of the panel, to include four mental health providers, did not believe the military examples would increase PTSD symptoms (Table 3.2). Feedback indicated that 34% of the panel recommended more practical tips and 24% believed the booklet was too long. Most of the remaining recommendations from the medical panel included formatting the final version with clearer sections and images to help Veterans follow the content of the PNE (Table 3.4). These recommendations were addressed by the authors of the booklet prior to writing the next version and presenting to patients with PTSD and pain.

43.5% of the Veteran sample completed the feedback and comprehension questionnaires after reading the PNE booklet. The Veteran panel attained higher levels of education than the PTSD/Pain panel (Table 3.1). The Veteran panel represented every Service of the U.S. Military (Table 3.1) with combat deployments ranging from Vietnam to Afghanistan and Iraq. Veterans who completed the questionnaires rated the booklet very positively (Table 3.2). 20% of the Veteran panel reported chronic pain.

Veterans with PTSD (n=13, 62% response rate) believed the PNE booklet was just as interesting as other participants and tolerated the length well (Table 3.2). A smaller proportion of Veterans with PTSD, however, recommended the booklet compared to the other panels ($p=.001$). In addition, more Veterans with PTSD were concerned that the PNE materials using military examples could possibly increase PTSD symptoms ($p<.001$). Across several book characteristics, Veterans with PTSD were less likely to rate the PNE as favorably as the medical and Veteran panel (Table 3.2). Veterans with PTSD were older than the medical and Veteran panels (Table 3.1).

Since most of the negative feedback from Veterans with PTSD came from one specific focus group, responses for each category of this particular support group of four compared to the remaining participants with PTSD were analyzed. The focus group rated the booklet differently than other participants with PTSD across several questions: they were less likely to recommend the book or find the military examples helpful (Table 3.2). If the focus group were excluded, Veterans with PTSD rated the PNE booklet the same as the remaining panels (data not shown).

The medical panel and Veteran panel scored higher on the comprehension questionnaire than Veterans with PTSD (88.9 vs. 85.1 vs. 78.3, $p=0.018$). However, after adjusting for education, comprehension scores were not statistically different ($p=.121$). 90% of Veterans with PTSD reported they read all the PNE booklet. 84% of participants correctly answered the identification question which served as a proxy for reading adherence. Table 3.3 identifies the main messages of the PNE booklet according to participants.

Discussion

The results from this study indicate that Veterans with PTSD and pain can comprehend neuroscience education at a comparable rate to an expert medical panel and a well-educated Veteran sample according to the comprehension evaluation designed for this study, once adjusting for years of formal education in participants. This is important because mental health providers are sometimes skeptical about an individual's ability to understand their psychological disorder³⁸. Furthermore, healthcare providers typically under-estimate a patient's ability to understand neuroscience education⁵⁶. Therefore, despite neurocognitive deficits which are prevalent in patients with PTSD⁵⁷, the results from this study indicate that a sample of Veterans with PTSD and pain are able to understand a booklet about the neuroscience of pain and PTSD and tolerated the length of the booklet better than predicted by a medical panel.

That some Veterans with PTSD and pain did not believe all the education provided in the PNE booklet may indicate that PNE challenged some beliefs of the PTSD panel. It is common

for patients in chronic pain to believe that ongoing pain indicates persistent tissue damage^{55,138}. Avoidance is a core symptom in individuals with PTSD¹⁴. It is likely that Veterans with PTSD and pain avoid painful activities because they believe they may further harm their condition⁵⁵. PNE, on the other hand, de-emphasizes tissues and instead educates patients that chronic pain is often the result of a hypervigilant nervous system¹³⁹. According to a recent systematic review⁴⁷, PNE is successful in challenging these type of fear-avoidant beliefs²⁹ in individuals with pain. Since exercise can alleviate both pain¹⁴⁰⁻¹⁴² and PTSD symptoms¹³³, reducing the fear of pain is a vital step in promoting active therapies³⁹.

While written materials are frequently utilized to reinforce PNE messages to patients in pain⁴⁷, written materials are not necessarily endorsed as a stand-alone treatment¹⁴³. Although there is research to suggest written PNE materials can improve pain beliefs⁴⁶, a PNE booklet was ineffective in changing pain beliefs or disability in individuals with fibromyalgia¹⁴³. Likewise, since written materials alone did not improve PTSD symptoms in individuals after a traumatic experience^{144,145}, it is possible that Veterans with PTSD and pain will require a therapeutic relationship with a provider who will use the PNE book as a common reference¹²⁶.

Even though most of the concern about increasing PTSD symptoms from the PNE book came from one specific support group, using a PNE book with military examples may not be appropriate for all Veterans with combat PTSD. Although avoidance of traumatic memories can increase both PTSD and pain symptoms^{106,146}, there is a growing recognition that exposure therapy is not necessary for all patients with PTSD⁴³. Nonetheless, the booklet attempted to use non-threatening, non-violent scenarios in the PNE booklet¹⁴⁷. Furthermore, the book was developed with the assistance of military behavioral therapists who did not believe that military examples would increase PTSD. In fact, for many Veterans with PTSD, they re-live and re-experience their military combat trauma regardless of external cues^{64,148}. Since Veterans with

PTSD most trust fellow Veterans with combat experience⁴², the PNE book was written from a military perspective to achieve cultural relevance¹⁴⁹.

Utilizing focus groups to elicit feedback can be an efficient manner to gather opinions¹⁵⁰. The representative nature of these opinions, however, may not extend beyond the specific focus group¹⁵⁰. In focus groups, a group opinion frequently emerges. This phenomenon has been identified in PTSD support groups. Specifically, PTSD support groups that are quite homogenous may silence dissenting viewpoints that challenge the group identity¹⁵¹. Although participants in this research study filled out surveys individually, one particular group (n=4) openly discussed the survey as they were filling out their feedback questionnaires. The group also admitted that they had critically discussed the PNE booklet the week before during their therapy session. Since the majority of the criticism and negative ratings about the PNE booklet came from the 4 individuals in this specific PTSD group, it is possible that the feedback from the group represents one opinion as opposed to four unique viewpoints. Although feedback from this focus group was not dismissed, the opinions of this one group may not be representative of all Veterans with PTSD. Nonetheless, the limited sample size of this study precludes definitive conclusions to this regard.

Despite some of the critical feedback regarding the PNE curriculum, Veterans with PTSD and pain represent an ideal population for PNE because they have high pain catastrophizing beliefs³¹ and altered nervous system processing¹⁵². PNE is recommended for patients with high catastrophizing and central sensitization¹⁵³. Patients with PTSD and pain frequently avoid activities that might cause harm. They may also avoid ideas that conflict with their current belief system. As demonstrated in this research study, a PNE book directed towards Veterans with PTSD and pain can directly challenge patients' beliefs about pain. Veterans with PTSD and pain comprehended PNE materials and concepts as well as Veterans without PTSD and an expert medical panel after controlling for education. The PNE book for Veterans with PTSD and pain

can be an entry-point in a therapeutic relationship that demonstrates a plausible, biological explanation for why it is safe to engage in physical exercise, even in the presence of chronic pain.

Limitations

This study has some limitations. First, participants consisted of a convenience sample to read and give feedback on the PNE book. The sample in this study might not reflect the general opinion of other Veterans. Furthermore, the response rate by the panel was less than desirable¹⁵⁴, but comparable to overall declining response rates, particularly among medical providers¹⁵⁵. Next, this study did not use a validated questionnaire to determine comprehension of the neurophysiology of pain. Although this study could have included the Pain Neurophysiology Questionnaire⁵⁶, that would have prevented PTSD-specific questions as well as basic content-identification questions to ensure participants read the materials. In addition, participants could have completed a PTSD-symptom questionnaire before and after Veterans read the book to more definitely assess whether the book increased PTSD symptoms as opposed to asking Veterans if they felt the book would increase PTSD symptoms in other Veterans. Finally, the PNE materials were longer than recommended for health communication¹²⁶. Although Veterans with PTSD tolerated the length of the materials better than the medical panel, it would be helpful to determine if a shorter version of the PNE booklet can increase Veterans' willingness to read without compromising PNE comprehension.

Conclusion

The PNE curriculum written for this research is the first set of materials specifically designed to explain the neurophysiology of pain or PTSD in Veterans after trauma. PNE has the potential to improve both pain and PTSD symptoms in Veterans with PTSD and pain. These materials will be tested in a randomized clinical trial at a VAMC facility. Based on the results of this current research, clinicians can be confident that Veterans with PTSD and pain will be able to

comprehend PNE materials and this PNE curriculum may serve as a common reference for clinicians to discuss the neuroscience of pain and PTSD.

Table 3. 1 Panel Demographic Information

	Medical Panel n=29	Veteran PTSD/Pain Panel n=13	Veteran Panel n=20	F/Chi-square (df) p value
Age (sd)	39.6 (11.1)	55.8 (16.3)	44.9 (15.0)	6.39 (2) p=.003*
Sex				
Male, n (%)	19 (65.5%)	11 (84.6%)	19 (95%)	6.3 (2)
Female, n (%)	10 (34.5%)	2 (15.4%)	1 (5%)	p=.034*
Discipline				
PT (n)	21 (72.4%)	NA	NA	NA
Mental Health (n)	4 (13.8%)			
Other (n)	4 (13.8%)			
Ethnicity				
White, n (%)	Not assessed	13 (100%)	18 (90%)	1.3 (2)
Hispanic, n (%)		0	1 (5%)	p=1.0 ^a
Asian, n (%)		0	1 (5%)	
Education				
Terminal Degree (%)	15 (51.7)	1 (7.7%)	0	26.4 (6)
Graduate Degree (%)	13 (44.8)	0	12 (60%)	p<.001*
Associate/Bachelor's (%)		5 (38.5%)	7 (35%)	
High School (%)		5 (38.5%)	1 (5%)	13.0 (3)
Other (%)		2 (15.4%)		p=.002* ^a
Income				
>\$100,000	Not assessed	0	5 (25%)	4.9 (3)
\$50,001-100,000		6 (46.2%)	7 (35%)	p=.153 ^a
\$10,000-50,000		6 (46.2%)	8 (40%)	
<\$10,000		1 (7.7%)	0	
Military Service (%)	13 (44.8%)	100%	100%	25.2 (2), p<.001*
Service (n)				
Army	Not assessed	11 (84.6%)	16 (80%)	2.9 (4)
Marines		0	1 (5%)	p=.909 ^a
Navy		2 (15.4%)	1 (5%)	
Air Force			1 (5%)	
Coast Guard			1 (5%)	
Deployments				
Vietnam (%)	Not assessed	6 (46.2%)	4 (20%)	4.2 (6)
Gulf War I (%)		1 (7.7%)	1 (5%)	p=.761 ^a
Afghanistan (%)		1 (7.7%)	3 (15%)	
Iraq (%)		3 (23.1%)	6 (30%)	
Iraq/Afghanistan (%)		1 (7.7%)	4 (20%)	
Other (%)		0	1 (5%)	
None (%)		1 (7.7%)	1 (5%)	
Response Rate (%)	46.7%	62.5%	43.5%	1.93, p=.233

^aComparison only between Veterans with and without PTSD. *Significant at the level of $\alpha=.05$

Table 3. 2 Panel Pain Neuroscience Education (PNE) Written Materials Feedback

	Medical Panel (%) n=29	Veteran PTSD/Pain (%) n=13	Veteran (%) n=20	Chi-Square (p value) PTSD (n=13) vs. All others (n=49)	Chi-Square (p value) PTSD (n=9) vs. Focus group (n=4)
Readability					
Very easy	21 (72%)	10 (77%)	19 (95%)	5.9 (2)	4.5 (2)
Somewhat easy	8 (28%)	1 (8%)	1 (5%)	p=.037	p=.077
Difficult	0	2 (15%)			
Interest-level					
Interesting	29 (100%)	11 (85%)	18 (90%)	2.18 (1)	5.3 (1)
Boring	0	2 (15%)	2 (10%)	p=.191	p=.077
Clarity					
Clear	26 (90%)	9 (69%)	18 (90%)	8.93 (2)	13.0 (1)
Not very clear	2 (7%)	0	2 (10%)	p=.008*	p=.001*
Completely confusing	1 (3%)	4 (31%)	0		
Learn					
New and helpful	18 (62%)	5 (38%)	18 (90%)	8.322 (2)	7.6 (2)
Already knew	11 (38%)	5 (38%)	1 (5%)	p=.012*	p=.028
Not helpful	0	3 (23%)	1 (5%)		
Credibility					
Believed most	29 (100%)	9 (69%)	20 (100%)	13.6 (1)	5.3 (1)
Believed some	0	4 (31%)	0	p=.001*	p=.052
Didn't believe any	0	0	0		
Order					
Easy to follow	26 (90%)	8 (62%)	19 (95%)	7.8 (2)	11.7 (2)
Mixed up	3 (10%)	4 (31%)	1 (5%)	p=.015*	p=.001*
Missing	-	1 (8%)	-		
Recommend					
Yes	29 (100%)	7 (54%)	18 (90%)	12.5 (2)	11.7 (2)
No	0	5 (39%)	1 (5%)	p=.001*	p=.001*
Missing	-	1 (8%)	1 (5%)		
Military examples					
Helpful	29 (100%)	7 (54%)	18 (90%)	15.7 (2)	7.0 (2)
Will increase PTSD	0	5 (39%)	1 (5%)	p<.001*	p=.021*
Missing	-	1 (8%)	1 (5%)		
Helpfulness					
Will help	29 (100%)	9 (69%)	19 (95%)	9.0 (1)	13.0 (1)
Will not help	0	4 (31%)	1 (5%)	p=.006*	p=.001*
Length					
Just about right	22 (76%)	10 (77%)	17 (85%)	3.8 (2)	3.1 (2)
Too long	7 (24%)	1 (8%)	2 (10%)	p=.1	p=.203
Too short	0	2 (15%)	1 (5%)		

Table 3.2, Continued

Practical tips					
Enough tips	18 (62%)	6 (46%)	17 (85%)	7.5 (3)	4.6 (3)
Wanted more tips	10 (34%)	4 (31%)	3 (15%)	p=.038	p=.194
Tips not clear	1 (3%)	2 (15%)	0		
Missing	-	1 (8%)	-		
Comprehension/ Compliance					
Correct	25 (82%)	10 (77%)	17 (85%)	4.9 (4)	1.17 (2)
Incorrect	4 (18%)	3 (23%)	3 (15%)	p=.277	p=1.0

*Denotes significance at the level of $\alpha=.05$ after Benjamini-Hochberg correction.

Table 3. 3 Participant Top 3 Messages

Theme	Participant Quotation
Knowledge about the nervous system is helpful	<p>“It's helpful to know how the nervous system works as it responds to pain and PTSD.”</p> <p>“There are logical, and basically physical, explanations for the symptoms and pain and PTSD and by understanding them, you can better overcome them.”</p>
Helpful tips	<p>“There are things I can do. I am not helpless to suffer with PTSD/Pain.”</p> <p>“We must learn to manage pain and stress, and this can be done through diet, lifestyle choices, and goals. I loved you took time to talk through breathing exercises.”</p>
Change is possible	<p>“Recovery is possible.”</p> <p>“Trauma is not destiny.”</p>

Table 3. 4 Recommendations for booklet

Theme	Participant Quotation
Appearance of initial draft ^a	<p>“Obvious page breaks to transition from one topic to the next. Images of real individuals.”</p> <p>“Graphics need to be improved throughout.”</p>
Reinforce metaphors with neurobiology	<p>“I would suggest anytime you refer to a given area of the body that in paren(theses)[sic] you put the military comparison, and vice versa. It would help me to keep focused and not have to go back and remind myself of what various parts did or were correlated to.”</p>
Clarify pain vs. PTSD	<p>“Try to better differentiate the issues of chronic pain and PTSD within each section.”</p>

^aThese comments came only from the medical panel regarding the initial draft

Chapter 4: Effect of Chronic Low Back Pain and Post-Traumatic Stress Disorder on the Risk for Separation from the U.S. Army.

Introduction

As the number one reason for a Service Member to visit a healthcare provider⁷, low back pain (LBP) disables more Soldiers annually⁸ than combat operations¹⁵⁶. Likewise, post-traumatic stress disorder (PTSD) is the third leading cause for a Soldier to be medically discharged from the Army⁸ and contributes to disability in its own right including increased mortality¹⁵⁷ and poorer health outcomes¹⁵⁸. As physically and mentally demanding combat operations for U.S. military forces have endured for the past 15 years, the burden of PTSD¹⁵⁹ and injuries¹⁶⁰ like LBP¹⁶¹ contribute significant cost to the Department of Defense (DOD). It is estimated that Iraq and Afghanistan-era Veterans will cost the DOD \$300-700 billion over the course of their lifetime due to medical costs and disability compensation⁶¹, half of which is due to LBP and PTSD⁸.

In addition to the independent burdens of PTSD and LBP, there is a growing recognition of the co-occurrence of these two conditions; 66% of Veterans seeking treatment for PTSD also have chronic pain¹⁸. PTSD is a risk factor for developing chronic pain, with combat-related PTSD increasing the odds of a chronic pain condition more than three-fold²⁷. Likewise, chronic pain increases the likelihood of developing PTSD at a similar ratio of 3.4²⁶. Veterans with co-morbid PTSD and pain have greater disability³¹ and experience higher costs⁷⁶, pain, and catastrophizing beliefs³¹. Most studies examining the relationship between PTSD and pain in Veterans, however, have been cross-sectional^{19,30-32}.

Since medical discharge from the Army represents a significant cost and threat to military readiness¹⁶² and greatly contributes to prolonged disability¹⁶³ and societal burden, it is critical to understand the longitudinal risk factors of LBP and PTSD, beginning with active duty service. Cross-sectional data in the Army has demonstrated that almost half of medical discharges can be attributed independently to LBP and PTSD⁸. One problem with the existing literature about co-morbid PTSD and pain^{8,76}, though, is the potential for selection bias¹⁶⁴ resulting from only studying cases who have already been medically discharged. The majority of individuals who

experience an index case of LBP do not develop chronic LBP¹⁶⁵ (cLBP). Similarly, only a small sub-set of individuals exposed to a traumatic experience develop PTSD¹⁶. Finally, not all individuals with these chronic conditions will be medically discharged. Therefore, investigating the longitudinal pathway from active duty service to medical discharge is an important step in understanding how the combination of LBP and PTSD affect disability in the military.

The purpose of this research is to examine whether the combination of cLBP and PTSD exerts a greater risk for medical discharge than when these two conditions are not present or only in isolation. This analysis will determine if the combination of cLBP and PTSD is a significant source of disability that begins during Active Duty or if it is a phenomenon primarily restricted to the Veteran community¹⁷. The study hypothesis was that Soldiers diagnosed with cLBP would have higher risk for medical discharge compared to Soldiers who are not diagnosed with cLBP, followed by Soldiers with PTSD, and, finally, Soldiers with both PTSD and cLBP would have the highest relative risk for medical discharge.

Methods

Participants

This retrospective cohort utilized the Total Army Injury and Health Outcomes Database (TAIHOD)¹⁶⁶ to examine medical disability discharges in U.S. Army Soldiers. The TAIHOD is a comprehensive database that includes administrative data for all personnel assigned to the active component of the U.S. Army as well as all medical encounters from inpatient and outpatient visits. Although it is possible for Soldiers to receive healthcare at a non-military facility, annual health examinations and insurance reconciliation ensures all medical conditions are included in the Soldier's electronic medical record. This study was amended from an IRB-approved protocol examining factors related to medical disability in U.S. Army soldiers. All Active Duty U.S. Army Soldiers were eligible for this cohort and were selected from January 1st 2002 until December 31st 2008. All members of the cohort were followed until the Soldier was medically discharged or left the Service for any other reason until December 31st, 2012 (See Figure 1).

Study Variables

Dependent Variables

The primary outcome of interest was medical disability retirement. When Soldiers are deemed unfit to continue service in the U.S. Army due to a mental or physical condition, they are referred to a Physical Evaluation Board (PEB)¹⁶⁷. If the PEB determines the Soldier does not meet retention standards, the Soldier is medically discharged. As service-connected disability is a major source of financial cost and healthcare utilization in the Veterans Administration services¹⁶⁸, this was the study's dependent variable. Medical discharge and PEB data are included within the TAIHOD.

Independent Variables

Chronic Low Back Pain (cLBP)

The first exposure of interest was cLBP. LBP diagnoses were identified as a medical encounter with an International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9 CM) diagnosis consistent with LBP¹⁶⁹. Chronic LBP was defined as a LBP diagnosis after 90 days from the initial LBP diagnosis had passed¹³⁶. If a period of 365 days elapsed after the index LBP diagnosis, however, subsequent LBP diagnoses were considered a new incident case and evaluated separately for chronicity. Since most LBP cases resolve within approximately 4-6 weeks^{170,171}, cLBP²³ may represent a poor prognostic factor making one more likely to be medically discharged compared to acute LBP.

PTSD

Soldiers with the ICD-9-CM diagnosis of 309.81 for at least 3 medical encounters were considered positive for PTSD. Soldiers are routinely screened for PTSD with the Primary Care PTSD Screen¹⁷² during primary care medical encounters¹⁷³. Since it has been documented that Soldiers under-report and under-utilize healthcare for PTSD^{174,175}, this study used 3 visits to capture chronic, PTSD behavior^{77,175}.

History of LBP and PTSD

Soldiers who met criteria for both cLBP and PTSD exposure as defined above were considered to have both cLBP and PTSD. Although this study did not specifically measure for an overlap in calendar time, adding a temporal requirement between cLBP and PTSD diagnoses might have reduced the potential sample of the exposure of interest. Furthermore, because of delayed reporting and deployments, since this study relies on secondary analysis of medical visits, adhering to a strict temporal algorithm might not have reflected the actual co-morbidity of PTSD and cLBP symptoms in subjects. In addition, once chronic, the symptoms of these two conditions appear to remain relatively persistent and stable^{165,176,177}. Therefore, it is likely that the Soldiers in this group had cLBP and PTSD concurrently. Even if the conditions were not concurrent, this group represents a unique combination of symptoms in the Army warranting investigation.

Other Covariates

The following variables were included to control for possible confounding as they have been identified as risk factors for disability, LBP, and PTSD: age¹⁷⁸, rank^{167,178}, sex¹⁷⁸⁻¹⁸⁰, deployment history⁸, military occupation specialty⁸, sleep disorder diagnoses¹⁸¹, and other mental health diagnoses¹⁶⁷. Furthermore, obesity¹⁸², tobacco¹⁸³, and alcohol abuse¹⁸¹ were included as potential covariates due to their contribution of risk towards LBP or medical discharge. Other mental health disorders were defined by mental health ICD-9 codes¹⁸⁴ excluding PTSD. Military occupation specialty was divided into combat and non-combat specialties¹⁸⁵. Finally, months in service was included as a continuous variable to determine the impact of time as a potential cumulative risk factor for medical discharge¹⁷⁸. Misclassification was minimized through the operational definitions of the cohort in which cLBP and PTSD exposures were only selected after several diagnoses over time. This decreased the likelihood that Soldiers entered the groups of exposure through an errant medical diagnosis¹⁸⁶.

Statistical Analysis

This study utilized modified Poisson regression¹⁸⁷, which is the preferred statistical method for estimating relative risks (RRs) for rare event count data¹⁸⁷ (in this study, medical discharge). First, crude RRs with 95% confidence intervals were calculated evaluating medical disability for the following mutually exclusive groups: Soldiers with neither cLBP nor PTSD (group 1), Soldiers with cLBP only (group 2), Soldiers with PTSD only (group 3), and Soldiers with a history of both cLBP and PTSD (group 4). Group 1—those with neither cLBP nor PTSD—served as the reference group. Crude RRs measure the overall association between group membership and the outcome event of medical discharge. To ensure that the RRs were not biased due to confounding, this study also adjusted for potential confounding variables controlling for all covariates listed in the previous section. Statistical analysis was performed with SAS Software, version 9.3 from March-May 2016 (SAS Institute Inc, Cary, NC, USA). At the time of data analysis, the TAIHOD had data available through 2012 for this study cohort.

Results

From 2002-2008, the TAIHOD database identified 1,011,849 Active Duty Soldiers who were eligible for the cohort (Figure 4.1). Among the eligible Soldiers, 80.2% (n=811,337) had neither cLBP nor PTSD during their service; 15% (n=159,629) were determined to have cLBP only; 2.8% (n=27,940) were diagnosed with PTSD only, and 2.1% (n=20,943) had both cLBP and PTSD. The outcome of interest, Soldiers medically discharged from the U.S. Army from 2002-2012, was present in 6.7% (n=68,175) of the cohort (Figure 4.1). Sociodemographic characteristics of the cohort and groups can be found in Table 4.1.

Group 1, the reference group, had an absolute medical discharge rate of 4%. Soldiers with a diagnosis of cLBP only had a crude risk of discharge 3.29 times that of Group 1 (Table 4.2). Soldiers with PTSD only had 3.76 times the risk for medical discharge compared to the reference group. When Soldiers had both a cLBP and PTSD diagnosis during Active Duty Service, they had 5.27 times the risk for medical discharge compared to the reference group.

When adjusted for sex, age, rank, time in service, deployment, mental health, sleep disorders, alcohol abuse, tobacco use, obesity, and military occupation, the relative risks associated with the group membership variables remained significant (Table 4.2). Contrary to the study hypothesis, after adjusting for all characteristics, cLBP demonstrated a slightly greater relative risk for medical discharge than PTSD, although their confidence intervals were nearly identical. These results indicate that a Soldier who had cLBP had 3.65 times the risk of being medically discharged compared to a Soldier who had neither condition (95% CI 3.6-3.7) and a Soldier with PTSD had a RR of 3.64 (95% CI 3.5-3.8). These represent moderate effect sizes for relative risk¹⁸⁸. Consistent with the study hypothesis, Soldiers who had PTSD and cLBP at any point during their service had an even greater relative risk, 5.17 (95% CI 5.01-5.33), of medical discharge compared to Soldiers who did not have either of these two diagnoses, even after adjusting for potential confounding variables. This effect size for relative risk of medical discharge in Soldiers with cLBP+PTSD is considered large¹⁸⁸.

According to the results, officer rank, previous deployment, self-reported alcohol use, and female sex demonstrated a protective association against medical discharge after adjusting for all covariates in the full model. On the other hand, having a sleep disorder, older age, obesity, mental health disorders, tobacco use, and combat military occupation were associated with increased risk for being medically discharged from the Army when accounting for all other variables (Table 4.3).

Discussion

The results from this retrospective cohort fill an important gap in the literature. Although the co-morbidity of LBP and PTSD is a well-recognized occurrence in both Veteran^{18,19,32} and civilian populations^{20,106,189}, no longitudinal study has provided evidence that the presence of both PTSD and cLBP leads to a substantial increase in risk for medical discharge compared to either condition alone. This study found that a Soldier who experiences both cLBP and PTSD has over

five-times the relative risk of discharge compared to a Soldier without these conditions, even after adjusting for other potential risk factors.

Previous Veteran cohorts also demonstrate worse health outcomes when PTSD and chronic pain—of which LBP is the most prevalent pain condition^{18,19,32}—are co-morbid, ranging from higher medical costs to increased suicide-related behavior^{76,77,83,85}. Less than half of eligible Veterans utilize VA services⁷⁶, however. Prior to this research, the natural trajectory of active duty Soldiers with both PTSD and cLBP were unknown. The population level analysis in this study, however, confirm that the presence of both PTSD and cLBP lead to negative health outcomes beginning in active duty.

There are several theoretical constructs which may explain the results from this study. Shared vulnerability⁷⁰ suggests some individuals may be more at-risk for developing disability due to low resilience. On the other hand, the Fear Avoidance Model²⁹ and mutual maintenance theory²⁵ suggests that PTSD and pain re-enforce the chronicity of each condition. An individual with PTSD exhibits hypervigilance¹³⁴ and magnifies potential threats¹⁹⁰; pain may be perceived as an on-going threat which then further elevates hypervigilance. An individual with only LBP or PTSD may be able to actively cope enough to continue active duty service. Individuals with co-morbid PTSD and pain, however, demonstrate decreased active coping abilities^{32,92}, likely reducing their ability to continue active duty service. A treatment that is recommended for individuals with a hypervigilant nervous system is Pain Neuroscience Education (PNE)⁴⁷. PNE aims to help individuals understand that on-going pain is not due to damaged tissues but rather explains how neuroplasticity can promote chronic pain¹⁹¹. Since PNE has helped in LBP populations¹⁹², it would helpful to test PNE in Active Duty Soldiers to determine if education about pain and PTSD could decrease disability when these conditions are combined.

This study had sufficient power to investigate multiple covariates that represent possible contributors to medical discharge from the Army. The results from this study are consistent with the biopsychosocial model¹⁹³ in which a combination of psychosocial and physical factors appear

to influence disability¹⁹⁴⁻¹⁹⁸. Similar to other research, Soldiers who had mental health^{167,199} visits had a 20% greater risk of medical discharge. Other than the primary exposures of interest in this study, however, the variable which raised the risk of medical discharge the most was having a sleep disorder diagnosis, which increased the risk of medical discharge by more than 50% when all other variables are held constant. In the literature, poor sleep is frequently reported in subjects with cLBP^{200,201} and PTSD²⁰². The results from this study support the relationship between poor sleep, cLBP, PTSD, and disability, but the design from this study does not elucidate which variable appears to initiate the path to medical discharge.

Some of the results from this study at first glance appear surprising. First, Soldiers who deployed were 50% less likely to be discharged than Soldiers who never deployed, when controlling for all other variables. Deployment has been labeled as a risk factor for discharge^{8,203} and would certainly contribute to the likelihood of being exposed to combat trauma—and hence, PTSD¹⁷⁹—or LBP²⁰⁴. This finding, however, has been reported as the “healthy warrior effect,”^{59,205} in which Soldiers with poorer health or injuries are less likely to meet medical standards to deploy and therefore would be more likely to be discharged from the Army.

Additionally, according to the results from this cohort, alcohol use appears to be protective against medical discharge when controlling for all other variables. Alcohol use is typically under-reported in the military²⁰⁶, however. It is possible that individuals who drink moderately would be more willing to report alcohol use to a medical provider than a Soldier who abuses alcohol to self-treat symptoms of PTSD or pain, masking the contribution of alcohol to disability.

Higher rank, particularly the rank of officers, also provides protection from medical discharge and is likely related to education, socioeconomic status, and more control over their work environment than lower ranks^{167,178}. Finally, keeping all other factors equal, females were less likely to be medically discharged from the Army when accounting for cLBP and PTSD status. This is a very interesting finding since female sex has been implicated independently as a

risk factor for PTSD¹⁷⁹, LBP¹⁸⁰, and medical discharge¹⁷⁸. While female Soldiers might be at higher risk for PTSD and LBP, the results from this cohort indicate that when holding all other characteristics equal, females were not observed to have higher risk of medical discharge relative to male Soldiers.

Other research supports that PTSD contributes to chronic pain at a greater rate in males than females²⁷. This finding may be due to different types of trauma that males and females experience²⁰⁷⁻²⁰⁹. Some theories also suggest this could be a result of how females cope with stress following trauma. “Tend or befriend”²¹⁰ proposes that female Soldiers might be more likely to seek social support and possibly medical help following a traumatic experience than male Soldiers and would therefore achieve some amount of protection from disability. Results from the literature, however, demonstrate that male and female Soldiers and Veterans utilize mental health services equally^{211,212}. Furthermore, female Soldiers generally experience less social support in the military than males^{179,213} which makes their relative resilience to medical discharge in the presence of cLBP and PTSD quite intriguing. Although it was beyond the aim of this cohort, future investigation into this phenomenon is certainly warranted.

Limitations

As with any observational research, there are limitations within this study. First, the results of this study may not generalize to non-military populations. In addition, this study relied on secondary analysis of data entered by various medical providers and their judgment for ICD-9-CM diagnoses. It is not uncommon for Soldiers to receive the diagnosis of PTSD through self-report measures^{172,175}, even though the Clinician Administered PTSD Scale is considered the gold standard for PTSD diagnosis⁸⁸. As with chronic LBP, however, this study utilized a more stringent operational definition of 3 PTSD visits which should increase the specificity of classification into the PTSD group(s) in this study. Furthermore, the methods in this study did not analyze whether PTSD precedes cLBP or the other way around on the pathway towards medical discharge. Further research and design could test whether the presence of LBP serves as

a risk factor for developing PTSD or whether PTSD serves as a risk factor for cLBP in the Army. Even if this study did attempt to control for initial timing of PTSD or cLBP diagnoses, it is not uncommon for delayed reporting of PTSD^{214,215} due to potential stigma and not having the time to seek treatment¹⁷⁴.

Finally, it was not possible to ascertain the nature of how individuals were injured. It is possible that Soldiers with a history of both cLBP and PTSD experienced more severe, combat-related injuries, which could contribute to their risk of medical discharge. Only a small percentage of war-time medical evacuations involving injuries to the spine, however, are due to severe combat injuries^{161,216}.

Conclusion

In conclusion, PTSD and cLBP independently remain a significant target for therapies in the U.S. Army Soldier, as they contribute a three-fold increased risk of medical discharge than when these conditions are not present. Since the most common trajectory for both acute LBP and trauma exposure is recovery without disability, Soldiers with cLBP or PTSD possibly represent a vulnerable population at-risk for disability and medical discharge from the Service. When cLBP and PTSD converge during active duty service, the relative risk for medical discharge rises five-fold compared to a Soldier who does not have either of these conditions. Future research to evaluate therapies directed to this high-risk group and determine if they can prevent medical discharge, which incurs a substantial financial and military readiness burden, may be an important next step. Future research to further investigate the chronological relationship between PTSD, cLBP, and other possible mediators along the pathway to medical discharge may also provide informative details for potential therapeutic options.

Figure 4. 1 Cohort Flow Diagram of Active Duty U.S. Army Soldiers from 2002-2012

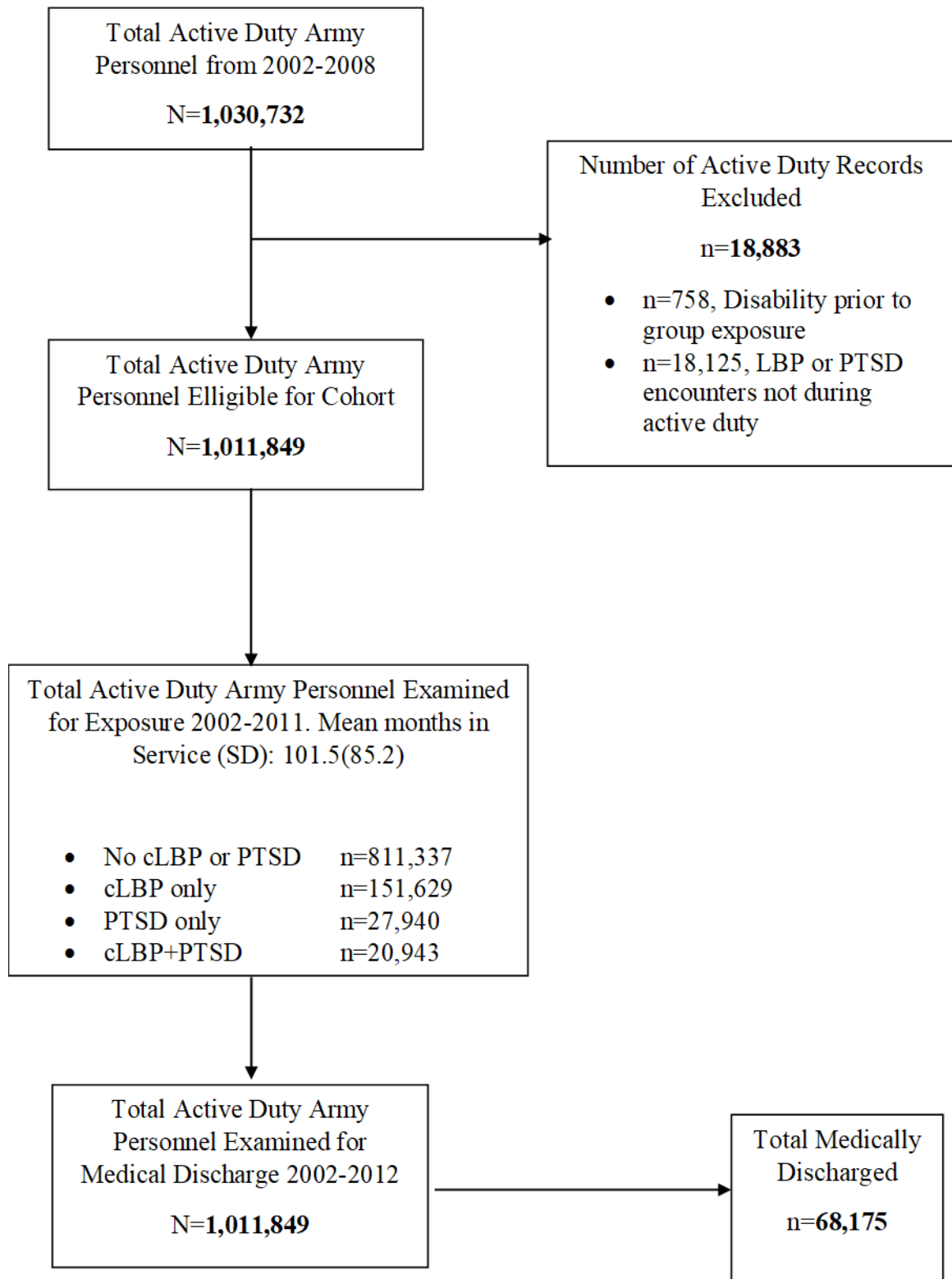


Table 4. 1 Sociodemographic and Military Service Characteristics of Active Duty U.S. Army Soldiers from 2002-2008 (n=1,011,849^a).

Characteristic	Soldiers without cLBP/PTSD (%)	Soldiers with cLBP (%)	Soldiers with PTSD (%)	Soldiers with cLBP+PTSD (%)	Total
Sex					
Female	121,914 (15.0)	33,794 (22.3)	3150 (11.3)	3136 (15.0)	161,994 (16.0)
Male	689,375 (85.0)	117,835 (77.7)	24,790 (88.7)	17,807 (85.0)	849,807 (84.0)
Age					
18-29	537,097 (66.2)	66,890 (44.1)	16,479 (59.0)	9012 (43.0)	629,478 (62.2)
30-39	179,211 (22.1)	46,244 (30.5)	8240 (29.5)	7197 (34.4)	240,892 (23.8)
40+	94,724 (11.7)	38,485 (25.4)	3221 (11.5)	4734 (22.6)	141,164 (14.0)
Rank					
E1-E4	403,778 (49.8)	55,107 (36.3)	12,846 (46.0)	7614 (36.4)	479,345 (47.4)
E5-E9	310,919 (38.3)	78,597 (51.8)	13,642 (48.8)	11,942 (57.0)	415,100 (41.0)
Officer	96,601 (11.9)	17,915 (11.8)	1452 (5.2)	1387 (6.6)	117,355 (11.6)
Military Occupational Specialty					
Combat	196,134 (24.2)	26,508 (17.5)	9595 (34.3)	6478 (30.9)	238,715 (23.6)
Support	615,203 (75.8)	125,121 (82.5)	18,345 (65.7)	14,465 (69.1)	773,134 (76.4)
Deployment History					
Yes	510,400 (62.9)	101,209 (66.7)	25,408 (90.9)	18,610 (88.9)	655,627 (64.8)
No	300,937 (37.1)	50,420 (33.3)	2532 (9.1)	2333 (11.1)	356,222 (35.2)
Obesity Diagnosis					
Yes	119,669 (14.7)	45,044 (29.7)	7384 (26.4)	7945 (37.9)	180,042 (17.8)
No	691,668 (85.3)	106,585 (70.3)	20,556 (73.6)	12,998 (62.1)	831,807 (82.2)

Table 4.1, continued

Mental Health Diagnoses^b					
Yes	245,966 (30.3)	73,010 (48.2)	25,155 (90.0)	19,549 (93.3)	363,680 (35.9)
No	544,519 (69.7)	68,982 (51.8)	2452 (10.0)	1114 (6.7)	648,169 (64.1)
Sleep Disorder Diagnoses					
Yes	125,863 (15.5)	56,823 (37.5)	17,058 (61.1)	16,416 (78.4)	216,160 (21.4)
No	685,474 (84.5)	94,806 (62.5)	10,882 (38.9)	4527 (21.6)	795,689 (78.6)
Alcohol Use					
Yes	82,443 (10.2)	15,815 (10.4)	8874 (31.8)	5647 (27.0)	112,779 (11.1)
No	728,894 (89.8)	135,814 (89.6)	19066 (68.2)	15,296 (73.0)	899,070 (88.9)
Tobacco Use					
Yes	213,962 (26.4)	59,983 (39.6)	15,180 (54.3)	12,277 (58.6)	301,402 (29.8)
No	597,375 (73.6)	91,646 (60.4)	12,760 (45.7)	8666 (41.4)	710,447 (70.2)
Number Discharged (%)	36,247 (4.5)	22,297 (14.7)	4697 (16.8)	4934 (23.6)	68,175 (6.7)
Group Total (%)	811,337 (80.2)	151,629 (15.0)	27,940 (2.8)	20,943 (2.1)	1,011,849 (100)

^aNote, 374 Soldiers had missing values and therefore did not contribute to some demographic totals.

^bExcluding PTSD diagnosis.

Table 4. 2 Crude and Adjusted Relative Risk (RR) for Independent Variables

Group	Total Number Soldiers	Number Soldiers with Medical Discharge (%)	Unadjusted Relative Risk (95% CI)	Adjusted Relative Risk ^a (RR) (95% CI)	P value of Adjusted RR
No cLBP or PTSD	811,337	36,247 (4.5)	1 (ref)	1	
cLBP	151,629	22,297 (14.7)	3.29 (3.24-3.34)	3.65 (3.59-3.72)	<.0001*
PTSD	27,940	4697 (16.8)	3.76 (3.66-3.87)	3.64 (3.53-3.75)	<.0001*
cLBP+PTSD	20,943	4934 (23.6)	5.27 (5.14-5.41)	5.17 (5.01-5.33)	<.0001*

^aAdjusted for sex, age, rank, time in service, deployment, mental health, sleep disorders, alcohol use, tobacco use, obesity, and military occupation. Medical discharge % calculated as number of Soldiers in group that were discharged divided by total number of Soldiers in that group.

*Denotes significance at the level of $\alpha = .05$

CI: Confidence Interval

Table 4. 3 Adjusted Relative Risk for Covariates

Characteristic	Adjusted Relative Risk (95% CI)	95% CI Lower Limit	95% CI Upper Limit	P
Sex (Female vs. Male)	0.85	0.84	0.87	<.0001*
Age				
30-39 vs. 18-29	1.47	1.44	1.49	<.0001*
>40 vs. 18-29	1.12	1.07	1.16	<.0001*
Rank				
E5-E9 vs. E1-E4	0.98	0.96	1.00	.075
Officer vs. E1-E4	0.35	0.34	0.37	<.0001*
Military Occupational Specialty				
Combat vs. Support	1.15	1.13	1.17	<.0001*
Deployment History ^a	0.52	0.51	0.52	<.0001*
Obesity Diagnosis ^a	1.3	1.28	1.32	<.0001*
Mental Health Diagnoses ^b	1.24	1.22	1.26	<.0001*
Sleep Disorder Diagnoses ^a	1.57	1.54	1.60	<.0001*
Alcohol Use ^a	0.72	0.70	0.73	<.0001*
Tobacco Use ^a	1.15	1.14	1.17	<.0001*

^aCo-morbidities treated as dichotomous variables: yes versus no.

^bAll mental health diagnoses excluding PTSD.

*Denotes significance at the level of $\alpha = .05$

CI: Confidence Interval; vs: versus.

Chapter 5: Veterans with Chronic Low Back Pain and Trauma Exposure have Elevated Stress but Equal Sensitivity Levels Regardless of Post-Traumatic Stress Disorder Diagnosis

Introduction

Many research trials evaluating quantitative sensory testing (QST) have demonstrated that individuals with post-traumatic stress disorder (PTSD) have higher pain thresholds than healthy subjects without PTSD²¹⁷⁻²²⁰. Some authors have attributed this observation to stress-induced hypoalgesia, in which general or trauma-specific stressors activate endogenous inhibition requiring a greater amount of nociceptive input to induce pain in individuals with PTSD⁷². Higher pain threshold and decreased pain ratings among individuals with PTSD is a fascinating phenomenon given that Veterans with PTSD generally report higher pain levels^{19,30,31,92} and are more likely to have chronic, widespread pain compared to Veterans without PTSD⁹⁵.

In addition, Veterans with PTSD have higher disability^{19,30,31}, pain catastrophizing beliefs³⁰⁻³², and opioid use⁸⁵ compared to their counterparts without PTSD. Veterans with PTSD also have lower self-efficacy and function^{30,31}. Clinicians may have some difficulty, therefore, reconciling clinical observations that individuals with PTSD report greater subjective pain when objective findings in research have reported the opposite effect⁷².

There are two gaps in the literature which may help to explain the apparent discrepancy. First, many individuals with PTSD included in QST research may not represent the typical patient with PTSD because it was not reported if subjects had baseline chronic pain during QST^{218,220,221}. In fact, most patients with post-traumatic stress disorder (PTSD) also have chronic pain¹⁸. Therefore, excluding individuals with chronic pain in experimental pain studies²¹⁸ may explore important mechanisms of nociceptive processing but fail to translate to a clinician treating patients with co-morbid PTSD and pain.

Second, many of the negative pain-related outcomes attributed to PTSD may be due to how PTSD is diagnosed in some observational studies that have reported worse outcomes in Veterans with PTSD^{19,30-32}. In these studies, Veterans were dichotomized to PTSD status based

on exceeding cut-off scores of the PTSD Check-list⁸⁹. None of the above studies, however, assessed exposure to traumatic events. Furthermore, PTSD symptoms in these studies^{19,32} were correlated to many other psychosocial variables that are known to confer poor prognosis, like pain catastrophizing⁹⁶. In fact, one study in patients with chronic low back pain (LBP) found that some participants had significant levels of PTSD symptomology, even though they had not experienced trauma before²⁰.

It is possible, then, that PTSD symptomology in patients with chronic LBP is really a sign of a hypervigilant nervous system. Recent research has proposed a hypervigilant nervous system as a core contributor to both chronic pain and PTSD symptoms^{22,131}. A hypervigilant nervous system may result in central sensitization, which is the up-regulation of nociceptive afferents coupled with impaired endogenous inhibition²²². This results in an amplified pain experience and is common in many chronic pain states to include chronic LBP²²³. LBP is routinely the most common pain condition among Veterans with PTSD^{18,19} and central sensitization may help explain why Veterans with PTSD are more likely to have LBP than Veterans without PTSD⁹².

Indeed, central sensitization has been reported in some Veterans with PTSD¹⁵². However, since these Veterans did not have co-morbid chronic pain and given the ample evidence that finds hypoalgesia in individuals with PTSD⁷², it is important to investigate the sensory profiles of Veterans with PTSD and chronic pain. Furthermore, since a hypervigilant nervous system has been proposed as a common source of persistent symptoms for both PTSD³⁷ and chronic LBP²³, it will be beneficial to explore if PTSD symptoms uniquely contribute to pain and sensory profiles of Veterans with chronic LBP. Because central sensitization is common in individuals who have chronic LBP, regardless of PTSD status²²⁴, the negative outcomes in the literature attributed to PTSD symptomology might be due to characteristics associated with central sensitization rather than trauma. The purpose of this paper is to explore PTSD

symptomology and pain-related beliefs and pressure sensitivity levels in Veterans with LBP but no PTSD diagnosis compared to Veterans with LBP and PTSD diagnosis. It was hypothesized that a substantial portion of Veterans without a PTSD diagnosis would still display relevant symptoms of PTSD.

Methods

Participants

This report is a secondary analysis of a randomized-controlled trial evaluating the effectiveness of pain neuroscience education⁴⁷ compared to traditional education about LBP²²⁵ and PTSD/stress¹¹⁹ in Veterans and Service Members with chronic LBP. This study examines the baseline characteristics of participants comparing subjects with PTSD to those with LBP only. Participants were included if they were between the ages of 18-65 and had LBP for longer than 3 months duration. Subjects were excluded if they met the following criteria: neurogenic LBP (sensory, motor, and reflex deficits consistent to a nerve root and crossed-straight leg raise test that reproduces radicular symptoms)²²⁶ or back pain consistent with red flags²²⁷; bipolar disorder, personality disorder, or schizophrenia²²⁸; substance abuse within the last 6 months²²⁹; unstable suicidal ideation²³⁰; spine surgery in the past 12 months; or a complete trial of physical therapy for LBP within the previous 3 months.

Participants were recruited from a physical therapy clinic in a Veterans Affairs Medical Center (VAMC). This study was approved by the respective VA and Department of Defense institutional review boards.

Outcomes

Pain Pressure Threshold (PPT): Patients were tested in the prone position with a pillow under their shins to achieve approximately 15 degrees of knee flexion. A research personnel who was blinded to PTSD status applied a digital algometer probe (SBMEDIC Electronics, Sweden) with a gradual increase in force (40 kPa/s) 5 cm lateral to the spinous process of L3 of the most

symptomatic side until the participant reported the pressure as painful and pressed a button attached to the algometer^{50,231}. This procedure was performed three times at the low back and averaged to determine the patient's PPT with 30 seconds between repetitions. The procedure was then performed at the suprascapular region contralateral to the side tested in the low back, midway between the posterior border of the acromion and the 7th spinous process of the cervical spine^{50,232}. Reliability testing resulted in Intraclass Coefficient, two-way random with measurements averaged=.93.

PTSD Check-list for DSM 5 (PCL): The PCL is a 20-item checklist that measures the clusters of symptoms associated with PTSD according to the revised DSM 5²³³. Scores range from 0-80. The recommended cut-off score for PTSD is 33²³⁴. Participants were placed in the PTSD group if they indicated on self-report a PTSD diagnosis and scored ≥ 33 on the PCL.

Pain Catastrophizing Scale (PCS): The PCS measures pain catastrophizing which is defined as an exaggerated negative appraisal of noxious stimuli²³⁵. The PCS has good validity and excellent reliability in a LBP population²³⁶. Catastrophizing has been identified as an important construct in both PTSD populations²³⁷ and chronic LBP patients²³⁸.

Roland-Morris Disability Questionnaire (RMDQ): The RMDQ is a subjective measure of disability recommended for LBP²³⁹. Users are asked to identify among 24 activities or statements that are influenced by their back pain. The answers provide a score between 0 and 24, with higher scores representing more disability. The RMDQ has acceptable validity, reliability, and responsiveness compared to other disability constructs¹⁰².

Numeric Pain Rating Scale (NPRS): The NPRS is an 11-point scale used to rate subjective pain intensity. It is commonly used in LBP research and offers a brief and efficient measurement of pain^{240,241}. The NPRS is a reliable and valid measure of adult pain²⁴². This study's scale was anchored at 0, "no pain at all", to 10, "the worst pain you could imagine."

Pain Self-Efficacy Questionnaire (PSEQ): The PSEQ is a questionnaire that measures an individual's self-perceived confidence to cope with physical activities "despite the pain."²⁴³ Many studies demonstrate that individuals who have low self-efficacy have higher disability²⁸.

Brief Survey of Pain Attitudes (SOPA-35): SOPA-35 is a valid, reliable, and sensitive questionnaire that measures beliefs about pain across 7 domains⁹⁹. Analysis will be performed across sub-scales with particular exploration of the harm sub-scale²⁴⁴ to assess whether participants believe that pain means damage or whether they believe exercise will make their condition worse.

Stressometer: The stressometer is a short, one-questionnaire scale that measures patient distress on a scale from 0-10. The stressometer is valid and responsive and correlates with more in-depth assessments of psychological stress^{245,246}.

Sociodemographic questionnaire: Participants were asked whether they had experienced a traumatic event based on common categories taken from the Life Events Checklist²⁴⁷.

Statistical analysis

Sociodemographic characteristics between participants who had PTSD and chronic LBP compared to chronic LBP only were examined with independent t-tests for continuous variables and chi-square for categorical or frequency analysis. When possible, Fisher's exact test was used for frequency analysis. Group differences for sensory testing were analyzed using a General Linear Model (GLM) to allow for testing the contribution of the covariates of gender and pain. Bivariate correlation analysis was also performed to determine the relationship between PTSD symptomology and pain-related beliefs and variables. The Kolmogorov-Smirnov test was used to examine normality of variables prior to analysis. The frequency distributions were also inspected visually for approximate normal distribution. Outcomes that failed to meet normality assumptions were assessed with the non-parametric Mann-Whitney U test. Statistical

significance was set at .05 using a 2-tailed test. All data were analyzed with Statistical Package for Social Sciences (IBM, version 24).

Results

A total of 33 Veterans were analyzed in this study. Seventeen participants (52%) indicated by self-report that they had been diagnosed with PTSD and tested above the cut-off score for PTSD ($PCL \geq 33$). Out of the 16 participants (37.5%) who had never been diagnosed with PTSD, 6 still scored above the cut-off for PTSD symptomology. Participants who scored above the cut-off for PTSD symptoms but did not indicate a self-report diagnosis of PTSD were analyzed in the no PTSD group according to the study's operational definitions. 97% of participants reported a history of at least one traumatic event (Table 5.1). 82.4% and 56.3% of Veterans with and without PTSD, respectively, had previously deployed at least one time, although this difference was not statistically significant. Most Veterans had served in the Army (75.8%). Table 5.1 describes the sociodemographic characteristics of the participants.

Veterans with diagnosed PTSD were more likely to report co-morbid neck/thoracic spinal pain in addition to LBP compared to Veterans without PTSD ($p=.039$, Table 5.1). Participants with and without PTSD were similar across sociodemographic characteristics to include equal likelihood of reporting current depression (Table 5.1). The only outcome that Veterans with or without PTSD differed was PTSD symptoms (Table 5.2). Veterans with PTSD had higher levels of PTSD than Veterans without a PTSD diagnosis ($p<.001$). Participants had similar levels of stress, pain, disability, pain self-efficacy, pain catastrophizing, and beliefs about pain (SOPA, Table 5.2). If participants were classified into groups based solely on cut-off scores of the PCL (≥ 33), participants who scored above the threshold had significantly higher levels of stress and pain catastrophizing beliefs (data not shown).

Veterans with or without PTSD did not have statistically different PPT values for the low back or the suprascapular region, even after adjusting for gender and pain. PPT values for the

low back were not significantly correlated with any outcomes measured for this study ($|r| < 0.2$, $p > .05$ for all values, Table 5.3). PTSD symptoms were positively correlated with pain catastrophizing beliefs (Table 5.3).

Discussion:

This paper provides evidence that Veterans without a PTSD diagnosis with chronic LBP are as likely to have experienced a traumatic event as Veterans with PTSD, given that 97% of participants in this study reported exposure to a traumatic life event. Although participants with a PTSD diagnosis had higher levels of post-traumatic stress symptomology as measured by the PCL, the results from this study did not provide evidence that Veterans with PTSD differed in levels of pain-catastrophizing, pain, disability, or pain self-efficacy despite significant differences reported in other research^{30,31}. Furthermore, this study did not provide evidence that participants with PTSD and LBP have lower or higher pain thresholds than Veterans without PTSD.

Like previous research²⁴⁸, this study confirms the importance of pain catastrophizing beliefs in the relationship between co-morbid PTSD and chronic pain. PTSD symptoms were positively correlated with pain-catastrophizing beliefs. On average, Veterans with and without PTSD had elevated pain-catastrophizing beliefs²⁴⁹. The association between pain-catastrophizing scores and PTSD symptoms could partially explain why this study failed to find a significant difference among outcomes between Veterans with and without PTSD. When participants were dichotomized by PCL scores, Veterans scoring at or above the cutoff of 33 had significantly higher pain-catastrophizing beliefs and self-reported stress levels. This indicates that regardless of a formal PTSD diagnosis or trauma history, individuals who score higher on PTSD symptomology are more likely to have higher pain catastrophizing beliefs.

This analysis reveals the importance of PTSD symptomology within the context of chronic pain that shares many similarities to the Fear Avoidance Model (FAM)²⁹. The FAM

proposes that individuals with high pain catastrophizing beliefs avoid potentially harmful situations that may cause pain, leading to disuse, deconditioned tissues, and greater disability. In addition to pain catastrophizing beliefs, avoidance of potentially harmful situations is also a core tenet of PTSD¹⁴. Interestingly, 37.5% of participants who have never been diagnosed with PTSD still report clinically relevant PTSD symptoms as measured by the PCL (≥ 33). This finding may indicate fear-avoidant beliefs or hypervigilance in participants who are not diagnosed with PTSD yet display high levels of PTSD symptomology.

Since Veterans have greater awareness and assign less stigma towards PTSD than other mental health disorders⁴², addressing PTSD or stress symptoms may be an acceptable way to navigate pain catastrophizing beliefs and potential nervous system sensitivities that are common in chronic pain patients²⁴. Veterans routinely complete the Primary Care PTSD (PC-PTSD) screen⁸³. The PC-PTSD Screen is a 4-item questionnaire that assesses the 4 tenets of PTSD: hyperarousal, avoidance, intrusive thoughts, and negative cognitions like depression¹⁴. A recent study found that for each PTSD symptom endorsed on the PC-PTSD Screen by chronic pain patients, pain and disability incrementally increased²⁵⁰.

Addressing fear-avoidance beliefs is a critical component of managing LBP in Physical Therapy^{251,252}. A systematic review has shown that Pain Neuroscience Education (PNE) is beneficial in reducing fear-avoidance beliefs⁴⁷. PNE may represent a novel therapy to help Veterans and Soldiers understand the neurobiological link between PTSD hyperarousal and nervous system hypervigilance²². PNE decreases pain catastrophizing by helping individuals understand that on-going pain can be attributed to a sensitive nervous system rather than damaged tissues. Routinely utilizing the PC-PTSD screen in military physical therapy settings might be an efficient manner to identify patients who would benefit from PNE or other additional psychosocial management strategies²⁵². Although this study did not specifically utilize the PC-

PTSD Screen, a similar efficient tool used in this research was the stressometer²⁴⁶, which was correlated with PTSD symptoms.

The results of this study did not provide evidence, however, that PTSD symptoms or psychosocial characteristics like pain self-efficacy contributed to hypersensitivity or altered pain pressure thresholds. This was somewhat surprising given the reported relationship between pain self-efficacy and pain pressure thresholds^{253,254}. One reason for this could be that traumatic experiences were consistent across all participants whether they were diagnosed with PTSD or not. Research has shown altered pain sensory profiles in individuals who have experienced traumatic exposure regardless of PTSD diagnosis²⁵⁵. In other words, it may be that trauma and stress contribute to altered pain sensory profiles independent of PTSD. This study was not powered or able to detect this relationship, however, nor did it have sufficient individuals who had not experienced trauma previously to examine the relationship between trauma exposure and PPT. However, this study did find that Veterans with PTSD were more likely to have current neck/thoracic pain in addition to LBP. This may indicate more widespread pain, which has been found previously in Veterans with PTSD⁹⁵.

Another reason for the failure of this study to find evidence for a relationship between PPT and PTSD status could be the inherent limitations of PPT. A meta-analysis on the relationship between pain and quantitative sensory testing determined that PPT only explains approximately 2% of the variance associated with pain or disability in LBP²⁵⁶. Although PPT is the easiest to clinically administer and was the most significant sensory difference between chronic LBP patients with and without trauma in one study²⁵⁵, PPT measures only one static component of nociceptive processing. A more dynamic measure like diffuse noxious inhibitory control might be more appropriate to determine hypersensitivity or central sensitization in Veterans with or without PTSD²⁵⁷.

Finally, it was interesting to note that, on average, participants in this research study scored below functionally normal values of pain self-efficacy (PSEQ<40)²⁵⁸, regardless if they were diagnosed with PTSD. Pain self-efficacy is a major protective factor against disability²⁸. In one study with Active Duty Soldiers with LBP, self-efficacy accounted for 40% of the variance in predicting duty status, above and beyond physical measures²⁵⁹. In addition to low self-efficacy, Veterans presenting to physical therapy for LBP also reported moderate levels of stress²⁶⁰. Addressing pain from a stress or post-traumatic stress approach may be an important paradigm for Veterans with chronic LBP¹⁷.

Limitations

In addition to the lack of dynamic QST procedures, this study also has other limitations. Most participants had current neck pain, making the suprascapular region an inadequate control site to assess for possible central sensitization. In addition, since Veterans were included from a study that consented participants to receive education about pain and stress/PTSD, it is possible that physical therapists referred Veterans with elevated stress and PTSD symptomology compared to the average Veteran with chronic LBP, representing a possible selection bias. Furthermore, this study did not employ a control group to compare PPT values in a non-painful population. Finding higher PPT values in a pain-free population, however, would not have been very surprising²⁴⁸ or informing since study participants presented with a complaint of chronic LBP. The sample size was limited and this study may have been able to show more significant effects between Veterans with and without PTSD with a larger sample, although all effect sizes were still only small or moderate. In addition, since combat was one of the most common types of trauma reported among participants, the results from this study may not apply to non-military individuals and the heterogeneity of trauma types might also mask sensitivity differences that could be specific to certain trauma exposures. As mentioned previously, this study did not have a sufficient sample to explore the relationships between specific traumas and PPT. Finally, the

cross-sectional design of this study limits the ability to infer a causal or temporal relationship between PTSD and pain symptoms.

Conclusion

In this study, 97% of participants attending physical therapy for chronic LBP had experienced a traumatic event. 37.5% of participants who had not been diagnosed with PTSD still reported relevant PTSD symptoms above the recommended cut-off score for PTSD. Veterans with PTSD were more likely to have neck pain in addition to LBP compared to Veterans without PTSD. Veterans with PTSD had higher levels of PTSD symptomology than Veterans without a PTSD diagnosis. Otherwise, Veterans with and without PTSD had similar pain, beliefs about pain, disability, and PPT values.

Table 5. 1 Sociodemographic characteristics of participants by PTSD and Veteran status

Characteristic	Veterans PTSD n=17	Veterans No PTSD n=16	P value
Age, Years (sd)	41.9 (7.4)	40.9 (11.9)	.78
Gender			.398
M (%)	12 (70.6%)	14 (87.5%)	
F (%)	5 (29.4%)	2 (12.5%)	
Race			.919
African American, n (%)	1 (5.9%)	1 (6.3%)	
Hispanic, n (%)	3 (17.6%)	2 (12.5%)	
White, n (%)	13 (76.5%)	13 (81.3%)	
Education, Years (sd)	14.5 (2.3)	13.6 (2.2)	.29
Service			.137
Army	15 (88.2%)	10 (62.5%)	
Navy	1 (5.9%)	1 (6.3%)	
Marines	1 (5.9%)	3 (18.8%)	
Air Force	0 (0%)	2 (12.5%)	
Deployment ^a , n, (%)	14 (82.4%)	9 (56.3%)	.141
Persian Gulf, n (%)	2 (11.8%)	0 (0%)	
Iraq, n (%)	10 (58.8%)	6 (37.5%)	
Afghanistan, n (%)	7 (41.2%)	2 (12.5%)	
Iraq and Afghanistan, n (%)	4 (23.5%)	1 (6.3%)	
Other, n (%)	2 (11.8%)	3 (18.8%)	
Trauma ^a , n (%)	17 (100%)	15 (93.8%)	.485
Combat, n (%)	13 (76.5%)	8 (50%)	
Sexual Assault, n (%)	5 (29.4%)	1 (6.3%)	
Personal Violence, n (%)	7 (41.2%)	6 (37.5%)	
MVA, n (%)	7 (41.2%)	8 (50%)	
Natural disaster, n (%)	3 (17.6%)	3 (18.8%)	
Other, n (%)	3 (17.6%)	3 (18.8%)	
Duration of LBP, months (sd)	114.5 (92.6)	84.7 (88.7)	.353
Depression, n (%)	14 (82.4%)	11 (68.8%)	.438
Presence of neck pain, n (%)	16 (94.1%)	10 (62.5%)	.039*
# Co-morbidities, (sd)	8.6 (4.2)	7.2 (4.9)	.40
+PTSD Symptoms (PCL _≥ 33) n (%)	17 (100%)	6 (37.5%)	<.001*

^aNote, individual traumas and deployments may add up to greater than 100% as some individuals reported more than one type of trauma and more than one deployment.

*Denotes significance at the level of $\alpha=.05$

Table 5. 2 Comparison of self-reported outcome measures by PTSD and Veteran status

Outcome	Veterans PTSD n=17	Veterans No PTSD n=16	t	Effect size ^a	P value
PTSD Checklist	54.1 (12.9)	31.9 (18.7)	4.0	1.39	<.001*
Pain NPRS					
Current	5.5 (1.7)	5.4 (1.8)	.26	.06	.80
Best	3.6 (1.7)	3.9 (2.3)	.41	-.15	.69
Worst	8.1 (1.1)	7.8 (1.5)	.83	.23	.42
RMDQ	11.1 (5.4)	11.9 (6.1)	.41	-.14	.69
PCS	26.0 (14.1)	19.7 (11.3)	1.4	.49	.17
Stress	7.5 (2.2)	5.9 (3.0)	1.8	.61	.09
SOPA: Control	1.7 (.70)	1.6 (.58)	.46	.16	.65
SOPA: Disability	2.3 (.81)	2.4 (.76)	.47	-.13	.64
SOPA: Harm	2.1 (.73)	1.9 (.54)	.98	.31	.33
SOPA: Emotion	2.6 (.80)	2.1 (.79)	1.6	.63	.12
SOPA:	2.4 (1.1)	2.4 (1.0)	.04	.00	.97
Medication	1.1 (1.1)	1.3 (1.1)	.50	-.18	.62
SOPA: Solitude	1.6 (.73)	1.8 (.60)	.79	-.30	.43
SOPA: Cure					
PSEQ	35.9 (10.8)	32.2 (14.4)	.85	.29	.40

RMDQ: Roland Morris Disability Questionnaire; PCS: Pain catastrophizing scale; NRS: Numeric rating scale; SOPA: Survey of Pain Attitudes; PSEQ: Pain self-efficacy questionnaire.

^aCohen's d effect size. Positive effect sizes indicate a higher standardized mean difference favoring Veterans with PTSD. Negative effect sizes indicate Veterans with PTSD have a lower standardized mean than Veterans without PTSD.

*Denotes significance at the level of $\alpha=.05$

Table 5. 3 Pain Pressure Threshold (PPT) by PTSD Status

Test	Veterans PTSD n=17	Veterans No PTSD n=16	F	Effect size ^d	P value
Mean PPT Low Back, kPA (95% CI)	269.7 (200.8-338.6)	222.9 (151.8-293.9)	.93	.34	.34
Mean PPT Low Back ^a , kPA (95% CI)	272.6 (202.0-343.1)	219.8 (147.1-292.5)	1.1	.37	.30
Mean PPT Shoulder, kPA (95% CI)	296.4 (206.2-386.6)	273.6 (180.7-366.6)	.28	.12	.72
Mean PPT Shoulder ^b , kPA (95% CI)	310.6 (220.0-401.1)	266.9 (170.2-363.5)	.44	.24	.51
Forward Bend ^c , cm	29.2 (21.6-36.9)	28.4 (20.5-36.2)	N/A ^c	.06	.51

CI: Confidence interval. Cm: Centimeter. kPA: Kilopascals.

^aThe results were analyzed adjusting for gender.

^bThe results were analyzed adjusting for gender and neck pain.

^cForward bend was not normally distributed and therefore was tested with the non-parametric Mann Whitney U test.

^dCohen's d effect size. Positive effect sizes indicate a higher standardized mean difference favoring Veterans with PTSD.

^eNote, a lower number indicates greater range of motion.

Table 5. 4 Intercorrelations between PTSD symptoms and pain-related outcomes and beliefs

Outcome	1	2	3	4	5	6	7	8	9	10	11
1. PTSD Checklist	1										
2. Pain NPRS	.17	1									
3. RMDQ	.05	.40*	1								
4. PCS	.61*	.35*	.34	1							
5. Stress	.56*	.07	-.04	.28	1						
6. SOPA: Harm	.30	.09	.47*	.47*	.18	1					
7. SOPA: Control	-.32	-.01	-.01	-.34	-.27	-.22	1				
8. PSEQ	-.14	-.37*	-.62*	-.45*	.10	-.55*	.19	1			
9. PPT Low back	.15	.16	-.10	.07	-.09	-.11	-.20	-.02	1		
10. PPT Shoulder	.19	-.04	-.05	.12	-.08	-.24	-.23	.01	.70*	1	
11. FB	.07	.07	.23	.09	-.08	.29	.10	-.35*	-.17	-.08	1

NRS: Numeric rating scale; RMDQ: Roland Morris Disability Questionnaire; PCS: Pain catastrophizing scale; SOPA: Survey of pain attitudes; PSEQ: Pain self-efficacy questionnaire; PPT: Pain pressure threshold; FB: Forward bend test.

*Denotes significance at the level of $\alpha=.05$

Chapter 6: Pain Neuroscience Education Improves Pain Self-Efficacy and Stress in Veterans with Chronic Low Back Pain

Introduction

Although stress may be a common characteristic in life, dysregulation of stress can have dire consequences for an individual's health¹⁰. In addition to the negative effects on general health and wellness, chronic stress dysregulation plays a prominent role in chronic pain conditions²⁴, specifically chronic low back pain (LBP)⁵². In the military, increased stress is the normative condition, particularly with recent increases in combat deployments¹¹.

When stress from combat or other traumas becomes excessive or persistent, individuals can develop post-traumatic stress disorder (PTSD). PTSD is defined as a cluster of symptoms following trauma exposure that includes hypervigilance, negative cognitions, re-experiencing trauma reminders, and avoidance that persist for greater than 30 days¹⁴. Although these symptom clusters are specifically tied to a traumatic experience for a PTSD diagnosis, it is common for individuals with chronic LBP to exhibit PTSD symptoms²⁰. The consequences of chronic stress and post-traumatic stress (PTS) symptoms include dysregulation of the hypothalamus-pituitary-adrenal (HPA) axis¹³⁵. Acutely, stress hormones like cortisol can help inhibit nociception and decrease pro-inflammatory cytokines^{24,261}. Following chronic stress dysregulation, however, the HPA axis becomes dysfunctional and hypocortisolism ensues²⁴. This contributes to a hypervigilant nervous system characteristic of central sensitization⁵³ and is prominent in a number of chronic states in which deficiencies in cortisol regulation have been identified²⁴. Central sensitization may play a relevant role in maintaining chronic LBP symptoms²³ and is believed to be a primary contributor of symptoms for a substantial proportion of patients with chronic LBP^{224,262}.

Patient education is a common and top strategy for managing LBP²⁶³. Traditionally, patient education has been approached from a biomedical perspective that outlines pathoanatomical causes and treatments for LBP²²⁵. Although this type of education is still

common³⁵, it is not recommended by clinical practice guidelines²⁶³. Traditional biomedical back school education may contribute to increased protective strategies and feelings of vulnerability³⁵. Since this type of education is still common in military settings³⁴, it is not surprising that many Veterans strongly believe that pain is a sign of tissue damage and avoid activities that may cause pain⁵⁵. Given that avoidance is a core tenet of PTSD¹⁴, it is also not surprising that traditional back education is particularly ineffective in Veterans with PTSD³⁴.

On the other hand, because changes to low back tissues do not fully explain LBP outcomes²⁶⁴, treatments targeting psychosocial characteristics²⁵² and stress^{265,266} are recommended for managing LBP. Psychosocial characteristics frequently explain more variance regarding pain and disability than physical factors^{259,267}. Approaching physical pain from a psychological perspective, however, has led to high drop-out rates in clinical trials and there is speculation that participants in pain desire a medical explanation for their symptoms³⁹. In addition, patients with psychosocial symptoms frequently feel dismissed and stigmatized by providers who may attribute physical symptoms to psychosocial characteristics³⁶.

Pain Neuroscience Education (PNE), on the other hand, may represent an appropriate education strategy for military Service Members who have chronic LBP and psychosocial stress. Instead of focusing on anatomy and pathology of body tissues, PNE educates patients about the neurophysiology of pain using stories and metaphors⁴⁶. PNE is effective in a number of chronic pain conditions like fibromyalgia, chronic LBP, chronic fatigue syndrome, and chronic neck pain⁴⁷. Some research proposes that PNE helps decrease the pain experience by top-down modulation of the nervous system by decreasing the threat and perceived danger of on-going pain^{49,50}. After PNE, patients may be less likely to believe that persisting pain indicates current tissue damage and harm¹⁹². Instead, patients understand that the nervous system can become sensitive and amplify the pain experience even after body tissues have healed.

PNE has not been tested in military populations. Since education should be culturally relevant¹²⁵, a PNE curriculum using military examples and stories was developed for this research. In addition, the impact of PNE on self-reported stress or PTSD symptoms has not been specifically tested in a clinical trial. The purpose of this research is to determine if PNE is more effective than traditional education about back pain and stress management in reducing stress, pain, maladaptive beliefs about pain, and disability in military Service Members with chronic LBP attending physical therapy.

Methods

Participants

Military Service Members and Veterans with chronic LBP (symptoms > 3 months duration)¹³⁶ were referred to participate in this clinical trial. Participants were included if they were between the ages of 18-65. Although individuals with PTSD were purposefully sampled to examine PNE effectiveness on stress symptoms—in particular, PTSD symptoms—a PTSD diagnosis was not required to participate in this study. Subjects were excluded if they met the following criteria: neurogenic LBP (sensory, motor, and reflex deficits consistent to a nerve root and crossed-straight leg raise that reproduces radicular symptoms)²²⁶ or back pain consistent with red flags²²⁷; bipolar disorder, personality disorder, or schizophrenia²²⁸; substance abuse within the last 6 months²²⁹; unstable suicidal ideation²³⁰; spine surgery in the past 12 months; or a complete trial of physical therapy for LBP within the previous 3 months.

Participants were recruited from physical therapy clinics in a Veterans Affairs Medical Centers (VAMC) and an Active Duty Military Treatment Facility located on an Army base. This study was approved by the respective Veterans Affairs (VA) and Department of Defense institutional review boards.

Study Procedures

After individuals consented to participate in the research study, participants were scheduled to complete baseline testing. After baseline measures, participants were randomly allocated to the experimental (PNE) or traditional group by opening opaque, sealed, consecutively numbered envelopes which were prepared by a researcher not involved in this study. Participants completed a 4-week intervention by attending a weekly education and exercise session for one hour each week. Upon completing the intervention, participants completed follow-up testing at four weeks. Finally, participants returned at eight weeks to complete self-reported outcome measures. All measurements were assessed by a physical therapist who was blinded to group allocation.

Primary Outcome Measures

PTSD Check-list for DSM 5 (PCL): The PCL is a 20-item checklist that measures the clusters of symptoms associated with PTSD according to the revised DSM 5²³³. Scores range from 0-80 with higher numbers indicating higher PTSD symptomology. The recommended cut-off score for PTSD is 33²³⁴. Participants were considered to have PTSD if they indicated on self-report a PTSD diagnosis and scored ≥ 33 on the PCL. The minimal clinically important difference (MCID) is at least 10 points²⁶⁸.

Stressometer: The stressometer is a short, one-item scale that measures patient distress on a scale from 0-10. The stressometer is valid and responsive and correlates with more in-depth assessments of psychological stress^{245,246}. A score of 4 or higher is considered positive for moderate distress²⁶⁰.

Roland-Morris Disability Questionnaire (RMDQ): The RMDQ is a subjective measure of disability recommended for LBP²³⁹. Users are asked to identify among 24 activities or statements that are influenced by their back pain. The answers provide a score between 0 and 24, with higher scores representing more disability. The RMDQ has acceptable validity, reliability, and

responsiveness compared to other disability constructs¹⁰². The MCID for the RMDQ is a 30% reduction in baseline scores²⁴¹.

Numeric Pain Rating Scale (NPRS): The NPRS is an 11-point scale used to rate subjective pain intensity. The NPRS has been shown to have good validity and reliability²⁴². The scale ranges from 0 to 10 and has been shown to have acceptable responsiveness in patients with LBP²⁴⁰. This study's scale was anchored at 0, "no pain at all", to 10, "the worst pain you could imagine." The MCID for the NPRS is 2²⁴¹.

Secondary Outcome Measures

Objective Outcome Measures

Spinal flexion: Participants were asked to bend forward at the waist while keeping their knees straight and attempting to touch the floor¹³⁹. The distance from the floor to the patient's most distal finger-tip was measured to the nearest tenth of a centimeter (cm). Participants were instructed to stop "whenever you feel you need to stop." Participants completed this procedure two times and the measures were averaged.

Pain Pressure Threshold (PPT): Patients were tested in the prone position with a pillow under their shins to achieve approximately 15 degrees of knee flexion. A research physical therapist applied a digital algometer probe (SBMEDIC Electronics, Sweden) with a gradual increase in force 5 cm lateral to the spinous process of L3 of the most symptomatic side until the participant reported the pressure as painful and pressed a button attached to the algometer^{50,231}. This procedure was performed three times at the low back and averaged to determine the patient's PPT with approximately 30 seconds rest between repetitions. The procedure was then performed at the suprascapular region contralateral to the side tested in the low back, mid-way between the posterior border of the acromion and the 7th spinous process of the cervical spine^{50,232}.

All physical measures were completed by a physical therapist who was blinded to participant treatment-group allocation (reliability testing resulted in Intraclass Coefficient, two-way random with measurements averaged=.93).

Pain Catastrophizing Scale (PCS): The PCS measures pain catastrophizing which is defined as an exaggerated negative appraisal of noxious stimuli²³⁵. The PCS has good validity and excellent reliability in a LBP population²³⁶. Catastrophizing has been identified as an important construct in both PTSD populations²³⁷ and chronic LBP patients²³⁸.

Pain Self-Efficacy Questionnaire (PSEQ): The PSEQ is a questionnaire that measures an individual's self-perceived confidence to cope with physical activities "despite the pain."²⁴³ Many studies demonstrate that individuals who have low self-efficacy have higher disability²⁸. The MCID for the PSEQ is 5²⁶⁹.

Brief Survey of Pain Attitudes (SOPA-35): SOPA-35 is a valid, reliable, and sensitive questionnaire that measures beliefs about pain across 7 domains⁹⁹. This study was particularly interested in the harm sub-scale²⁴⁴ to assess whether patient's beliefs that pain means harm changes after the intervention.

Post-program questionnaire:

This study adapted a questionnaire to assess the satisfaction and acceptability of the intervention²⁷⁰ on a numerical scale from 0-10 with 10 indicating "strongly agree" and 0 "strongly disagree."

1. This is the first time I have received this education [Novelty].
2. The education program helped explain why I have chronic pain after post-traumatic stress (or stress) [Explain].
3. The education program applies personally to my symptoms [Applies].

4. The education program treated my symptoms as real and helped me understand why I have post-traumatic stress (or stress) and pain symptoms [Symptoms real].
5. I am satisfied in the way the education program explained why common treatments for pain can help after stress [Satisfied].
6. The education program connected with me personally as a Veteran and with my experiences in the Armed Forces [Connected].
7. The education program implied that chronic pain after post-traumatic stress (or stress) means that my physical pain is only a mental health problem [Mental health problem].
8. I believe I was in the experimental education group.

Intervention

Experimental education:

Participants attended a PNE session that lasted approximately 30 minutes, once a week for 4-weeks. The education was based on *Why do I Hurt?*¹²⁷ and was adapted for military Service Members. The education included content recommended by a systematic review⁴⁸ and compared the nervous system to a military radar which becomes sensitive and hypervigilant following an attack. Participants also received a PNE booklet developed for this research and were asked to read through the booklet at home.

Traditional education:

Similar to the experimental arm, participants attended an education session that lasted approximately 30 minutes, once a week for 4-weeks. The education was based on one traditional “Back School”²²⁵ session followed by 3 stress management sessions adapted from the VA National Center for PTSD²⁷¹. A research panel of mental health specialists and physicians rated the modules from the PTSD Coach¹¹⁹ and reviewed the education materials developed to provide traditional and standard of care education for stress and post-traumatic stress symptoms in

military Veterans. Participants in the traditional group also received a booklet that was similar in length to the experimental education. The traditional booklet was from “*Afterdeployment.org*”²⁷².

Both education programs included recommendations for sleep hygiene²⁷³, the importance of exercise²⁷⁴, breathing²⁷⁵/relaxation techniques²⁷⁶, and setting goals. To maintain treatment fidelity, physical therapists utilized a printed slide presentation and followed a standardized outline for each participant.

Exercise program:

Immediately following each education session, participants completed an exercise circuit based on the “Back to Fitness” program²⁷⁷. To allow for different activity levels across participants, research subjects were given the option of performing an easy, moderate, or difficult exercise in each of the 10 exercises from the “Back to Fitness” program. Participants performed each exercise for 1-minute each, followed by a 5-minute cool-down period. Participants received an ordinal score for each exercise completed; “1” for easy, “2” for moderate, “3” for difficult, and “0” if they did not complete any of the options for the exercise. Participants received an average exercise completion score for all exercise sessions. Higher numbers indicate completion of exercises deemed more difficult and challenging, whereas lower numbers indicate potentially easier and less threatening exercises.

Participants in the research program attended individual education and exercise sessions except for 9 individuals who attended group sessions (PNE, n=4, Traditional, n=5, all of which were Active Duty Soldiers due to provider scheduling requirements).

Statistical analysis

Sociodemographic characteristics and baseline measures between the experimental and traditional groups were analyzed with independent t-tests for continuous variables and chi-square for categorical or frequency analysis. When possible, Fisher’s exact test was completed for

frequency analysis. For primary and secondary outcome measures, data were analyzed with a 2-factor (treatment group and time) repeated measures analysis of variance (ANOVA) using a General Linear Model (GLM) with three time-points: baseline, 4-weeks, and 8-weeks. A group by time interaction was assessed for outcome measures with a plan for post-hoc testing between baseline to 4-weeks and baseline to 8-weeks for variables with a significant interaction. Physical measures were only tested at baseline and 4-weeks. Furthermore, a one-way ANOVA between treatment conditions for the post-program questionnaire and exercise completion score was planned. The contribution of age, co-morbidities, and medication use during testing for objective outcome measures was assessed by adding these variables as a covariate into the GLM. The Kolmogorov-Smirnov test was used to examine normality of variables prior to analysis. The frequency distributions were also inspected visually for approximate normal distribution. Outcomes that failed to meet normality assumptions were assessed with the non-parametric Mann-Whitney U test. Finally, Cohen's d effect sizes were calculated based on the between-group differences for the change scores from baseline to immediately following the intervention at 4-weeks to provide a clinically interpretable effect between interventions. Statistical significance was set at .05 using a 2-tailed test. All data were analyzed with Statistical Package for Social Sciences (IBM, version 24).

Results

In total, 45 Veterans and Soldiers consented to participate in the research project (Figure 6.1). The experimental group included 17 participants and 20 participants were allocated to the control group. For participants who began the treatment protocol, two individuals in the experimental and two in the control group dropped out of the research study with reasons that can be found in Figure 6.1. Five participants failed to schedule the initial treatment session after completing baseline testing. Complete data analysis for repeated measures was available for 13 participants in the experimental group and 16 in the control group. Table 6.1 displays

sociodemographic characteristics of study participants. Groups were similar across all characteristics. 90% of participants reported at least one traumatic event and on average participants had at least moderate levels of stress ($\geq 4/10^{260}$).

Primary Outcome measures

There was a main effect for time for both pain and disability across both groups. Although the experimental group had a greater reduction in disability, the overall GLM ANOVA failed to find a significant group by time interaction. At the 8-week follow-up, however, the experimental group achieved a greater proportion (69.2% vs 27.8%) of reducing disability by at least 30%, which is the MCID. PTSD symptoms decreased in both groups (main effect for time). When comparing only participants with PTSD, the experimental group achieved a large effect of reducing PTSD symptoms that exceeded the MCID; however, this difference was not statistically significant (Figure 6.3). Participants in the experimental group reported decreased levels of stress following the intervention whereas the control group's perceived levels of stress did not change (Figure 6.4).

Secondary outcomes:

The PNE group significantly improved pain self-efficacy compared to traditional education (Cohen's $d=1.21$, large effect). Post hoc testing revealed significantly higher pain self-efficacy immediately following the intervention for the experimental group (Figure 6.5). Although the PNE group's PSEQ scores were almost 10 points higher than the control group, the 8-week difference between groups did not maintain significance after post-hoc testing (Figure 6.5). In addition, the PNE group was much less likely to believe that pain indicates tissue damage or that exercise is harmful (SOPA-Harm, Figure 6.6). Participants in the experimental group believed they had greater control of their pain after the treatment (SOPA-Control, Table 6.2). Both groups reported decreased pain catastrophizing after the study (main effect for time, $p=.01$).

Although there was also a significant main effect for group with decreased PCS scores in the PNE group, the group by time interaction was not significant (Table 6.2).

Both groups increased their PPT scores for the low back as well as suprascapular region, but participants in the PNE group were able to tolerate higher levels of pressure in their low back before rating the sensation as painful (Table 6.3). Both groups increased their ability to reach forward towards the ground after the intervention (main effect for time).

Participants in both groups were equally as likely to report that they had not previously received the type of education in their respective research group (Novelty, Figure 6.2). Participants in both groups believed the education applied to their symptoms personally and did not feel that the education programs implied physical pain is due to a mental health problem. Participants in the PNE group, however, reported greater satisfaction in understanding the relationship between pain and stress compared to the control group. PNE participants thought their symptoms were treated as “real” to a greater degree than traditional stress education. Participants in the experimental group were more satisfied with the explanations that PNE gave for why stress management strategies can help with pain and stress. Furthermore, participants in the experimental group believed that PNE from a military perspective connected with them personally more than traditional stress education (Figure 6.2).

Participants who dropped out after beginning the intervention had significantly lower pain than participants who completed the therapy program ($p=.043$, Table 6.6). Furthermore, participants who did not complete the research study reported significantly higher levels of stress and were more likely to believe that it is appropriate to use medications for pain (SOPA-medication, Table 6.6). Participants who completed baseline testing but failed to begin treatment were less likely to believe that it is appropriate to seek help from family (SOPA-solicitude, $p=.039$, Table 6.6). 83% (5/6) of participants who completed baseline testing but did not begin treatment and 80% (4/5) of participants who dropped out had PTSD. Otherwise, participants who

failed to begin treatment or who failed to complete the research study were similar across sociodemographic characteristics and baseline outcomes to participants who began and completed the research program.

Success of participant blinding

Participants in the traditional and PNE groups were equally likely to believe they were in the experimental group, indicating successful participant blinding (Figure 6.2, $p=.23$).

Discussion

The experimental group consisting of PNE achieved superior outcomes across several important domains compared to a control group of traditional pain and stress education. Although the average disability did not significantly differ between groups after the intervention, a significantly higher proportion of participants in the experimental group achieved the recommended minimal improvement of 30% reduction in disability²⁴¹ compared to the control group at the 8-week follow-up. After the intervention, the PNE group had higher pain self-efficacy with a large effect size. Participants in the PNE group had a higher PPT in their low back following the intervention. Furthermore, participants in the PNE group were better satisfied with the explanation of their symptoms, and believed the education personally connected with their military experiences than traditional stress education. Although the experimental group did not achieve significantly lower PTSD symptoms, this study did not have enough participants with PTSD to statistically detect a difference between the interventions. However, the results from this study do support that PNE from a stress perspective decreases perceived levels of stress and on average decreased PTSD symptoms by more than the MCID for participants with a PTSD diagnosis.

This is the first study to demonstrate that PNE effectively reduces self-reported stress, although it was also somewhat surprising that the control group, which received evidenced-based recommendations and skills for stress management from the National PTSD Center reported

increased stress following the intervention. It could be that participants in the control group attended to their stress levels more following explicit education about stress. A similar phenomenon has been reported with pain in which hearing words associated with pain activate the pain neuromatrix²⁷⁸. Regardless of the mechanism, reducing stress has important implications in many clinical conditions. Dysregulated stress is linked to several chronic pain conditions like chronic LBP, fibromyalgia, chronic fatigue syndrome, and temporomandibular joint dysfunction²⁴. In addition, dysregulated stress has also been identified as an important contributor to many psychiatric disorders²⁷⁹. Making the connection between psychosocial stressors and physical symptoms frequently challenges clinicians^{37,41} and makes patients feel stigmatized³⁶. According to the results of this research, PNE may be a logical bridge between psychosocial stressors and physical symptoms.

The results of this study add to the literature that PNE is an effective intervention for individuals with chronic LBP^{139,192,280}, although this is the first time PNE has been tested in a military population and the first trial to demonstrate PNE can improve PTSD symptoms equally as well as education from the National PTSD Center. A strength of this research is the design by allocating equal education contact between the experimental and control group. This design helps to postulate treatment mechanisms in military members with chronic LBP. Previous research that lacked a control group with equitable educational contact could not definitively conclude improvements were specific to PNE^{280,281}. Since participants in both groups received the same total time in education, completed the same exercise program, and even received many of the same recommendations for coping with stress and pain, this study may suggest that the results were specific to the content of PNE.

A primary goal of PNE is to decrease the threat associated with pain. Ultimately, PNE contends that the nervous system produces pain to respond to potential tissue danger⁴⁹. Therefore, if individuals perceive a greater threat, they may experience higher pain to ensure

protection from danger. PNE challenges the belief that on-going, persistent pain is directly attributable to damaged tissues. Instead, on-going pain can be explained by a hypersensitive nervous system. If participants believe the message of PNE, they may feel that their tissues are safe to exercise, even in the presence of on-going pain. The results from this study indicate that participants in the experimental arm did, in fact, change their beliefs about pain as indicated by the SOPA-Harm subscale. Participants in the PNE group were less likely to believe that pain was a sign of damage and that exercise might be harmful after the intervention.

Another finding that possibly informs mechanisms for improvement in the PNE group is changes in pain pressure thresholds (PPT). Participants in the PNE group tolerated significantly higher levels of pressure in their low back before they rated the stimulus as painful. If participants in the experimental group were less vigilant to danger in their tissues, then it might take more force to activate the pain neuromatrix⁴⁹ after learning how a hypervigilant nervous system contributes to pain. PNE has improved PPT values in patients with whiplash²⁸² but not fibromyalgia⁵⁰; a recent trial²⁸³ also found improvements in individuals with spinal pain but with a smaller effect size than the current study.

According to the current study, a large effect of PNE in military members with chronic LBP is improving pain self-efficacy. Improving pain self-efficacy is one of the top targets for PNE²⁸⁴. Beyond PNE research, self-efficacy is one of the most transcendent constructs influencing health behavior change²⁸⁵ and is one of the top mediators of disability²⁸. Since participants in the experimental group were more likely to understand the connection between pain and stress, they might have been more confident in implementing recommended strategies that were common to both groups, indicated by high pain self-efficacy scores. In addition, since PNE emphasizes that tissues are safe to move, even in the presence of pain, it is likely that participants would be more confident to move despite pain, corresponding to the earlier discussion about improvements in the SOPA-Harm scale. A previous study found that PNE

alone, but not combined with a traditional exercise program, improved pain self-efficacy scores²⁸⁶. Ryan, et al, reported that an exercise program delivered by therapists who may hold biomedical beliefs may contradict lessons delivered by PNE. The results from this study support that adding exercises with a PNE perspective has a beneficial effect to PNE in improving pain self-efficacy. Although pain self-efficacy scores were not significantly different after post-hoc testing in the repeated measures ANOVA for the 8-week follow-up, the experimental group had higher pain self-efficacy that exceeded the MCID of 5 points²⁶⁹ at both the 4-week and 8-week follow-up compared to the control group and had an average PSEQ score that is considered “normal:” $\geq 40/60$ ²⁵⁸.

Another reason why the PNE intervention in this trial was effective in Veterans and Soldiers could be because the PNE curriculum was delivered using military examples and stories that connected with the participants. Participants rated the experimental education as connecting personally with their experiences as a military member to a greater degree than the control education. It is critical to communicate about pain in a culturally relevant and specific way^{123,125}. Although the control education also used military images and came from Veteran resources^{119,272}, participants in the experimental group may have personally reflected on the education and lessons in the PNE intervention due to the narrative form of stories which encourages personal reflection²⁸⁷. Further qualitative inquiry on what messages participants understood from PNE would be helpful.

Finding effective treatments for co-morbid pain and PTSD has been reported as challenging¹⁷. Exercise is an effective therapy for both low back pain¹⁴¹ and PTSD¹³³. A main barrier to implementing exercise therapy, however, is that military members will avoid activities like exercise if it is painful⁵⁵. Avoidance of possible dangers is a core symptom of PTSD. Another symptom that is central to PTSD is hypervigilance¹³⁴. Co-morbid pain and PTSD might be due to a hypervigilant nervous system that becomes more sensitive to potential dangers^{22,131,190}.

PNE is recommended for patients with a hypersensitive nervous system¹⁵³, and the results from this study indicate that patients with PTSD might be a population that could particularly benefit from PNE.

Since participants in the experimental group decreased their PTSD symptoms by a large effect size compared to traditional stress and pain education, the fact that at least 80% of the participants who did not initiate or complete treatment had PTSD potentially represents a missed opportunity. Drop-outs for participants with pain and PTSD have been reported as high as 50% in previous research^{17,75} and approximately 30% for participants with PTSD in general¹³³. In this study, only 13.5% of participants who began therapy dropped out. Although this relatively low rate of drop-outs may indicate perceived legitimacy of treatments by research participants, the rate of individuals who consented to participate in this study but failed to complete study requirements was 30.4%. Since a higher proportion of participants who did not begin or did not complete treatment had PTSD, it is possible that the overall drop-out rate would have been higher even if all participants began treatment after consenting to research. The results of this study indicate potential treatment resistance for individuals with PTSD. In addition, participants who dropped out could have believed they did not need thorough treatment (they had lower pain) or may have desired a more traditional biomedical approach that included pharmacological interventions (drop-outs were more likely to believe medications should be used for pain than completers, SOPA-Medication sub-scale). Further research is needed to determine if brief PNE interventions, or written PNE materials alone, might be able to influence outcomes in a group of patients who may be less likely to commit to a longitudinal intervention. Currently, research is mixed on the effectiveness of PNE written materials alone^{46,143}.

Limitations:

One of the main limitations of this study is a small sample size. Despite appearing to favor the experimental group, several outcomes lacked sufficient confidence to statistically

determine the effectiveness of PNE, likely due to a small sample size. Although this study lacked statistical power for some of the outcomes, it is possible that this same lack of power failed to statistically identify important prognostic differences between the groups at baseline. For example, on average the experimental group was younger, more educated, and had a shorter duration of back pain. The experimental group, however, also had higher service-connected disability, where higher numbers indicate more mental and physical health disability incurred from military service. Although these differences were not statistically significant, a larger sample could more definitively demonstrate that the results from this study were due to the intervention rather than participant intrinsic characteristics that favored the experimental group despite randomization.

In addition, although this study found improvements in PPT in the experimental group, PPT is considered a static measure that explains only a small amount of variance in individual's pain and disability²⁵⁶. A more dynamic measure like diffuse noxious inhibitory control²⁵⁷ might be a more appropriate quantitative sensory test (QST) to determine improvements in top-down, or endogenous inhibition⁵⁰. Another limitation is only having an 8-week follow-up; however, this study will analyze healthcare utilization pending a formal VAMC healthcare utilization data request that will be submitted so that all participants can be followed for 6 months following their final research appointment. The results from this RCT may not generalize to civilian populations, although it would be interesting to determine if PNE can be similarly adapted to affect PTSD in different trauma settings.

Conclusion:

PNE was more effective than traditional stress and pain education in improving disability, stress, pain-pressure thresholds, pain self-efficacy, and beliefs about pain. Future research should confirm the results of this study in a larger sample, particularly regarding PTSD symptoms. Future research should also recruit and analyze Active Duty Soldiers separately to

increase participant homogeneity and develop greater confidence in the effect sizes for PNE in Soldiers. In addition, it may help to remove patho-anatomical education about the spine and purely include psychosocial education in the control group to determine if PNE's effectiveness was due to its superiority over traditional stress education or due to the deleterious effects of education that focuses on tissues. Finally, it would also be helpful to have an exercise-only group to separate the effects of the education versus supervised exercise.

Figure 6. 1 Participant Flow through the Randomized Controlled Trial

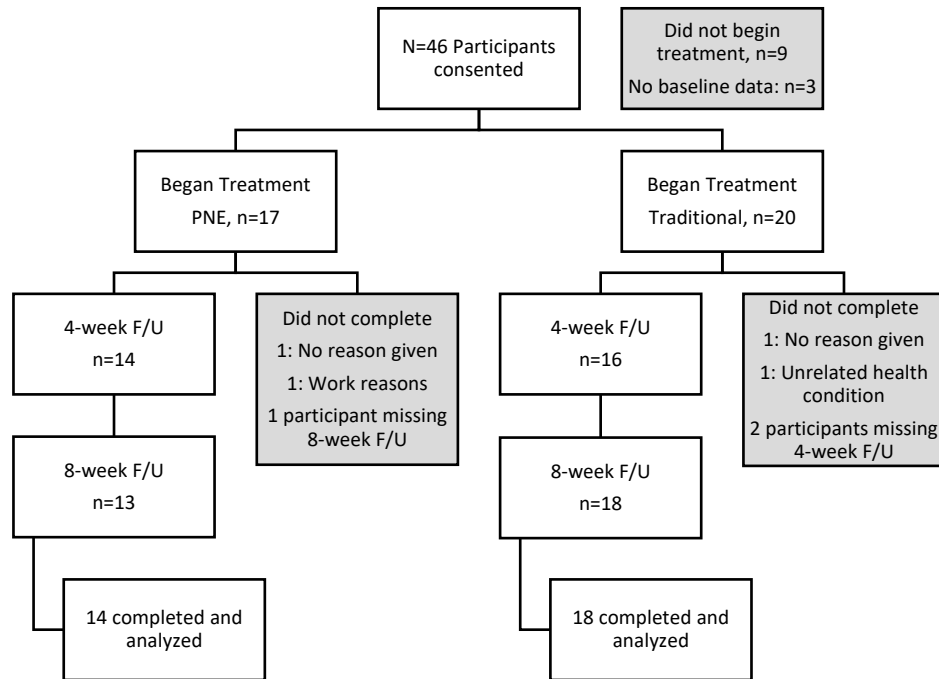


Table 6. 1 Baseline sociodemographic characteristics of participants.

Characteristic	Experimental Group, PNE n=14	Control Group, Traditional n=18	P value
Age, Years (sd)	36.7 (9.8)	42.6 (11.1)	.13
Gender, M (%) F (%)	12 (85.7%) 2 (14.3%)	14 (77.8%) 4 (22.2%)	.67
Race			.70
African American (%)	1 (7.1%)	3 (16.7%)	
Hispanic (%)	3 (21.4%)	4 (22.2%)	
White (%)	10 (71.4%)	11 (61.1%)	
Education, Years (sd)	14.6 (1.8)	13.3 (2.1)	.09
Service			.23
Army (%)	10 (71.4%)	14 (77.8%)	
Navy (%)	2 (14.3%)	0	
Marines (%)	2 (14.3%)	1 (5.6%)	
Air Force (%)	0	2 (11.1%)	
Previous Deployment (%)	9 (64.3%)	10 (44.4%)	.73
Previous Trauma (%)	13 (92.9%)	14 (77.8%)	.36
PTSD Diagnosis (%)	5 (35.7%)	5 (27.8%)	.71
Current Depression (%)	8 (57.1%)	11 (61.1%)	1.0
Active Duty (%)	4 (28.6%)	5 (27.8%)	1.0
Duration of LBP, Months (sd)	53.5 (60.7)	105.4 (101.3)	.15
Co-morbidities, # (sd)	6.4 (5.8)	6.3 (4.9)	.94
% Service Connected Disability (sd)	42.9 (41.6)	22.8 (34.1)	.16

M: Male; F: Female; PTSD: Post-traumatic stress disorder; LBP: Low back pain; sd: Standard deviation. PNE: Pain Neuroscience Education.

Table 6. 2 Study Outcome Group by Time Effects. PNE, n=13; Traditional, n=16

Outcome	Baseline	4-weeks	8-weeks	Effect size ^d	F	P value
PCL (0-80)						
PNE (sd)	33.8 (23.4)	23.5 (19.6)	24.8 (18.1)	-0.76	1.8	.18
Traditional (sd)	34.8 (22.5)	32.8 (25.6)	31.6 (25.0)			
PCL (0-80)^e						
PNE (sd)	56.4 (12.2)	41.4 (17.6)	40.0 (14.7)	-1.25 ^f	3.3	.097
Traditional (sd)	56.0 (14.4)	58.6 (21.1)	58.4 (12.0)			
Stress (0-10)						
PNE (sd)	6.7 (2.2)	5.5 (2.1)	5.4 (1.9)	-.93 ^f	3.2	.047*
Traditional (sd)	5.6 (3.5)	6.8 (2.2)	6.4 (3.0)			
Pain NPRS (0-10)						
Experimental (sd)	4.8 (1.3)	3.5 (1.8)	3.5 (1.5)	-.18	.23	.76
Traditional (sd)	6.2 (1.8)	5.0 (2.5)	5.3 (2.9)			
RMDQ (0-24)						
PNE (sd)	10.8 (5.5)	7.7 (4.4)	7.7 (6.0)	-.60	.55	.52
Traditional (sd)	12.8 (4.8)	11.3 (5.3)	11.1 (6.6)			
PCS (0-52)						
PNE (sd)	18.4 (13.7)	9.2 (7.6)	11.9 (11.3)	-.76	2.1	.134
Traditional (sd)	26.3 (12.1)	24.8 (12.1)	22.7 (12.7)			
SOPA (0-4)						
SOPA: Control						
PNE (sd)	1.8 (.56)	2.7 (.40) ^a	2.8 (.81) ^b	1.49 ^f	6.8	.006*
Traditional (sd)	1.6 (.73)	1.6 (.62)	1.5 (1.1)			
SOPA: Disability						
PNE (sd)	2.0 (.72)	1.7 (.81)	1.8 (.91)	-.22	.15	.86
Traditional (sd)	2.5 (.72)	2.3 (.83)	2.4 (.93)			
SOPA: Harm						
PNE (sd)	2.0 (.59)	1.0 (.59) ^a	1.2 (.65) ^b	-1.52 ^f	9.7	<.001*
Traditional (sd)	2.2 (.72)	2.0 (.74)	2.1 (.69)			
SOPA: Emotion						
PNE (sd)	2.1 (1.0)	2.1 (.96)	2.2 (.74)	.02	.03	.97
Traditional (sd)	2.2 (.78)	2.1 (.93)	2.1 (.94)			
SOPA: Medication						
PNE (sd)	2.2 (.84)	1.9 (.93)	1.9 (1.0)	-.71	2.6	.096
Traditional (sd)	2.6 (1.0)	2.6 (.84)	2.7 (.76)			
SOPA: Solicitude						
PNE (sd)	1.3 (1.2)	1.0 (.80)	1.0 (.94)	-.23	1.3	.27
Traditional (sd)	1.1 (1.1)	1.0 (1.0)	1.3 (1.2)			
SOPA: Cure						
PNE (sd)	1.5 (.58)	1.5 (.72)	1.5 (.60)	-.44	1.6	.21
Traditional (sd)	1.8 (.82)	1.5 (1.0)	1.7 (.83)			
PSEQ (0-60)						
PNE (sd)	36.1 (9.5)	42.0 (11.7) ^a	42.0 (12.4) ^c	1.21 ^f	3.8	.028*
Traditional (sd)	34.6 (13.3)	30.0 (11.3)	32.0 (16.1)			

PCL: Post-traumatic stress disorder checklist; RMDQ: Roland Morris Disability Questionnaire; PCS: Pain catastrophizing scale; PNE: Pain Neuroscience Education; NPRS: Numeric pain rating scale; SOPA: Survey of Pain Attitudes; PSEQ: Pain self-efficacy questionnaire.

*Denotes group by time significance at the level of $\alpha = .05$. ^aSignificant difference between groups at 4-weeks after post-hoc tests. ^bSignificant difference between groups at 8-weeks after post-hoc tests. ^c $p = .07$. ^dCohen's d effect sizes were calculated based on the between-group differences for the change scores from baseline to 4-weeks. Negative effect sizes indicate a greater decrease in scores from baseline favoring the experimental group. Positive effect sizes indicate a greater increase in scores from baseline favoring the experimental group. ^ePCL scores among participants with PTSD, PNE: n=5, Traditional: n=5. ^fIndicates a large effect size.

Table 6. 3 Objective Outcome Measures

Test	Baseline	4-weeks	Effect size	P value
Mean PPT Low Back, kPA PNE (sd) Traditional (sd)	259.1 (157.7) 257.2 (141.8)	380.4 (145.4) 267.7 (203.8)	.78	.02 ^{a*}
Mean PPT Shoulder, kPA PNE (sd) Traditional (sd)	340.8 (225.9) 284.8 (177.9)	393.6 (185.6) 254.7 (147.0)	.61	.08
Forward Bend ^b , cm from floor PNE (sd) Traditional (sd)	20.0 (15.1) ^{*c} 32.5 (12.6)	12.1 (10.9) 28.8 (16.1)	.51	.19
Exercise Score PNE (sd) Traditional (sd)	-- --	18.5 (4.8) 15.4 (3.4)	.77	.065

PPT: Pain Pressure Threshold. PNE: Pain Neuroscience Education. kPA: Kilopascals. Sd: Standard deviation. Cm: Centimeters.

*Denotes significance at the level of $\alpha = .05$. ^aMann Whitney U test of change scores from baseline to 4-week follow-up due to PPT values failing to meet test assumptions of normality.

^bNote, a lower number indicates greater range of motion. ^cSignificantly different at baseline.

Table 6. 4 Percentage of Participants meeting Minimal Clinically Important Difference (MCID) for Outcomes

Outcome	MCID	PNE	Traditional	P value
Disability, RMDQ 4-weeks	Yes (%)	8 (57.1%)	4 (25%)	.135
	No (%)	6 (42.9%)	12 (75%)	
Disability, RMDQ 8-weeks	Yes (%)	9 (69.2%)	5 (27.8%)	.033*
	No (%)	4 (30.8%)	13 (72.2%)	
Pain, NPRS 4-weeks	Yes (%)	8 (57.1%)	6 (37.5%)	.46
	No (%)	6 (42.9%)	10 (62.5%)	
Pain, NPRS 4-weeks	Yes (%)	4 (30.8%)	4 (22.2%)	.69
	No (%)	9 (69.2%)	14 (77.8%)	
PCL, 4-weeks	Yes (%)	5 (35.7%)	2 (12.5%)	.20
	No (%)	9 (64.3%)	14 (87.5%)	
PCL, 8-weeks	Yes (%)	4 (30.8%)	2 (12.5%)	.36
	No (%)	9 (69.2%)	14 (87.5%)	
PSEQ, 4-weeks	Yes (%)	8 (57.1%)	1 (6.3%)	.00*
	No (%)	6 (42.9%)	15 (93.8%)	
PSEQ, 8-weeks	Yes (%)	8 (61.5%)	4 (22.2%)	.06
	No (%)	5 (38.5%)	14 (77.8%)	

MCID: Minimal clinically important difference. RMDQ: Roland Morris Disability Questionnaire. NPRS: Numeric pain rating scale. PCL: Post-traumatic stress disorder checklist. PSEQ: Pain self-efficacy questionnaire. *Denotes significance at the level of $\alpha = .05$

Table 6. 5 Sociodemographic Characteristics for Participants by Treatment Initiation and Completion Status

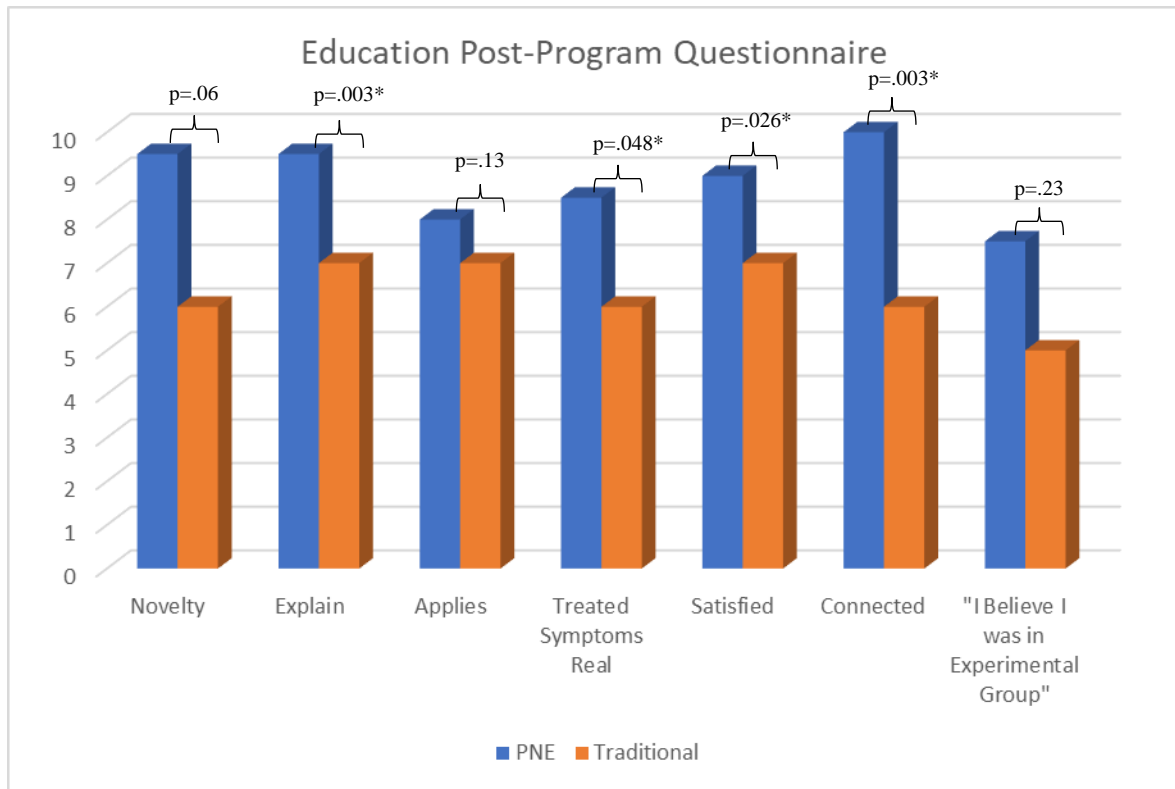
Characteristic	Non-starters n=6	Starters n=37	P value	Non- Completers n=5	Completers n=32	P value
Age, Years (sd)	36.8 (7.0)	38.9 (10.7)	.65	31.8 (6.8)	40.0 (10.8)	.11
Education, Years (sd)	14.8 (2.7)	13.6 (2.0)	.24	12.0 (0)	13.9 (2.0)	.079 ^a
Previous Trauma (%)	6 (100%)	31 (83.8%)	.57	4 (80%)	27 (84.4%)	1.0
PTSD Diagnosis (%)	5 (83.3%)	15 (40.5%)	.08	4 (80%)	11 (34.4%)	.14
Depression (%)	4 (66.7%)	22 (59.5%)	1.0	3 (60%)	19 (59.4%)	1.0
Active Duty (%)	2 (33.3%)	11 (29.7%)	1.0	2 (40%)	9 (28.1%)	.62
Duration of LBP, Months (sd)	69.0 (55.7)	82.6 (82.8)	.75	78.4 (45.0)	83.5 (88.9)	.90
Co-morbidities, (sd)	6.33 (4.8)	6.2 (4.97)	.96	5.4 (3.4)	6.3 (5.2)	.70
% Service Connected Disability (sd)	62.5 (47.9)	32.2 (37.9)	.15	36.0 (39.1)	31.6 (38.3)	.81

Table 6. 6 Baseline Outcomes for Participants by Treatment Initiation and Completion Status

Characteristic	Non-starters n=	Starters n=	P value	Non- Completers n=	Completers n=	P value
PCL	47.3 (16.9)	35.9 (21.4)	.22	42.2 (15.8)	34.9 (22.1)	.49
Pain NPRS Current	4.7 (1.6)	5.3 (1.8)	.42	3.8 (1.8)	5.5 (1.7)	.043*
RMDQ	11.1 (5.4)	11.9 (6.1)	.49	9.4 (4.7)	12.5 (5.2)	.22
PCS	24.3 (15.6)	22.5 (12.7)	.75	21.0 (13.8)	22.7 (12.7)	.78
Stress	7.3 (2.8)	6.4 (2.7)	.46	8.8 (1.3)	6.0 (2.7)	.035*
SOPA: Medication	1.8 (.70)	2.5 (.95)	.063	3.4 (.49)	2.4 (.93)	.027*
SOPA: Solicitude	.27 (.30)	1.2 (1.1)	.039*	1.6 (.74)	1.1 (1.1)	.33
PSEQ	34.0 (18.2)	34.5 (11.9)	.94	.29		.40

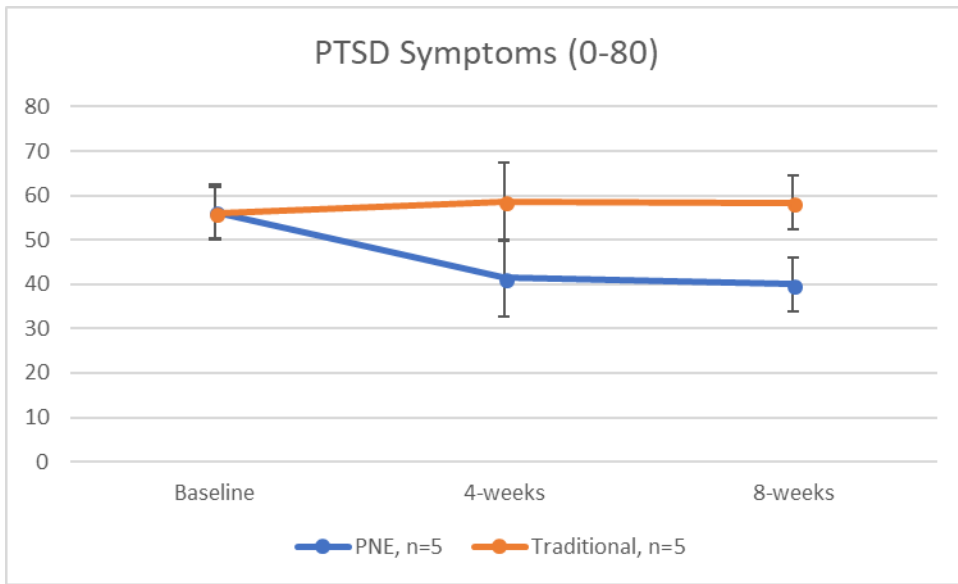
PCL: Post-traumatic stress disorder checklist. RMDQ: Roland Morris Disability Questionnaire. NPRS: Numeric pain rating scale. PCS: Pain catastrophizing scale. SOPA: Survey of Pain Attitudes. PSEQ: Pain self-efficacy questionnaire. *Denotes significance at the level of $\alpha = .05$

Figure 6. 2 Post-Program Questionnaires about Education



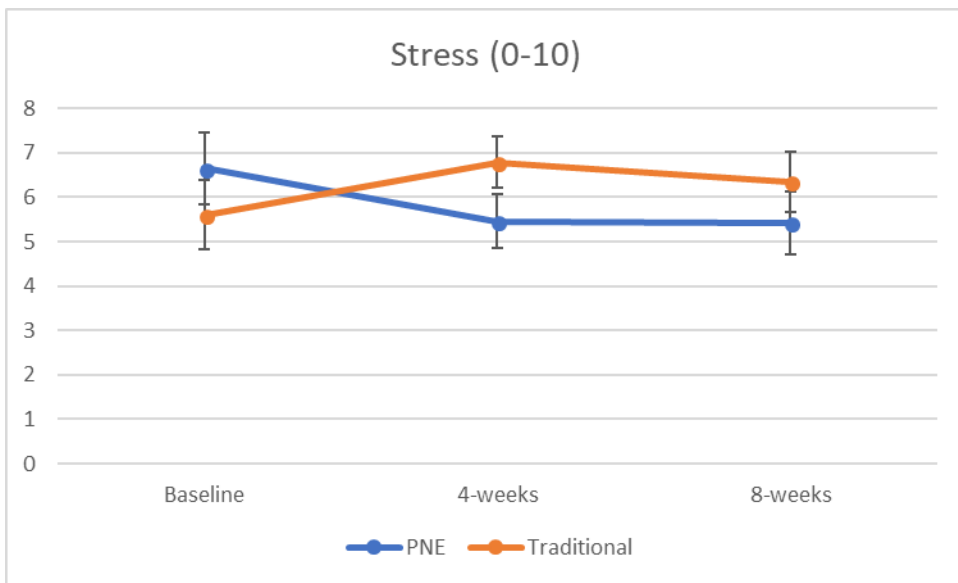
*Denotes between group significance at the level of $\alpha = .05$. Mann Whitney U test.

Figure 6. 3 Group by Time Effects for Post-Traumatic Stress Disorder (PTSD) Symptoms



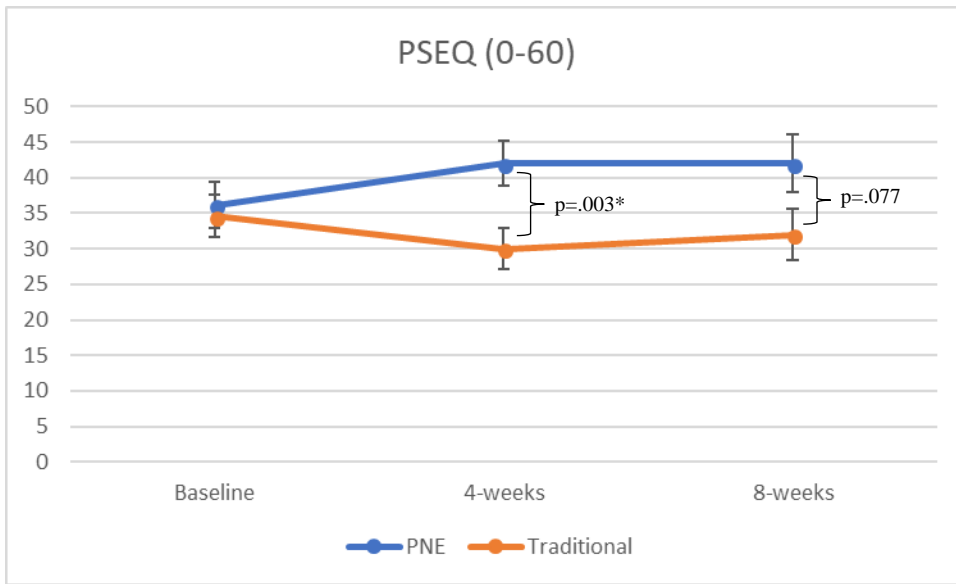
Group by Time Interaction, $p=.097$

Figure 6. 4 Group by Time Effects for Stress



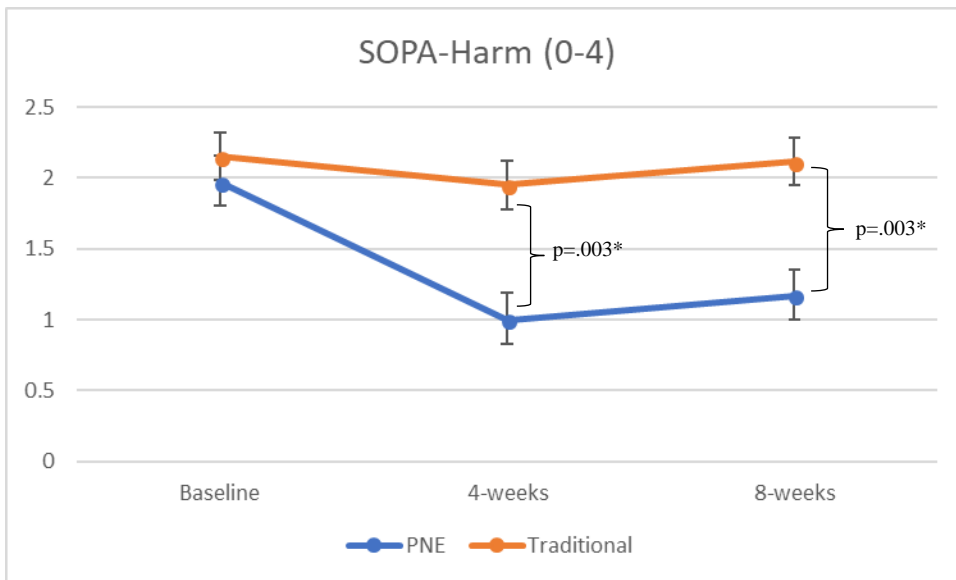
Overall Group by Time Interaction, $p=.047^*$

Figure 6. 5 Group by Time Effects for Pain Self-Efficacy



Overall group by time interaction $p = .028$, significant at $\alpha = .05$. *Denotes significant p value after Bonferroni correction.

Figure 6. 6 Group by Time Effects for SOPA-Harm Beliefs



*Overall group by time interaction significant at $\alpha = .05$. p values given after Bonferroni correction.

Chapter Seven: Summary of Findings

Purpose:

1. Develop a PNE curriculum for Veterans with PTSD and pain and determine if Veterans can comprehend PNE materials (Chapter 3).

Hypothesis: Veterans with PTSD and pain would be able to successfully comprehend a PNE curriculum and would find the materials helpful for pain and PTSD.

2. Determine if co-morbid PTSD and chronic LBP increases disability in Active Duty Soldiers compared to chronic LBP alone (Chapter 4).

Hypothesis: Soldiers with LBP and PTSD would have a higher relative risk of medical discharge compared to Soldiers without these conditions.

3. Determine if Veterans and Soldiers with PTSD and LBP have poorer health outcomes compared to Veterans and Soldiers without PTSD (Chapters 2 and 5).

Hypothesis: Veterans and Soldiers with PTSD will have higher pain and disability than Service Members without PTSD. Service Members with PTSD will have greater negative beliefs about pain. Finally, Service Members with PTSD will have lower pain pressure threshold values than Service Members without PTSD.

4. Determine the effectiveness of PNE for Veterans and Soldiers with chronic LBP (Chapter 6).

Hypothesis: PNE will improve pain, stress, disability, and pain-related beliefs and outcomes to a greater degree than traditional education about pain and stress.

Summary of Findings

1. Develop a PNE curriculum for Veterans with PTSD and pain and determine if Veterans can comprehend PNE materials (Chapter 3).

Finding: This dissertation demonstrated that Veterans with PTSD can comprehend the neuroscience of pain and PTSD at a comparable level to a highly educated Veteran and medical panel without PTSD when controlling for years of education. Since a proportion of participants were concerned that using military examples in PNE might increase PTSD symptoms, however, results from Chapter 3 suggested that the PNE materials developed for this dissertation should be tested in a clinical trial to ensure they do not increase PTSD symptoms.

2. Determine if co-morbid PTSD and chronic LBP increases disability in Active Duty Soldiers compared to chronic LBP alone (Chapter 4).

Finding: A U.S. Army Soldier with a history of both PTSD and chronic LBP is more than 5 times at risk for being medically disabled compared to Soldiers without these two conditions, even after controlling for other important demographic characteristics and co-morbidities. Therefore, the results from this dissertation support implementing an intervention that targets PTSD and chronic LBP in Active Duty Soldiers to attempt to reduce disability related to these conditions.

3. Determine if Veterans and Soldiers with PTSD and LBP have poorer health outcomes compared to Veterans and Soldiers without PTSD (Chapters 2 and 5).

Finding: A systematic review and meta-analysis demonstrated that Veterans with PTSD have higher depression and pain-catastrophizing beliefs for a large effect size compared to Veterans without PTSD. Furthermore, Veterans with PTSD have significantly lower pain self-efficacy with a large effect size. Compared to Veterans without PTSD, Veterans with PTSD have higher pain and disability.

These results, however, were not confirmed in Veterans presenting to physical therapy. In fact, this dissertation revealed that many of the negative outcomes previously attributed to PTSD in the literature may be due to the correlation between PTSD symptoms and pain catastrophizing beliefs rather than from trauma. Furthermore, Veterans with chronic LBP do not appear to have different sensitivity levels to pressure based on PTSD symptoms.

4. Determine the effectiveness of PNE for Veterans and Soldiers with LBP. (Chapter 6).

Finding: At 8-weeks, participants in the experimental arm viewed themselves as less disabled compared to the control group. In addition, the experimental group perceived lower levels of stress following the intervention. The results from this RCT indicate that PNE improves Service Members' confidence to increase participation in social, work, and life roles despite the pain as measured by the PSEQ. Because participants receiving PNE were less likely to view pain as harmful following the intervention, the mechanism for these improvements could be due to a top-down reconceptualization of pain. This is supported by increased pain pressure thresholds in the experimental group following PNE.

Furthermore, the PNE curriculum personally connected with participants to a greater degree than traditional pain and stress education. Likewise, participants in the experimental group were more satisfied with how the connection between pain and stress were made by PNE compared to traditional education. In addition, participants in the experimental group believed they had greater control of their pain following the PNE intervention compared to traditional education about stress. Although pain improved equally in both groups, this study was not primarily powered to show a difference in pain and

therefore did not have sufficient statistical evidence to confidently conclude PNE improves pain more than traditional pain and stress education.

Synthesis of Results and Future Research Implications

All individuals experience stressors in life¹². For many Service Members and Veterans, cumulative high levels of stress can lead to PTSD. Although PTSD by itself can be quite disabling, this dissertation provides evidence that PTSD and co-morbid pain lead to many negative health outcomes compared to a Veteran who has pain but no PTSD (Chapter 2). LBP is one of the top reasons for a Service Member to seek healthcare⁷ and, when combined with PTSD, raises the risk for medical discharge from the U.S. Army by more than 5 times even when controlling for other co-morbidities (Chapter 4). Compounding the problem, once Service Members leave the service, they avoid activities that might be painful because they believe they could be damaging tissues⁵⁵.

If Veterans believe that pain indicates tissue damage, then according to the common-sense model⁵⁴ it is understandable that Veterans would avoid painful activities. According to longitudinal imaging research of anatomical tissues, however, psychosocial characteristics like depression were more influential in identifying new onset of LBP in Veterans than changes to the spine²⁶⁴. Focusing on patho-anatomical tissues, though, can promote over-protection of the spine and increase disability¹³⁹ and feelings of vulnerability³⁵. PNE, on the other hand, contends that the brain ultimately produces pain to protect body tissues from potential danger⁴⁹. Therefore, from a PNE perspective, promoting beliefs that on-going pain is synonymous with damaged tissues will only promote continued pain as a protective response to change behavior. One purpose of PNE, then, is to decrease the threat of pain by showing individuals how a hypersensitive nervous system can be responsible for pain even after tissues heal. Indeed, a hypervigilant nervous system has been proposed for co-morbid PTSD and pain¹³¹, chronic LBP²³, and chronic stress disorders²⁴. This dissertation aimed to determine if PNE in the context of

stress could be effective in reducing many of the negative beliefs about pain and improve a Service Member's willingness to engage in active rehabilitation and exercise.

This dissertation demonstrated that Veterans with PTSD can comprehend the neuroscience of pain and PTSD at a comparable level to a highly educated Veteran and medical panel without PTSD when controlling for years of education. Since a proportion of participants were concerned that using military examples in PNE might increase PTSD symptoms, however, results from Chapter 3 suggested that the PNE materials developed for this dissertation should be tested in a clinical trial to ensure they do not increase PTSD symptoms. The results from this research demonstrated conclusively that the PNE curriculum developed for Veterans does not increase PTSD symptoms. In fact, the PNE curriculum used in this dissertation decreased PTSD symptoms more than traditional education about PTSD and stress from the National PTSD Center¹¹⁹ (Chapter 6). Although this difference was not statistically significant due to a lack of power and only 5 participants with PTSD in each group, the difference exceeded the MCID for PTSD symptoms and was a large effect size (Chapter 6). Nonetheless, the results from Chapter 3 revealed that the PNE curriculum might best be utilized with a patient-clinician therapeutic alliance rather than a stand-alone resource, although this should be tested in a prospective trial.

Since the longitudinal cohort in Chapter 4 determined that co-morbid PTSD and LBP significantly increased the risk for medical disability from the U.S. Army (Chapter 4), this dissertation aimed to determine the effectiveness of PNE in Active Duty U.S. Soldiers with PTSD and LBP as well as in Veterans who have already separated from the Service. In addition, since clinical experience has shown some resistance to PNE in activity duty Soldiers, this dissertation set out to determine if Veterans and Soldiers believed PNE personally applied to their symptoms or if they believed PNE implied their pain was due to a mental health disorder.

Chapter 5 determined that Veterans with and without PTSD had, on average, elevated pain catastrophizing beliefs. Veterans with and without PTSD were equally as likely to report

current depression, high levels of stress, and have a history of traumatic events. Furthermore, Chapter 5 aimed to elucidate the sensory profile of Veterans with PTSD since previous research has been conflicted as to whether individuals with PTSD display signs of hypo- or hyper-sensitivity. This dissertation did not find evidence to conclude that Veterans with chronic LBP have different sensitivity as demonstrated by PPTs based on the presence of PTSD. In addition, 37.5% of participants scored above cut-offs for PTSD despite no formal PTSD diagnosis. Because of the presence of PTSD symptoms among many participants without a PTSD diagnosis and elevated baseline stress levels for most participants, the results from the dissertation support including PNE from a stress-perspective for Service Members with or without PTSD.

The final study in this dissertation aimed to determine the effectiveness of PNE in Service Members with chronic LBP with or without co-morbid PTSD compared to traditional education about pain and stress. Following PNE, participants in the experimental group reported decreased stress and saw themselves as less disabled. In addition, the results from the RCT provide evidence that PNE greatly improves Service Members' confidence to increase active participation despite the pain as measured by the PSEQ. Furthermore, participants that received PNE were more likely to be satisfied with the explanation given for the relationship between psychosocial stressors and chronic pain from a PNE perspective compared to traditional stress and pain education. Consistent with the intent of PNE, participants in the experimental arm were less likely to believe that exercise is harmful after receiving PNE compared to traditional pain and stress education.

Clinical Implications

The results from the research completed in this dissertation have several clinical implications. First, the preliminary studies provide additional evidence (Chapter 4) that SMs with co-morbid PTSD and LBP likely require tailored management that addresses both pain and PTSD symptoms as recommended in the literature²⁸⁸. PNE tailored to a military population appears to

be an effective intervention for Service Members with PTSD and chronic LBP. Based on the results of this dissertation, on average, clinicians can be confident that PNE from a military perspective reduces PTSD symptoms at least as well as from the National Center for PTSD, although results indicate that a higher powered study would find a large effect favoring PNE for PTSD symptoms.

In addition, exercise is efficacious for both chronic LBP¹⁴¹ and PTSD symptoms¹³³. Veterans may avoid exercising, however, when they have pain for fear of harming tissues⁵⁵. PNE appears to decrease these fears (SOPA-Harm) and greatly improve confidence for engaging in physical activity and exercise for Service Members. Furthermore, the results from this dissertation provide objective evidence that PNE may cause Service Members' nervous system to process nociceptive information as less threatening when considering the increase in PPT values following the intervention. Decreasing fear associated with exercise and pain is a major goal following injury²⁹. Therefore, clinicians should strongly consider educating Service Members who have chronic LBP from a PNE perspective as opposed to traditional patho-anatomic education^{263,289}.

Although PNE has been used in several research studies including participants with LBP^{139,192,280,286}, this is the first research study to investigate the effectiveness of PNE in Veterans or Soldiers with LBP. Furthermore, this is the first study to demonstrate that PNE specifically reduces stress symptoms. The results from this dissertation can alleviate concerns that educating patients with PNE may imply that physical symptoms are the result of mental health disorders. In fact, it appears that PNE is a more effective bridge between psychosocial stressors and physical symptoms compared to traditional stress education (Chapter 6). Therefore, clinicians should consider PNE for Service Members who appear to have elevated psychosocial stressors.

Although PTSD is a common psychosocial disorder in Soldiers and Veterans²³³ and is correlated with stress (Chapter 5), the results from this dissertation indicate that Service Members

with chronic LBP stand to benefit from PNE regardless of PTSD status. In addition, this dissertation found that 37.5% of Veterans without a formal PTSD diagnosis still display significant PTSD symptomology. Furthermore, PTSD symptoms are correlated with pain catastrophizing beliefs in Veterans with LBP (Chapter 5). Pain catastrophizing beliefs have been shown to significantly contribute to chronic pain^{267,290} and are a prime target for PNE interventions⁴⁶. Since short, validated PTSD screening questionnaires are regularly utilized in the VA and Active Duty military treatment facilities^{83,174,175}, clinicians may consider utilizing PTSD screening to serve as a proxy for identifying Service Members who might benefit from PNE to target stress and pain. The hyperarousal symptoms identified in the PC-PTSD screen¹⁷² might indicate a hypervigilant nervous system that is not uncommon in patients with chronic LBP²²⁴.

Future Research

Future research should determine if PC-PTSD screening can effectively identify military Service Members who would benefit from PNE. Furthermore, it would be helpful to repeat the results from the RCT in a larger sample to confirm the results from this dissertation and have sufficient power to analyze results among sub-groups (PTSD versus no PTSD; Soldiers versus Veterans). In addition, a future study might consider removing the patho-anatomical education and include only biopsychosocial stress education to clarify specific educational content that is most responsible for the results found in this dissertation. Also, it would be helpful to have an exercise-only group to help elucidate specific mechanisms for the outcomes found in Chapter 6.

Based on the feedback from participants in Chapter 3, a qualitative study examining participant interpretations of PNE compared to clinician views of PNE delivery would be fascinating and beneficial. It would also be helpful to develop military PNE for other conditions that are frequently co-morbid with chronic pain, like mild traumatic brain injury²⁹¹.

Conclusion:

PTSD symptoms are common in Veterans with chronic LBP, even among those who have never been diagnosed with PTSD before. Veterans without PTSD can effectively comprehend PNE written from a military perspective. The results from this dissertation demonstrate that PNE using military examples connects with participants more than traditional education about pain and stress. Clinicians can be confident that PNE from a military perspective decreases PTSD symptoms at least as well as education from the National Center for PTSD.

PNE from a military and stress perspective was effective in reducing stress and disability in Veterans and Soldiers with chronic LBP. Participants who received PNE were less likely to believe that pain was harmful and that active rehabilitation in the presence of pain should be avoided. Following PNE, participants believed they had greater control of their pain. The research from this dissertation provided evidence that these results may be due to a less hypervigilant nervous system given that participants in the experimental arm were able to tolerate higher levels of nociception prior to reporting pressure as painful in their low back. PNE from a military and stress perspective appears to be an effective bridge between physical and psychosocial symptoms and helps reduce stress as well as pain-related disability in Veterans and Soldiers with chronic LBP.

Appendices

Appendix A: Participant Demographic Information

Thank you for your participation in this study. Please provide the most appropriate answer to

each question. Please complete ALL questions. There is no right or wrong answer. All information will be handled in confidence and no personal data will be collected.

1. What is your age? _____ years

2. What is your gender? _____ male _____ female

3. What is your ethnic background?

- African-American
- Hispanic
- White, non-Hispanic
- Asian
- Other: Please specify: _____

4. What is your educational background?

- Post-graduate education (Masters, doctorate, etc.)
- Graduate (Bachelors)
- High school
- Other: Please specify: _____

5. Which of the following describes your income best?

- Less than \$10 000 per year
- Between \$10 000 and \$50 000 per year
- Between \$50 000 and \$100 000 per year
- More than \$100 000 per year

6. Describe your military service:

- Army
- Marines
- Navy
- Air Force
- Coast Guard

8. Describe your combat military deployments:

- Korea
- Vietnam
- Persian Gulf
- Iraq
- Afghanistan
- Other. Please specify: _____
- None

9. Have you personally experienced any of the following traumatic life events?

- Combat-related trauma
- Personal violence
- Military sexual trauma/Unwanted sexual assault
- Motor Vehicle Crash
- Natural Disaster
- Other. Please specify: _____
- Prefer not to answer

10. When did you experience this trauma (Check all that apply)?

- While serving in the military
- After serving in the military
- Before serving in the military
- Other. Please specify: _____

11. Have you ever been diagnosed with PTSD?

- Yes
- No
- Unsure

If "No", you have not been diagnosed with PTSD, please skip to question # 13

12. If **Yes**, How long have you had PTSD symptoms? ____ (# of years) ____ (# of months)

13. How did you injure your low back?

- Traumatic injury or accident (non-combat)
- Traumatic injury (combat)
- Gradual onset with physical activities
- Unknown
- Other. Please specify: _____

14. Have you used any of the following treatments for your **back pain**? (Check all that apply)

Opiod painkillers (prescription medications such as Vicodin, Lortab, Norco, hydrocodone, codeine, Tylenol #3 or #4, fentanyl, Duragesic, MS Contin, Percocet, Tylox, OxyContin, oxycodone, methadone, tramadol, Ultram, Dilaudid)	<input type="checkbox"/> Yes	<input type="checkbox"/> No
If you checked yes, are you currently using this medication?	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Injections (such as epidural steroid injections, facet injections)	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Exercise therapy	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Psychological counseling, such as cognitive behavioral therapy, <u>for your back pain.</u>	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Low-back Surgery	<input type="checkbox"/> Yes	<input type="checkbox"/> No

15. HOW LONG HAVE YOU HAD THIS EPISODE OF LOW BACK PAIN?

(fill in the blank) _____ YEARS _____ MONTHS

16. How does this pain affect your sleeping at night? (Check one)

- Does not affect
- Affects some, but I can sleep most of the night
- Cannot sleep well due to back pain
- Cannot sleep well due to issues other than back pain

17. How would you describe your cigarette smoking or tobacco use? (Check one)

- Never smoked/used tobacco
- Current smoker/tobacco user
- Used to smoke/use tobacco, but have quit now

18. The following is a list of common health problems. In the first column indicate if you currently have any of these conditions, or if you have ever had them in the past. In the second column indicate if you are currently receiving treatment for the problem. In the last column indicate if the problem limits any of your daily activities.

	Do you or have you had the problem?	Do you currently receive treatment for this problem?	Does this problem limit your daily activities?
Heart Disease	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
High Blood Pressure	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
Lung Disease	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
Diabetes	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
Vascular disease (Peripheral Arterial Disease, Vascular Claudication)	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
Cancer	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
Depression	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
Dizziness or Vertigo	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
Osteoarthritis	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
Rheumatoid Arthritis	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
Allergies	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
Upper back and/or neck pain	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
Drug or alcohol problem	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
TBI or concussion	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No
Other Medical Problems (<i>please specify</i>)			

Appendix B: Post-Traumatic Stress Disorder (PTSD) in Veterans, A Pain Neuroscience Approach, Evaluation

Please check **one** box in each question which describe your reactions to the booklet.

1. The booklet was very easy to read
The booklet was somewhat easy to read
The booklet was difficult to read
2. I found the booklet interesting
I found the booklet boring
3. I thought the information in the booklet was clear
I thought the information in the booklet was not very clear
I thought the information in the booklet was completely confusing
4. I learned some new, helpful things
I knew most of it already
I didn't really find the booklet helpful
5. I believed most of what the booklet said
I believed some of what the booklet said
I did not really believe any of what the booklet said
6. There are enough practical tips
I wanted more practical tips
The practical tips were not clear
7. The order of the contents was easy to follow
The contents seemed jumbled
8. I would tell a friend or family member to read the booklet
I would not recommend the booklet
9. The military examples are helpful
The military examples will increase PTSD symptoms
10. I think the booklet will help people
I don't think the booklet will help people
11. (Remember the recommendation is to read 1-2 sections at a time over 2 weeks.)
With this in mind:
The booklet is about right
The booklet is too long
The booklet is too short
12. I read the entire booklet
I read most of the booklet
I did not read the booklet

Appendix C Post-Traumatic Stress Disorder (PTSD) in Veterans: A Pain Neuroscience Approach,
Review Questionnaire

Thank you for your participation in this study. Please provide the most appropriate answer to each question. Please do your best and answer the questions from memory. This questionnaire is designed to measure how difficult some of the concepts are to understand in the booklet you just read.

1. It is helpful for the nervous system to develop some sensitivity to danger messages in the short-term; however, if this response lasts too long or too strongly, it is not helpful.
 - True
 - False
2. When the body releases stress hormones during a dangerous event, the hormones are not useful and damages the brain.
 - True
 - False
3. It is helpful for PTSD symptoms to avoid any type of memory or trigger of a Veteran's trauma.
 - True
 - False
4. During recovery from PTSD and pain, activities that are painful should always be avoided.
 - True
 - False
5. Physical exercise only benefits the body: muscles, joints, cardiovascular system, etc... but has no significant effect on the brain.
 - True
 - False
6. According to the book you just read, a primary purpose of the nervous system is to:
 - Tell your brain exactly what is going on in your tissues.
 - Transmit pain signals from the body to the brain.
 - Like an alarm, protect you with pain and stress responses.
 - Fight infections and produce immune cells.

7. When your nervous system is extra sensitive, it means the following part of your brain has turned up the sensitivity of the danger alarm:
- Command and Control Center
 - Supply Officer
 - Radar Operator
 - Chemical Officer
8. This book used the following example to help describe pain and PTSD:
- Pain and PTSD is like a smoke detector.
 - Pain and PTSD is like a home alarm system that becomes too sensitive.
 - Pain and PTSD is from increased nervous system sensitivity, similar to increased security measures after the Pearl Harbor attack.
 - Pain and PTSD are normal responses and so there is nothing that should be done to try and change your nervous system.
9. During a trauma:
- The brain is unable to remember any details from a trauma because of coping mechanisms.
 - Stress hormones amplify (turn-up) memories and help your brain to remember traumatic events.
 - If you develop PTSD, it is impossible to make new memories.
 - Pain is automatically produced by the brain.
10. What is the brain map?
- When you use your nervous system enough times, it makes a path that gets wider and wider each time you use your brain map.
 - The brain map is not possible to change once it is set.
 - The brain map helps you figure out if you are “left-brained” or “right-brained”.
11. According to the booklet you just read, all of the following ways are helpful strategies to improve pain and PTSD symptoms EXCEPT:
- Exercise
 - Mental imagery
 - Quality sleep
 - Avoiding painful activities

Appendix D: Traditional Post-Traumatic Stress Disorder (PTSD) Education Assessment
After reviewing the educational material about PTSD, please choose the one statement that best describes your reaction.

1. The information is accurate.
 The information contained some errors.
 The information is not appropriate for patients with PTSD.
2. The information provided is in accordance with clinical practice and guidelines.
 Only some of the information is in accordance with clinical practice and guidelines.
 The information included is not in accordance with clinical practice and guidelines.
3. No key information about PTSD is missing for patient education occurring in a primary care or physical therapy clinic.
 Some key information about PTSD is missing for patient education occurring in a primary care or physical therapy clinic.
 The information about PTSD for patient education occurring in a primary care or physical therapy clinic is missing significant content.
4. The recommended “do’s” included in this information is appropriate and complete for a patient with PTSD.
 The recommended “do’s” is mostly appropriate and complete but I would add some additional key “do’s”.
 The recommended “do’s” is not appropriate for a patient with PTSD.
5. The recommended “don’ts” included in this information is appropriate and complete for a patient with PTSD.
 The recommended “don’ts” is mostly appropriate and complete but I would add some additional key “don’ts”.
 The recommended “don’ts” is not appropriate for a patient with PTSD.

6. Based on the educational materials you just read, describe your opinion about including this type of education by Physical Therapists to patients who have pain and PTSD.

- Physical Therapists should not educate patients about PTSD because it is not in their scope of practice or training.
- Physical therapists should include this type of patient education about PTSD but only in a controlled, supervised environment like a research program.
- It is appropriate for Physical Therapists to include this type of patient education about PTSD in clinical practice.

7. Describe your opinion about Physical Therapists educating patients about PTSD *in general*.

- Physical Therapists should not educate patients about PTSD because it is not in their scope of practice or training.

PTs can educate patients about PTSD depending on the topic.

Physical Therapists should educate patients about PTSD as this will improve overall coordination of care for the patient.

8. Describe your opinion regarding the following topics: It is appropriate for Physical Therapists to educate patients with PTSD with the following skill

Mindfulness Agree Unsure Disagree

Resilience Agree Unsure Disagree

Self-efficacy Agree Unsure Disagree

Coping Skills Agree Unsure Disagree

Optimism Agree Unsure Disagree

Cognitive restructuring for pain. Agree Unsure Disagree

Prolonged exposure in vivo for pain. Agree Unsure Disagree

9. What percent of your patients have physical pain?

- 0-25%
- 26-50%
- 51-75%
- 76-100%

10. What describes your desires about pain education?

- I wish I had more knowledge how to educate patients with PTSD about pain.
- I have adequate knowledge about educating patients with PTSD about pain, I just do not have the time to routinely include it.
- Educating PTSD patients about pain is not a problem for me.

11. Which of the following modules from the *PTSD Coach Online* is most important for educating Veterans with PTSD to cope with avoidance (Please select only one):

- Change feelings by changing thoughts
- Learn to be assertive

- Weigh the pros and cons
- Change negative thinking patterns
- Learn to problem solve
- Deal with trauma reminders
- Look carefully at your thoughts

Based on your choice, do you feel this type of skill should be taught by Primary Care Providers?

- Yes
- No

Based on your choice, do you feel this type of skill should be taught during Physical Therapy Care?

- Yes
- No

12. Which of the following modules from the *PTSD Coach Online* is most important for educating Veterans with PTSD to cope with hypervigilance (Please select only one):

- Change feelings by changing thoughts
- Learn to be assertive
- Weigh the pros and cons
- Change negative thinking patterns
- Learn to problem solve
- Deal with trauma reminders
- Look carefully at your thoughts
- Relax through breathing
- Relax your body
- Relax through visualization

Based on your choice, do you feel this type of skill should be taught by Primary Care Providers?

- Yes
- No

Based on your choice, do you feel this type of skill should be taught during Physical Therapy Care?

- Yes
- No

13. Which of the following modules from the *PTSD Coach Online* is most important for educating Veterans with PTSD to cope with negative thoughts (Please select only one):

- Be in the moment
- Change feelings by changing thoughts
- Learn to be assertive

- Weigh the pros and cons
- Change negative thinking patterns
- Learn to problem solve
- Deal with trauma reminders
- Look carefully at your thoughts
- Relax through breathing
- Relax your body
- Relax through visualization
- Plan something enjoyable
- Notice your thoughts and feelings

Based on your choice, do you feel this type of skill should be taught by Primary Care Providers?

- Yes
- No

Based on your choice, do you feel this type of skill should be taught during Physical Therapy Care?

- Yes
- No

14. Which of the following modules from the *PTSD Coach Online* is most important for educating Veterans with PTSD to cope with re-experiencing (Please select only one):

- Be in the moment
- Deal with trauma reminders
- Relax your body
- Change feelings by changing thoughts
- Look carefully at your thoughts
- Weigh the pros and cons
- Change negative thinking patterns
- Relax through breathing

Based on your choice, do you feel this type of skill should be taught by Primary Care Providers?

- Yes
- No

Based on your choice, do you feel this type of skill should be taught during Physical Therapy Care?

- Yes
- No

Would you add any information to the material that was emailed to you in order to be part of standard educational materials for PTSD in a Primary Care or Physical Therapy setting?

Is there any information in the material that was emailed to you that you would remove or is inaccurate?

Is there any information in the material that was emailed to you that you believe is not appropriate to be delivered by a Physical Therapist?

Appendix E: Activity Log

Please let us know approximately how much time you spend each day performing the following activities.

NOTE, this log does NOT include the time you spend at your Physical Therapy appointments!

Please keep an accurate log. This log is not meant to grade you but instead to help us understand how this program and education influences your activity levels. Thank you!

Week 1	Exercise (walking, biking, running, etc...), (minutes)	PTSD/Pain Education booklet (minutes)	Other PTSD/Pain Education readings, websites, applications (site-minutes)
<i>Example</i>	<i>Walking, 15 min</i>	<i>10 min</i>	<i>PTSD Coach, 15 min</i>
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
Sunday			
Week 2	Exercise (minutes)	Education booklet (minutes)	Other education (site-minutes)
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
Sunday			

Activity Log

Please let us know approximately how much time you spend each day performing the following activities.

NOTE, this log does NOT include the time you spend at your Physical Therapy appointments!

Please keep an accurate log. This log is not meant to grade you but instead to help us understand how this program and education influences your activity levels. Thank you!

Week 3	Exercise (walking, biking, running, etc...), (minutes)	PTSD/Pain Education booklet (minutes)	Other PTSD/Pain Education readings, websites, applications (site-minutes)
<i>Example</i>	<i>Walking, 15 min</i>	<i>10 min</i>	<i>PTSD Coach, 15 min</i>
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
Sunday			
Week 4	Exercise (minutes)	Education booklet (minutes)	Other education (site-minutes)
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
Sunday			

Appendix F: Participant Exercise Program

Choose the 1 exercise for each number that you feel you could confidently perform for 1 minute:

1. Warm-up



Walk in place



Walk with high knees



Jog in place

2. Arms



Arm circles



Arm raise with weights



Squat/arm-raise w/ weights

3. Legs



Mini squat



Wall squats



Full squat

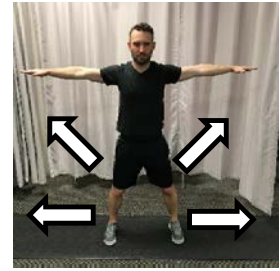
1. Side hip muscles



□
Side steps (slow)

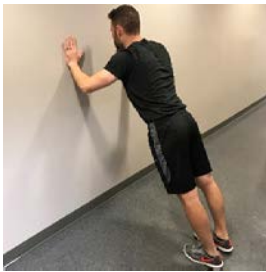


□
Side shuffle (quicker)



□
Half jumping-jack

2. Chest Muscles



□
Wall push-up



□
Knee push-up



□
Full push-up

3. Side Abdominals



□
Diagonal trunk curl



□
Side plank on knees



□
Side plank

4. Hip Muscles (Side)



□
Clam-shell



□
Leg raise



□
Band side steps

1. Hip Muscles (back)



□
Leg raise, bent knee



□
Leg raise, straight knee



□
Alternating arm/leg lift

2. Abdominals



□
Abdominal Crunch



□
Plank on knees



□
Full plank

3. Hip/back Muscles



□
Back bridge



□
Back bridge with leg raise

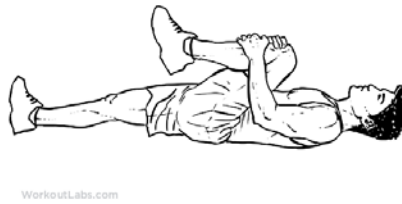


□
Alternating arm and leg

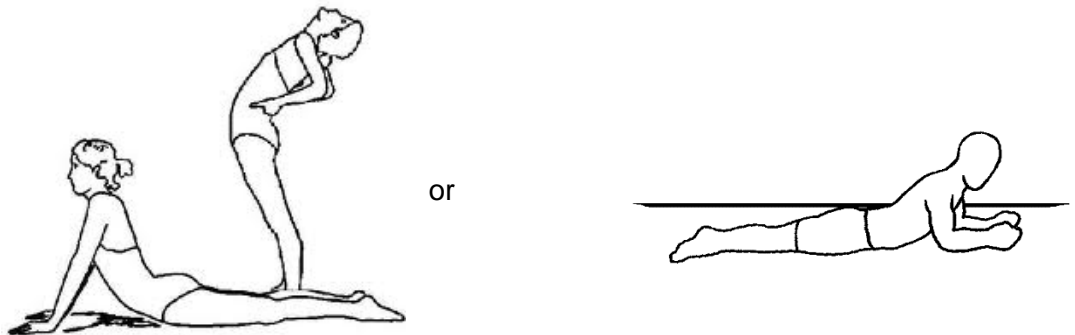
1. Cool down stretch #1



2. Cool down stretch #2



3. Cool down stretch #3



Since your last visit, any changes in your medications or medical treatments for back pain or PTSD/mental health?

Type	Yes/No	Dose	Frequency
Medication:			
Medication:			
Medication:			
Acupuncture			
Massage			
Chiropractor			
Counseling			
Injection			
Other:			

Appendix G: Pain and Post-Traumatic Stress Disorder (PTSD) Education Post-Program Questionnaire

For each number, please indicate how much you agree or disagree with each statement. Lower numbers mean you strongly disagree. The number 5 means you neither agree nor disagree. Higher numbers mean you strongly agree.

<u>Strongly Disagree</u>	<u>Neutral</u>	<u>Strongly Agree</u>								
0	1	2	3	4	5	6	7	8	9	10

1. This is the first time I have received this education.

<u>Strongly Disagree</u>	<u>Neutral</u>	<u>Strongly Agree</u>								
0	1	2	3	4	5	6	7	8	9	10

2. The education program helped explain why I have chronic pain after PTSD.

<u>Strongly Disagree</u>	<u>Neutral</u>	<u>Strongly Agree</u>								
0	1	2	3	4	5	6	7	8	9	10

3. The education program applies personally to my symptoms.

<u>Strongly Disagree</u>	<u>Neutral</u>	<u>Strongly Agree</u>								
0	1	2	3	4	5	6	7	8	9	10

4. The education program treated my symptoms as real and helped me understand why I have PTSD and pain symptoms.

<u>Strongly Disagree</u>	<u>Neutral</u>	<u>Strongly Agree</u>								
0	1	2	3	4	5	6	7	8	9	10

5. I am satisfied in the way the education program explained why common treatments for pain can help after being diagnosed with PTSD.

<u>Strongly Disagree</u>	<u>Neutral</u>	<u>Strongly Agree</u>								
0	1	2	3	4	5	6	7	8	9	10

6. The education program connected with me personally as a Veteran and with my experiences in the Armed Forces.

<u>Strongly Disagree</u>	<u>Neutral</u>	<u>Strongly Agree</u>								
0	1	2	3	4	5	6	7	8	9	10

7. The education program only applies to Veterans with exaggerated symptoms, not me personally.

Strongly Disagree Neutral Strongly Agree
0 1 2 3 4 5 6 7 8 9 10

8. The education program implied that chronic pain after PTSD diagnosis means that my physical pain is only a mental health problem.

Strongly Disagree Neutral Strongly Agree
0 1 2 3 4 5 6 7 8 9 10

9. I have already heard most of this education before.

Strongly Disagree Neutral Strongly Agree
0 1 2 3 4 5 6 7 8 9 10

10. I believe I was in the experimental education group.

Strongly Disagree Neutral Strongly Agree
0 1 2 3 4 5 6 7 8 9 10

Appendix H: Pain and Stress Education Post-Program Questionnaire

For each number, please indicate how much you agree or disagree with each statement. Lower numbers mean you strongly disagree. The number 5 means you neither agree nor disagree. Higher numbers mean you strongly agree.

<u>Strongly Disagree</u>	<u>Neutral</u>	<u>Strongly Agree</u>
0 1 2 3 4	5 6 7	8 9 10

1. This is the first time I have received this education.

<u>Strongly Disagree</u>	<u>Neutral</u>	<u>Strongly Agree</u>
0 1 2 3 4	5 6 7	8 9 10

2. The education program helped explain why I have chronic pain after stress or trauma.

<u>Strongly Disagree</u>	<u>Neutral</u>	<u>Strongly Agree</u>
0 1 2 3 4	5 6 7	8 9 10

3. The education program applies personally to my symptoms.

<u>Strongly Disagree</u>	<u>Neutral</u>	<u>Strongly Agree</u>
0 1 2 3 4	5 6 7	8 9 10

4. The education program treated my symptoms as real and helped me understand why I have stress and pain symptoms.

<u>Strongly Disagree</u>	<u>Neutral</u>	<u>Strongly Agree</u>
0 1 2 3 4	5 6 7	8 9 10

5. I am satisfied in the way the education program explained why common treatments for pain can help after stress.

<u>Strongly Disagree</u>	<u>Neutral</u>	<u>Strongly Agree</u>
0 1 2 3 4	5 6 7	8 9 10

6. The education program connected with me personally as a Soldier and with my experiences in the military.

<u>Strongly Disagree</u>	<u>Neutral</u>	<u>Strongly Agree</u>
0 1 2 3 4	5 6 7	8 9 10

7. The education program only applies to Soldiers with exaggerated symptoms, not me personally.

Strongly Disagree			Neutral				Strongly Agree			
0	1	2	3	4	5	6	7	8	9	10

8. The education program implied that chronic pain after stress means that my physical pain is only a mental health problem.

Strongly Disagree			Neutral				Strongly Agree			
0	1	2	3	4	5	6	7	8	9	10

9. I have already heard most of this education before.

Strongly Disagree			Neutral				Strongly Agree			
0	1	2	3	4	5	6	7	8	9	10

10. I believe I was in the experimental education group.

Strongly Disagree			Neutral				Strongly Agree			
0	1	2	3	4	5	6	7	8	9	10

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EDUCATION

Doctoral Student, Rehabilitation Science, University of Kentucky, Lexington, KY --Present--
DPT, US Army-Baylor Program, San Antonio, TX 2009
BS Electrical Engineering, United States Military Academy, West Point NY 2002

TEACHING RESPONSIBILITIES

Assistant Instructor, Anatomy and Dry-Needling at the COL Douglas A. Kersey Advanced
Clinical and Operational Practice Course. _____ 2014
Introduction to Dry-Needling in the Military Treatment Facility.
Assistant/Lead Instructor for introductory-level Dry Needling Course, accredited by Texas
Physical Therapy Association (TPTA) 23 CCU's. _____ 2013

MILITARY EMPLOYMENT

Intern Director, Fort Hood, TX 2014—2015
OIC Bennett Physical Therapy, Fort Hood, TX 2012—2014
Brigade Combat Team Physical Therapist, 3 BCT 25 ID 2010—2012
Assistant OIC Schofield Barracks Physical Therapy 2009—2010
Student, US Army-Baylor Doctoral Program in Physical Therapy 2006—2009
Executive Officer, HHC CJTF-76, Bagram Afghanistan 2005—2006
Executive Officer, HSC SETAF, Vicenza, Italy 2004—2005
Platoon Leader, B Company, 1-508th 173rd ABN BDE, OIF 1 2003—2004

PUBLICATIONS

Childs JD, Teyhen DS, **Benedict TM**, et al. Effects of sit-up training versus core stabilization
exercises on sit-up performance. *Med Sci Sports Exerc.* 2009;41(11):2072-2083.

PROFESSIONAL HONORS

Student Leadership Award AMEDD Officer Basic Course, Fort Sam Houston, TX 2006
Commandant's List Infantry Officer Basic Course, Fort Benning, GA 2002
COL David Greathouse Research Award: 2008
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