CHANGE AMONG VETERANS PARTICIPATING IN YOGA FOR STRESS AND POSTTRAUMATIC STRESS: A PILOT STUDY

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Timothy J. Avery

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CHANGE AMONG VETERANS PARTICIPATING IN YOGA FOR STRESS AND POSTTRAUMATIC STRESS: A PILOT STUDY

Timothy J. Avery
The PGSP-Stanford Psy.D. Consortium, Palo Alto University, 2016

Trauma-focused psychotherapies do not meet the needs of all veterans. Yoga shows some potential in reducing stress and perhaps even PTSD in veterans, although little is understood about the mechanisms of action. OBJECTIVE: Identify correlates of change in PTSD and perceived stress for veterans participating in yoga. METHOD: Nine veterans (7 male, 2 female) were recruited from an existing clinical yoga program and observed over 12 weeks. Severity of PTSD (PCL-5) and perceived stress (PSS-10) were collected at baseline and weeks 4, 6, 8, and 12. Psychological flexibility (AAQ-II), set-shifting (Trail Making Test A and B), and openness to experience (NEO-PI-R Openness Scale) were collected at baseline and week 6. Subjects attended yoga sessions freely, with the total ranging from 1 to 23 classes over the 12 weeks. RESULTS: Self-reported PTSD symptoms significantly reduced while perceived stress did not. Baseline set-shifting predicted improvements in PTSD between baseline and 4 weeks; early improvements in set-shifting predicted overall reduction in PTSD. Greater psychological flexibility was associated with lower PTSD and perceived stress; more yoga practice, before and during the study, was associated with greater psychological flexibility. Other predictors were not supported. CONCLUSION: Findings from previous research were supported in a clinical yoga program for veterans despite a small and uncontrolled sample. Recommendations for future research are provided.

Change Among Veterans Participating in

Yoga for Stress and Posttraumatic Stress: A Pilot Study

This dissertation by Timothy J. Avery, directed and approved by the candidate's committee, has been accepted and approved by the Faculty of The PGSP-Stanford Psy.D. Consortium, Palo Alto University in partial fulfillment of the requirements for the degree of

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William Froming, Ph.D.
Provost

Dissertation Committee:

Craig Rosen, Ph.D.
Chair

Christine Blasey, Ph.D.
Committee Member

Peter Bayley, Ph.D.
Committee Member

DEDICATION AND ACKNOWLEDGEMENTS

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INTRODUCTION

Stress and posttraumatic stress disorder (PTSD) have known negative effects on the psychological wellbeing, psychosocial and occupational role functioning, and physical health of veterans and their families. There are effective treatments for PTSD—primarily trauma-focused psychotherapies—yet many veterans are reluctant to engage in these trauma-focused treatments (Hundt et al., 2015; Hamblen et al., 2015), there is a high dropout rate (e.g., 17-22% dropout for CPT; Monson et al., 2006), and not all patients who receive them improve (Steenkamp et al., 2015). There is therefore a need for additional treatment options.

Yoga is a therapeutic approach included in the set of modalities referred to as "complementary and alternative medicine" (CAM) or "integrative medicine" that has demonstrated positive effects on overall stress. Yoga has also shown some promise as an acceptable and possibly efficacious treatment for PTSD in veterans. Although yoga shows some potential in reducing stress and perhaps even PTSD in veterans, little is understood about the means by which this change occurs. Improved understanding of the components of change could help make yoga more effective as a complementary and alternative intervention. The goal of this study is to elaborate cognitive-behavioral correlates of change involved in the positive effects of yoga on stress and PTSD, namely psychological flexibility, which incorporates appraisal and lack of experiential avoidance, and attentional control.

Negative Consequences of Stress and PTSD

Broad Effects of Stress

Stress and posttraumatic stress have many deleterious psychological and physical effects through complex interrelated mechanisms. A meta-analysis of 165 studies shows that

psychosocial stress is associated with higher incidences of cancer in previously healthy populations, and a meta-analysis of 330 studies indicates poorer survival rates among cancer patients who have higher stress (Chida, Hamer, Wardle, & Steptoe, 2008). Another meta-analysis revealed that general life stress is associated with poorer cardiovascular recovery which, in turn, is associated with other measures of disease such as high blood pressure, obesity, and atherosclerosis (Chida & Hamer, 2008). Stress even has measured effects on genetic markers (e.g., telomeres) which are associated with decreased longevity (Aviv, Kark, & Susser, 2015).

Stress not only affects the body but the brain as well. One way stress changes the brain is via activation of the hypothalamus-pituitary-adrenal (HPA) axis which affects mood, behavior, and even cognitions (Lupien, McEwen, Gunnar, & Heim, 2009). Stress affects development via different mechanisms at each stage of human development (Lupien et al., 2009). With regards to mental health, veterans with higher stress tend to have higher depression and anxiety (Smeeding, Bradshaw, Kumpfer, Trevithick, & Stoddard, 2010). This stress in turn affects health behaviors such as reduced physical activity (Stults-Kolehmainen & Sinha, 2014), or greater likelihood of initiating and difficulty stopping smoking (Pinsker, Hennrikus, Hannan, Lando, & Brosseau, 2015). Further, perceived stress is implicated in alcohol use disorders and PTSD symptoms, both of which significantly affect military veterans (De La Rosa, Delaney, Webb-Murphy, Johnston, 2015). Stress, in short, has broad, significant, and complicated effects.

Effects of PTSD

PTSD is one particular form of stress that can affect veterans and non-veterans who have been exposed, directly or indirectly, to traumatic events. The effects of stress are cumulative: among people exposed to potentially traumatic events, other life stressors exert a greater risk for PTSD than pre-trauma factors (Brewin, Andrews, & Valentine, 2000). Although estimates of the

prevalence of PTSD vary, a review of several studies on U.S. veterans of Iraq and Afghanistan estimates a 5.5% prevalence rate in the overall post-deployment population and 13.2% in operational infantry units (Kok, Herrell, Thomas, & Hoge, 2012).

The National Vietnam Veterans Readjustment Study (NVVRS) showed that 22% of Vietnam veterans with PTSD had a current diagnosis of an alcohol use disorder and 75% had a lifetime diagnosis of an alcohol use disorder (Kulka et al., 1988). PTSD is often associated with aggression in veterans (Angkaw et al., 2013). PTSD is often comorbid with depression and lower quality of life (Kessler, Chiu, Demler, Walters, 2000). Suicidality, one symptom of depression, is approximately four times more likely to be endorsed by Iraq and Afghanistan veterans with PTSD compared to those without (Jakupcak et al., 2009). PTSD is also associated with increased medical comorbidity, even more so than substance use disorders (Dobie et al., 2004; Nazarian, Kimerling, & Frayne, 2012).

PTSD also affects cognitive functioning. PTSD and perceived stress predicts cognitive failures in college students (Boals & Banks, 2012). Further, PTSD is associated with deficits in sustained attention, working memory, and initial learning (LaGarde, Doyon, & Brunet, 2010; Vasterling et al., 2002). Among veterans, those with PTSD have lower attentional control than those without (Beckham, Crawford, & Feldman, 1998). These deficits are particularly important to consider given that many veterans attend school after, or even during, their military service. Effective cognitive functioning also supports regular work tasks and life in general. Altogether, stress and PTSD contribute to negative effects for veterans and non-veterans in many areas of functioning, psychological and physical health.

Literature Review

Cognitive Models for PTSD and Stress

Cognitive model of stress. There are multiple models to explain stress and PTSD. The current study focuses on a cognitive model. The "Stress, Appraisal, and Coping" model proposed by Lazarus and Folkman (1984) identifies stress as "relational," a relationship between person and environment—stress is when a person appraises the environmental challenge to be "taxing or exceeding" one's resources. The model then identifies three stages in response to this stress. In primary appraisals, a subject evaluates a situation as benign, challenging, or threatening. Primary appraisal is shaped by the situation as well as by one's cognitive set or existing beliefs and physiological state. In secondary appraisals, a subject evaluates his or her ability to cope with the situation. Secondary appraisal involves evaluation of resources (e.g., physical, social, psychological) such as endurance and problem solving skills. Finally, coping encompasses all the cognitive and behavioral efforts one could make to reduce stress by mastering or tolerating internal and external demands of a stressful situation.

Primary appraisals, secondary appraisals, and coping influence each other. First, a primary appraisal of a particularly intense challenge may contribute to a secondary appraisal of one's limited resources to cope. In the other direction, repeated secondary appraisals of one's limited coping resources may become part of his or her set and thus shape primary appraisal. For example, someone may repeat the secondary appraisal that "I cannot endure this situation" or "I must avoid this situation." The repetition of a secondary appraisal becomes an automatic thought and similar future events will be perceived as a threat as it is now a "forgone conclusion" that one cannot endure the situation.

One coping task during control appraisals is to tolerate or adjust to events—these events include inner experiences. A person's appraisal of control changes throughout a stressful encounter; for instance, as stress is endured and the feared outcome does not occur reappraisal leads to a new experience and sense of control ("I can endure this"), thus decreasing stress. As stated by Bandura, "people register notable increases in self-efficacy when their experiences disconfirm misbeliefs about what they fear and when they gain new skills to manage threatening activities" (as cited in Folkman, 1984). This process begins with learned inhibition in the inhibitory learning model followed by fear reduction described in habituation-based models (Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014). For example, the secondary appraisal (i.e., learned belief) of one's increased coping capacity is not directly dependent upon the severity of fear involved in the primary appraisal. Not only does a feared outcome not occur, but one discovers that under increasingly distressing situations that "I can endure this." Repeated experiences of one's positive coping capacities during secondary appraisal will *then* decrease intensity of perceived distress during primary appraisal as habituation. One's approach to reappraisal is changeable. For instance, in one study training in reappraisal contributed to lower perceived stress in the lives of healthy adults post training (Denny & Ochsner, 2014).

Cognitive model of PTSD. The general concepts in the cognitive model of stress may be applied more specifically to symptom onset and maintenance in PTSD. In the cognitive model of PTSD, the strategies one uses to cope with intrusive memories prevents change in the traumatic memory and change in one's current appraisal process (Ehlers & Clark, 2000). Re-experiencing a trauma primarily consists of sensory impressions, to include physical sensations, rather than thoughts—this re-experiencing is a "situation" a person with PTSD may find him or herself in (Ehlers & Clark, 2000). In primary appraisals, sensory impressions, physical reactions,

and motor responses (i.e., proprioceptive feedback) trigger or are experienced as if the traumatic event were occurring 'right now' instead of in the past (Ehlers & Clark, 2000). Thus, the primary appraisal may be that these memories and physiological arousal are a threat rather than benign. If the individual has a negative secondary appraisal of their coping capacity (i.e., "I cannot handle these memories"), then the person is more likely to use avoidance coping and to work to actively suppress these memories and to avoid external cues related to the trauma. This avoidance short-circuits the normal process of recovery and contributes to maintenance of PTSD (Ehlers & Clark, 2000). At least in healthy adults, positive reappraisal training is associated with fewer intrusive memories following a traumatic film compared to those with negative appraisal training (Woud, Holmes, Postma, Dalgliesh, & Mackintosh, 2012). It is possible those with PTSD may also learn new approaches to reappraisal.

Based on their model, Ehlers and Clark (2000) offer three primary focus areas for treatment. First, decrease intrusive re-experiencing through elaboration and integration of traumatic memory into the context of one's previous and current experiences. Framed differently, this is a decrease in circumstances that are likely to be appraised as threatening during primary appraisal. Second, modify problematic appraisals (read, secondary appraisals) of the trauma and/or its sequelae. Third, stop dysfunctional strategies that hinder memory changes and adaptive appraisals and exacerbate symptoms. This third focus area includes psychological flexibility, cognitions, and behaviors that affect the reciprocal interaction between primary and secondary appraisals (e.g., avoidance prevents inhibitory learning and habituation). Current evidence-based treatments tend to focus on the first or second focus areas. The third area is potentially improved through yoga.

Psychological flexibility. The construct of psychological flexibility, although not mentioned in the above cognitive model, is another way of understanding the interaction between appraisal and avoidance. Psychological flexibility is the capacity to persist or change behavior in the face of stressors and in the service of long-term valued goals (Hayes, Luoma, Bond, Masuda, & Lillis, 2006). Its absence is the source of psychopathology per Relational Frame Theory, the foundational theory on which Acceptance and Commitment Therapy (ACT) is based. It includes a willingness to experience one's feelings and to take action in the face of distress (e.g., not experiential avoidance)(Bond et al., 2011). Inherent in the willingness to endure one's internal experience is an appraisal, however quick and imperceptible, that one can in fact *cope* with these thoughts, feelings, and physiological sensations. Psychological flexibility also includes action in the face of novel and hence unpredictable stimuli. The construct of *cognitive* flexibility is similar in that it has to do with one's awareness of alternative thoughts and behaviors and willingness to consider those alternatives. However, psychological flexibility is broader and includes behavioral flexibility as well as cognitive flexibility (Palm & Follette, 2011).

The cognitive model is supported by empirical observations of active duty personnel and veterans with PTSD as well as in observed changes associated with PTSD treatment. For instance, flexibility-rigidity as a temperamental trait was a significant predictor, among other predictors, of PTSD severity for 559 active duty military personal with at least one deployment (Escolas, & Escolas, 2015). Here flexibility-rigidity, as measured by the Dimensions of Temperament Scale-Revised (DOT-R), is similar to psychological flexibility and represents the degree to which someone accommodates to changes within the environment. Further, of 579 veterans seeking treatment secondary to combat or sexual trauma those with greater flexibility had lower levels of PTSD (Keith, Velezmoro, & O'Brien, 2015). A person must tolerate or

adjust to a stressful event (e.g., accommodate) to effectively cope—lack of flexibility interferes with that coping process thus contributing to and maintaining traumatic response per the model. Flexibility significantly accounted for PTSD symptom severity even after accounting for avoidance in 125 Operation Iraqi Freedom (OIF)/Operation Enduring Freedom (OEF) veterans (Meyer, Morissette, Kimbrel, Kruse, & Gulliver, 2013). Thus, the self-maintaining cycle of negative coping appraisal and avoidance is not likely a singular latent variable but involves both and separately the lack of flexibility *and* avoidance. Further, cognitive flexibility is not the same latent variable as psychological flexibility as demonstrated by findings that the Cognitive Flexibility Scale (CFS) no longer predicts PTSD severity when the scores from the Acceptance and Action Questionnaire (AAQ), a measure of psychological flexibility, are added to a model in a study on survivors of interpersonal violence (Palm & Follette, 2011). The AAQ scores did, however, predict PTSD severity in this model.

Attentional control. Attentional control (AC) is not explicitly part of the above cognitive model. However, it is a related cognitive function implicated in this model. AC is a central executive function by which a person selects different stimuli for mental processing; one's primary and secondary appraisals are going to depend upon the stimuli that receives attention for mental processing. Attentional control affects memory and anxiety and is elaborated within Attentional Control Theory (Eysenck & Derakshan, 2011). According to this theory, the central executive function must inhibit attention and switch attention in order to perform various tasks. Anxiety interferes with these functions thus affecting cognitive performance. Deficits in attentional control are associated with stress and are possibly due to arousal or intrusions from other sources (i.e., failures of inhibition; Boals & Banks, 2012). Although all of the mechanisms are not yet clear, functional imaging studies suggest attentional

control is implicated in emotion regulation and cognitive appraisal processes (Ochsner & Gross, 2005).

Attentional control is also implicated in PTSD onset and maintenance, as one must attend to new information during stressful encounters to encode it into explicit memory. PTSD is associated with attentional interference from threat-related stimuli (Pineles, Shipherd, Mostoufi, Abramovitz, & Yovel, 2009). However, attentional deficits are not solely associated with external threat-related stimuli. Deficits in attentional control in PTSD are possibly due to arousal or intrusions from other sources as well, such as intrusive thoughts and memories (Bardeen & Orcutt, 2011; Boals & Banks, 2012). For instance, Vietnam veterans with PTSD demonstrated lower attentional control on the Trail Making Test (discussed below) compared to those without PTSD (Beckham, Crawford, & Feldman, 1998). However, attentional control may be altered through effective treatment. The Attentional Control Theory for PTSD etiology is bolstered by the observed effects of multiple treatments. For instance, those in multiple psychological treatments for PTSD, including CBT, cognitive processing theory (CPT), and prolonged exposure (PE), demonstrated improved attentional control over the course of treatment (Walter, Palmieri, & Gunstad, 2010). Attentional control is implicit in Ehlers & Clark's model as one must be able to select which stimuli to attend to in order to interrupt learned experiential avoidance; sustained attention on conditioned stimuli is necessary for the habituation or extinction to occur in PTSD treatment (van der Kolk et al., 2014). In other words, if one cannot attend to information that disconfirms negative coping secondary appraisals (e.g., "I cannot endure this) then one cannot learn a new response to the same stimuli thus maintaining PTSD.

Limitations of Existing PTSD Treatments

There are currently four evidence-based treatments for PTSD: prolonged exposure (PE), cognitive processing therapy (CPT), eye movement desensitization and reprocessing (EMDR), and stress inoculation training (Steenkamp, Litz, Hoge, & Marmar, 2015). PE and CPT, the main EBPs provided by VA, focus on the first and second of three areas of focus recommended by Ehlers & Clark's (2000) cognitive model. In the case of PE, the intervention aims to decrease intrusive re-experiencing through elaboration and integration of traumatic memory into the context of one's previous and current experiences. CPT includes the second aim, to modify problematic appraisals of the trauma and/or its sequelae. Neither of these interventions directly address the third aim, to stop dysfunctional strategies that hinder memory changes, adaptive appraisals, and exacerbate symptoms.

PE and CPT are effective in veterans, producing an average of 30% improvement in PTSD symptoms on the PCL (Karlin et al., 2010). Yet there is also a significant drop out rate, 20%-27.3%, from exposure-based PTSD treatments (Steenkamp et al., 2015; Resick, Nishith, Weaver, Astin, & Feuer, 2010), and over 30% of patients who receive CPT or PE do not improve (Steenkamp et al., 2015). Many veterans are also unwilling or unable to engage in psychotherapy. There are various reasons veterans do not seek or remain in treatment – these include stigma, confidentiality concerns, time demands, belief that treatment is ineffective and that they can address their issues on their own, and discomfort with the therapist (Hoge et al., 2014). Other likely reasons for drop out in exposure-based treatments for PTSD are avoidance and low capacity to tolerate trauma-focused content (Eftekhari et al., 2013; Surís, Link-Malcolm, Chard, Ahn, & North, 2013). Of veterans that meet criteria for mental health problem, only 13%-53% receive care; further, only a third of Iraq and Afghanistan veterans undergoing

treatment for PTSD received minimally adequate care as defined by the number of treatment sessions received (Hoge et al., 2014).

Non-response rates exceed 50% for many treatments per a review of 55 studies of empirical treatments for PTSD that include veteran and non-veteran samples (Schottenbauer, Glass, Arnkoff, Tendick, & Gray, 2008). This meta-study further suggests that cognitive and personality variables may be related to drop-out and non-response. Two-thirds of military-veteran participants in CPT retain a PTSD diagnosis after treatment; fewer studies report on loss of diagnosis for similar samples receiving PE but results suggest the majority of PE participants also retain diagnosis (Steenkamp et al., 2015). Given these many limitations, adjunctive interventions that increase flexibility are recommended for veterans with PTSD (Keith et al., 2015). Increased psychological flexibility is one approach to stop dysfunctional strategies that hinder memory changes, adaptive appraisals, and exacerbate symptoms, the third focus area of Ehlers & Clark's model.

Yoga as Treatment for Stress and PTSD

One potential intervention to treat stress and PTSD is yoga, an approach within the larger set of modalities titled complementary and alternative medicine (CAM). Mental health consumers frequently request CAM interventions such as yoga, to include veterans and active duty personnel, for the purposes of managing stress and stress-related symptoms; further, they are perceived as less invasive and to have fewer side effects than other therapies (Williams, Jr., Gierisch, McDuffie, Strauss, & Nagi, 2011). Therefore, complementary and alternative interventions may provide additional options and support for veterans who have not yet achieved their treatment goals.

For instance, yoga may enhance attentional control. Yoga involves selective attention to interoceptive cues such as body position and breathing. Yoga also involves meta-cognition of one's thoughts, wandering or not, and continued return of attention to the current moment. This focus on selective attention may enhance attentional control (Meyer et al., 2012).

Effects of yoga on stress. Multiple review papers have shown the benefits of yoga in addressing stress as well as its consequences from and impacts on other psychological and physical conditions. A few reviews also offer potential mechanisms of action for yoga. For instance, a review of ten RCTs on yoga as treatment for major psychiatric disorders (e.g., schizophrenia, PTSD) found a pooled mean effect size in outcome measures of −3.25 (95% CI, −5.36 to −1.14; P = .002) (Cabral, Meyer, & Ames, 2011). Another review that is focused on depression, from mild depression without a diagnosis up to non-comorbid MDD, suggests yoga is a plausible treatment here as well (Uebelacker et al., 2010). The authors of this yoga and depression review offer several potential mechanisms of action. Mechanisms include regulation of the hypothalamic-pituitary-adrenal (HPA) axis; regulating neurotransmitters; increased sleep regulation; decreased rumination; altered cognitions such as greater self-efficacy, self-acceptance, and meaning and decreased perfectionism; and behavioral activation. These mechanisms are supported to varying degrees by studies on yoga specifically, or related CAM practices and Mindfulness Based Stress Reduction (MBSR; Uebelacker et al., 2010). Further, controlled studies of yoga have demonstrated improvements in mood and QoL for elderly, caregivers of persons with dementia, breast cancer survivors, and patients with epilepsy (Harvard Mental Health Letter, 2009). The authors of the mood and QoL-focused review suggest these benefits are achieved through modulation of stress through decreased physiological arousal.

Salmon and colleagues (2009) reviewed studies on the effects and mechanisms of yoga as a singular intervention and as included within MBSR. MBSR is an evidence-based intervention for chronic pain and other health issues and includes aspects of yoga, postures and meditation in particular. They found that yoga affects outcomes that may not be the primary complaint associated with an illness, such as improvement in sleep in persons with lymphoma. Of note, Salmon and colleagues' review also shows that yoga has been accepted as an intervention by ethnically diverse populations (2009). Their review goes on to suggest potential mechanisms of change for yoga to include attention-related cognitive processing, such as practicing attention to the moment, movements and physiological sensations, and thoughts and feelings. This is congruent with the Attentional Control Theory described above. Movement in yoga is important as some people may find sitting in meditation too boring —the inclusion of breath and movement provides "activity" on which to focus one's attention (Salmon, Lush, Jablonski, & Sephton, 2009).

Studies suggest that yoga is not only effective in treating mental illness and chronic disease, but also helps to improve the lives of healthy participants. Sharma (2014) reviewed 17 studies published from 2011 to 2013 on CAM effects on stress in healthy participants, including students, employees, and persons recruited from the community at large. Twelve out of 17 studies demonstrated positive changes in psychological or physiological outcome of stress; two showed no change and three had mixed results. Limitations, as with many other CAM reviews, include small sample sizes, lack of comparison conditions in many studies, and failure to identify the school of yoga. Of note in this review, Brazilian army participants showed lower depression, anxiety, and salivary cortisol (an indicator of stress) in yoga compared to physical exercise alone (Sharma, 2014).

Researchers in Britain sought to confirm findings on decreased workplace stress associated with yoga and, further, to simultaneously identify any changes in back pain (Hartfiel et al., 2012). Employees of a British local government were stratified by perceived stress and back pain, two major causes of absence in the workplace, and randomized to yoga or waitlist conditions. The yoga participants received Dru Yoga, which includes graceful movements, directed breathing and relaxation techniques such as visualization and affirmation. The average yoga participation was 21 sessions, taught at work or practiced alone at home, over eight weeks. Those participating in yoga reported lower perceived stress and back pain and improvements in psychological well-being, to include many domains within the Positive and Negative Affect Scale (PANAS-X). The authors did not report covariance of back pain and stress but their group stratification suggests that changes in these outcomes were independent. At a Swedish company, changes in self-report and biological markers of stress were not different between employees randomly assigned to yoga or CBT thus suggesting comparability of these two interventions in at least some treatment outcomes (Granath, Ingvarsson, von Thiele, & Lundberg., 2006). Therefore, yoga is a promising intervention to support workplace productivity and general well being.

Another review among military personnel and veterans (Elwy, Johnston, Bormann, Hull, & Taylor, 2014) found results regarding the limits of existing research similar to those from Salmon et al.'s (2009) broader review on CAM studies. They found that yoga is one of the most frequently delivered CAM practices for veterans yet meditation, imagery, and acupuncture are among the most studied in this population. They, too, recommend that yoga in particular requires more study given its frequent use by veterans and relatively limited extant research. As referenced by Elwy and colleagues' review, a study among active duty personnel deployed in Iraq (Stoller, Greuel, Cimini, Fowler, & Koomar, 2011) demonstrated reduced state and trait

anxiety for those randomly assigned to sensory-enhanced yoga compared to non-yoga where all continued regular physical training. They demonstrated multiple quality of life benefits and decreased anxiety. This study is significant in that military participants were not recruited based on the presence of any particular diagnosis or complaint; they were, however, in the midst of the stress inherent in deployment to a combat zone. Gender had no effect. The fact that gender had no effect is important given that many of the significant studies on the effects of yoga include only one gender.

Possible mechanisms of action of yoga on stress. A few yoga studies have evaluated mechanisms of change while most have measured correlates of change due to study designs. The current design enables a study of the correlates of change that may support future elaboration in mechanistic studies. Many of the above studies suggest improvements from yoga result from balancing of the SNS and PNS. However, several of these studies tangentially suggest that the two correlates of interest in the current study, psychological flexibility (which includes reappraisal and non-avoidance) and attentional control, may be implicated in changes associated with yoga. For instance, decreased rumination recommended by Uebelacker et al. (2010), as discussed previously in section "Effects of Yoga on Stress", may be directly associated with an increase in attentional control or via other mechanisms, such as by decreasing cognitive load. In two controlled studies with non-veteran samples, participants in yoga conditions demonstrated better performance in attentional control, set shifting in particular (Gothe, Pontifex, Hillman, & McAuley, 2013; Talwadkar, Jagannathan, & Raghuram, 2014). Counter to this point, findings in at least one study suggest that improvements in executive function following yoga are due primarily to reduced anxiety and not other mechanisms (Sarang & Telles, 2007).

Other mechanisms suggested by Uebelacker et al. (2010) collectively approximate the construct of psychological flexibility; they include altered cognitions such as greater self-efficacy, self-acceptance, meaning and decreased perfectionism, and behavioral activation. The studies reviewed consider these mechanisms as separate constructs but they may in fact be referring to aspects of the more inclusive construct of psychological flexibility. The above studies on stress and other conditions tend to measure biomarkers and not psychological markers thus limiting current understanding of psychological mechanisms of change. These several reviews indicate there are methodological limitations to studies regarding yoga but overall positive results (e.g., Uebelacker et al., 2010). Mechanisms of change in yoga should be studied further to clarify these positive but mixed results of the effects of yoga.

Effects of yoga on PTSD. Existing studies in different trauma populations have produced mixed results regarding the effectiveness of yoga in reducing PTSD symptoms. Researchers suggest a few mechanisms of action and some empirically test those mechanisms. We will organize these studies by the types of trauma the participants experienced.

Yoga for survivors of mass trauma. PTSD symptoms associated with mass traumas such as natural disasters and genocide decrease with participation in yoga. In one study, male Bihar flood survivors randomized to breath-focused yoga showed significant differences in anxiety and sadness compared to a waitlist control (Telles, Singh, Joshi, & Balkrishna, 2010). The intervention was one hour of yoga each day for seven days provided one month after the traumatic stressor (i.e., the flood). While sadness decreased in the yoga group, anxiety increased in the waitlist group; this suggests a possible prophylactic effect for anxiety following this mass trauma. The researchers also measured heart rate variability (HRV) and breath rate (BR) as potential mediators of changes in trauma symptoms; these mediators were not substantiated.

In another study conducted in South-East Asia, survivors in three refugee camps were each provided a different intervention following a 2004 tsunami (Descilo et al., 2009). One camp received yogic breath training called Breath, Water, Sound (BWS), another received BWS with traumatic incident reduction (TIR; an exposure intervention), and the third was assigned to the waitlist condition. Both the BWS and BWS+TIR groups experienced a significant decrease in PTSD and depressive symptoms compared to the waitlist. The addition of exposure (TIR) to the yogic breathing (BWS) was not associated with significant differences in outcomes. They identified no effects of age or gender. The authors acknowledge that these results are found within a society more familiar with yoga philosophy and techniques, but they point out that similar interventions have been shown to be effective in many societies (Descilo et al., 2009).

A review of studies on Energy Psychology, a set of approaches that include yoga, suggests these decreases in trauma symptoms associated with yoga are achieved through exposure and decoupling of traumatic events and affective arousal (Feinstein, 2008). If this is true then it might explain why the addition of exposure to yogic breath in the Descilo et al. study did not produce significantly different results compared to yogic breath alone. Another review that summarizes findings on yoga for survivors of natural disasters, combat, and terrorism finds that yoga is associated with decreases in trauma-related depression, anxiety, and PTSD, even for those that do not meet criteria for experiencing a traumatic event (Telles, Singh, & Balkrishna, 2012). These researchers speculate the likely mechanisms for change are increases in neurotransmitters GABA, serotonin, and dopamine, which help regulate affect, drive, and arousal.

Trauma related to abuse. Women survivors of both childhood and adult abuse also show changes in multiple outcomes from yoga interventions. For instance, women survivors of spousal abuse reported decreased depression (they did not measure PTSD) in a preliminary study

on the effects of three days of giving testimony and learning yogic breathing techniques, separately and in combination, compared to an inactive control (Franzblau, Echevarria, Smith, & Van Cantfort, 2008). The greatest effect compared to control appeared to be associated with the breathing techniques as opposed to the testimony, although both contributed to improvements. Race, education, number of children under five years old, and veteran-status of abuser did not show effects. These authors suggest breathing may operate through a cognitive-physiological process in which focus on breathing inhibits attention to negative ruminations. In a cross-sectional study, women with childhood or adult abuse experiences who reported incorporating yoga into more aspects of their life (i.e., outside the yoga sessions) showed more benefit in mood, self-concept, and coping style (Dale et al., 2011). Yoga is a promising intervention for women and men as well as disaster survivors with and without PTSD.

Uncontrolled studies of yoga in trauma-exposed veterans. There are an increasing number of studies on the effects of yoga on PTSD symptoms for veterans. The first few of the following studies are not further elaborated here due to the absence of control conditions; they are provided as a sample of the types of yoga available and highlight the need for more rigorous studies. Integrative Restoration yoga (iRest), a form of mindfulness meditation, was provided to military combat veterans in a single group pre-post design study (Stankovic, 2011). In qualitative data veterans reported reduced rage, anxiety, and emotional reactivity, and increased feelings of relaxation, peace, self-awareness, and self-efficacy. In another study using Kripalu inspired yoga for active military personnel and veterans with PTSD, within-subject changes showed decreases in PTSD and no significant change in mindfulness or resilience (Johnston, 2011). In a correlational study, participation in Bikram yoga, a fixed series of poses practiced at 105 degrees Fahrenheit, is associated with lower PTSD and depressive symptoms in active duty

and veterans (Mueller, 2013). The comparison condition was those who do not practice yoga or meditation. This study included self-reported yoga participation frequency and duration compared with responses to questionnaires for PTSD and depression. Of those suspected to have PTSD (a diagnostic interview was not conducted), the frequency of yoga but not the total duration was associated with lower PTSD scores. Among the female participants, duration but not frequency was associated with lower depression scores. Hence, yoga dosage (duration and frequency) may be associated with outcome variability. In yet another study, eight veterans with PTSD participated in MBSR, which includes meditation and Hatha yoga, and showed improvements in PTSD that were clinically significant compared to prior studies. Increases in heart rate variability among these veterans suggested increased PNS activity. The only female was also the only veteran of OIF/OEF, the males were all Vietnam veterans (Bhatnagar et al., 2013).

In one more non-randomized study, veterans with PTSD participated in yoga twice a week for six weeks (Staples, Hamilton, & Uddo, 2013). The classes were based on the yoga tradition of the Krishnamacharya Healing and Yoga Foundation (KHYF). Yoga classes included postures selected specifically to affect PTSD symptoms. PTSD scores did not improve, however, PTSD hyperarousal sub-scores did improve. Subjects reported lower daytime dysfunction and improved sleep. The study was small and short without a control but it shows that a yoga study was feasible and had good adherence; three participants dropped due to pain unrelated to the intervention, side effects of new medication, and a daycare scheduling conflict. Altogether, the authors suggest yoga may increase some neurotransmitters that decrease hyperarousal and in turn improve sleep; the improved sleep in turn supported improved daytime functioning. Results from non-randomized studies suggest possible mechanisms of change and areas for further study.

Randomized trials of yoga. Six randomized controlled studies provide more rigorous tests of the effects of yoga on trauma survivors and provide a more nuanced understanding of possible mechanisms of change from yoga. Van der Kolk and colleagues conducted a randomized study with a more active control condition (2014). The yoga condition was a trauma-informed hatha yoga class one hour long each week for ten weeks. The control condition was a supportive therapy group that included women's health education. Both conditions improved in PTSD in the first half of treatment but the gains were maintained only in the yoga group. There was a greater trend in decreased depression in the yoga group but it was not significantly different than the control. Tension reduction in the yoga group was near a medium effect size (d = -0.44) compared to a non-significant effect size for the control (d = 0.03) as measured by the Altered Self-capacities scale. Van der Kolk and colleagues suggest that, because the treatment included socializing for the control group, that effects from yoga are related to physical and interoceptive aspects of yoga and not social. They suggest yoga poses help participants observe and tolerate physical sensations and thus disconnect emotional reactions to assaults in the past from current physical feelings. Again, there were no differences in drop-out rates between yoga and active control conditions suggesting acceptability of the yoga intervention.

Veteran and non-veteran females with at least sub-threshold PTSD were randomly assigned to a Kripalu yoga condition and assessment control (Mitchell et al., 2014). PTSD scores decreased for yoga and assessment conditions but there was no difference between groups in total PTSD. A significant number of yoga participants reported coping better with their PTSD (92%) while fewer in the control group reported better coping (9%; Fisher exact test, 0.000016; $p < 0.001$). Though not significant, there was a trend toward decreased drug and alcohol use risk

among the yoga participants compared to the control; a study with greater statistical power may have found significant differences. Further, participation in yoga increased after the study, which again suggests adoptability of the intervention. PTSD hyperarousal decreased only for the yoga group, however. Anxiety and depression did not significantly decrease for either group. The authors suggest, largely based on participant feedback, that improvements in the assessment control condition may have resulted from the routine and attention involved in self-monitoring, as well as decreased isolation and stigma through social interaction with participants and researchers. Subjective reports from yoga participants were strongly positive. The positive reports and lack of adverse events at least suggest acceptability of the intervention for this sample of whom most (70.7%) met full criteria for PTSD and over half had experienced sexual abuse before the age of 13 (52.6%) or romantic partner violence (59.5%), experiences for which some providers might presume a largely body-based treatment to be contraindicated.

Mechanisms of change in this RCT were presented in a separate set of analyses (Dick, Niles, Street, Dimartino, & Mitchell, 2014). Expressive suppression decreased for the yoga group relative to the control. Expressive suppression is a presumed inefficient emotion regulation strategy in which one inhibits emotion-expressive behavior while emotionally aroused. This result suggests yoga contributes to a willingness to experience (i.e., not avoid) emotional experience, a component of psychological flexibility. Contrary to their hypotheses, however, the yoga group in comparison to the control group did not significantly increase in reappraisal, psychological flexibility, and mindfulness. They suggest the significant improvement in these variables in the control group, and hence lack of differences between groups, may be due to unmeasured variables. Most pertinent to the present study, only within the yoga group were improvements in PTSD associated with increases in psychological flexibility. The increase in

psychological flexibility may result from instructions in yoga class regarding emotions and sensations to which subjects were averse (Dick et al., 2014).

Sudarshan Kriya yoga, as mentioned above for use in samples of natural disaster survivors, was received by randomly assigned male veterans of OIF/OEF (Seppälä et al., 2014). The active intervention involved three hours per day for seven days of breathing techniques, discussion, and stretching; the control was a waitlist group. Before the end of the study, one person dropped out because he did not like the intervention and 90% remained in the active group; further, most completers (7:9) continued to practice the intervention techniques one year later suggesting acceptability of the intervention. However, amount of practice after the one-week intervention did not correlate with changes in PTSD – hence the benefits of a one-week intervention remained. In the yoga group there was a significant decrease in total PTSD scores, re-experiencing, and hyperarousal but not in avoidance. Active treatment participants also improved in mood and anxiety symptoms and had a lower respiration rate. Reductions in startle were associated with reductions in PTSD hyperarousal scores; to elaborate this point, participants reported "re-experiencing" traumatic memories while in a treatment-induced relaxed state and after the intervention these traumatic memories did not as strongly affect them. Hence, they recommend that the active mechanisms in yoga participation is the decoupling of trauma memories and affective arousal. The authors further suggest the active breath work is particularly beneficial for PTSD clients who tend to be aroused, especially compared to sitting in silent meditation which may be difficult for such clients.

Another study using SKY breath in Vietnam veterans resulted in significantly lower PTSD scores as well (Carter et al., 2013). This sample, however, consisted of veterans who all had PTSD and of whom most were heavy drinkers. The intervention consisted of 22 hours of

training over five days; thereafter they received follow-up sessions weekly for a month, then monthly for a total of six months. The intervention was associated with decreased PTSD and these improvements were maintained six months later. Measures of alcohol use disorder did not decrease. However, it is significant that the yoga intervention contributed to significant decreases in PTSD with the presence of co-occurring alcohol issues as these are often comorbid issues among veterans.

Many of the studies referenced here suggest possible mechanisms of change but few empirically study these mechanisms. Of the twenty studies with trauma-exposed samples in Table 1, only three studies (marked by ❖) evaluated proposed mechanisms within randomized controlled studies. Outcomes in this table are labeled as significant or not significant only if the study was an RCT. The first RCT that studied potential mechanisms found that among a Kripalu yoga group, PTSD improvements were associated with increased psychological flexibility; further, the yoga group decreased in expressive suppression compared to the assessment control (Dick et al., 2014). The second study found that a Sudarshan Kriya yoga (SKY) breath group demonstrated decreased startle response in association with decreased hyperarousal but not overall PTSD, even though overall PTSD was lower within the yoga group. The third and final study found that a trauma-informed hatha yoga group was associated with decreased tension compared to a women's health education group (van der Kolk et al., 2014). Both the Dick et al. (2014) and van der Kolk et al. (2014) studies did not find significant differences in total PTSD compared to control conditions. However, in all three studies the yoga conditions were associated with changes in at least one potential mechanism (i.e., psychological flexibility, expressive suppression, startle response, and tension) different than the control conditions.

Table 1

Proposed Mechanisms of Change from Yoga and CAM Studies for Persons Exposed to Trauma (alphabetical by author)

Source	Study type	Intervention	Population	Outcome	Proposed Mechanism
Bhatnagar et al., 2013	Single-group, pre-post	MBSR (includes meditation and Hatha yoga)	Veterans with PTSD	HRV, PTSD	Increased PNS Activation
Carter & Byrne, 2002	Single-group, pre-post	Iyengar Yoga for depression	Male war veterans (mostly Vietnam) with PTSD	PTSD, depression	None Identified
Carter et al., 2013	RCT, waitlist	SKY	Vietnam Veterans	+PTSD, -depression, -QoL, -alcohol use	Decreased SNS, Improved emotion regulation
Dale et al., 2011	Cross-sectional	Yoga (self-rated level of yoga practice)	Female survivors of abuse	Mood, Self-concept, Coping style, Yoga lifestyle	Decreased Dissociation/ Increased Mindfulness, Autonomic Regulation
Descilo et al., 2009	Non-randomized study	BWS, BWS & TIR (both SKY-enhanced)	Tsunami Refugees	PTSD, Depression, General health	Increased PNS Activation, Vagus Nerve Afferent Pathways
❖Dick et al., 2014	RCT – follow up to Mitchell et al., 2014	Kripalu yoga	Women - Veterans and non-veterans	-Mindfulness, -PTSD, +Suppression, -Reappraisal, -Psychological flexibility	Psychological Flexibility (assoc. with decreased PTSD in yoga grp), Expressive Suppression

Note. + indicates significant findings between groups, - indicates lack of significant findings between groups, ± indicates client perceived improvement, ❖ indicates mechanisms empirically tested, SKY=Sudarshan Kriya Yoga, BWS=Breath Water Sound, HRV=Heart Rate Variability, BR=Breath Rate, TIR=Traumatic incident reduction (exposure), ANS=Autonomic nervous system, PNS=parasympathetic nervous system, iRest=integrative restoration, QoL=Quality of Life, HRV=Heart rate variability, KHYF= Krishnamacharya Healing and Yoga Foundation, OEF=Operation Enduring Freedom, OIF=Operation Iraqi Freedom.

Table 1 (continued)

Proposed Mechanisms of Change from Yoga and CAM Studies for Persons Exposed to Trauma (alphabetical by author)

Source	Study type	Intervention	Population	Outcome	Proposed Mechanism
Feinstein, 2008	Anecdotal	Energy Psychology (Accupressure and imaginal exposure)	Survivors Genocide, War, Natural Disasters	Complex stress reactions, Chronic disorders	Decouple Trauma Memories and Affective Arousal
Franzblau, 2008	RCT, breathing and/or testimony, assessment	Disclosure and/or Yogic Breathing	Women survivors of domestic violence	+Depression	Inhibit Attention to Negative Ruminations (Cognitive Physiological)
Gerbarg & Brown, 2005	Case studies	Yogic Breathing (SKY, BWS)	Natural Disaster Survivors (trauma)	Anxiety, Depression, PTSD	Vagus Nerve Afferent Pathways (ANS flexibility)
Johnston, 2011	Pre-post	Kripalu Yoga	Active Military and veterans	PTSD, Resilience, Mindfulness	SNS Regulation, De-centering, Present-moment Awareness
Mitchell et al., 2014	RCT, Assessment control	Kripalu yoga	Females, Veteran and non-Veteran with at least subthreshold PTSD	-PTSD, -Depression, -Anxiety	None Identified
Mueller, 2013	Correlational	Bikram Yoga	Active Military and Veterans	PTSD, Depression	None Identified (Full manuscript unavailable)

Note. + indicates significant findings between groups, - indicates lack of significant findings between groups, ± indicates client perceived improvement, ❖ indicates mechanisms empirically tested, SKY=Sudarshan Kriya Yoga, BWS=Breath Water Sound, HRV=Heart Rate Variability, BR=Breath Rate, TIR=Traumatic incident reduction (exposure), ANS=Autonomic nervous system, PNS=parasympathetic nervous system, iRest=integrative restoration, QoL=Quality of Life, HRV=Heart rate variability, KHYF= Krishnamacharya Healing and Yoga Foundation, OEF=Operation Enduring Freedom, OIF=Operation Iraqi Freedom.

Table 1 (continued)

Proposed Mechanisms of Change from Yoga and CAM Studies for Persons Exposed to Trauma (alphabetical by author)

Source	Study type	Intervention	Population	Outcome	Proposed Mechanism
Reddy et al., 2014	RCT, Assessment control	Trauma-sensitive Kripalu yoga	Veteran and non-veteran women with at least sub-threshold PTSD	-Substance use, ±PTSD	Improved symptom management contributes to less substance use in PTSD
❖Seppälä et al., 2014	RCT, Waitlist control	SKY	OIF/OEF Veterans	+PTSD, +Mood/anxiety, -Startle, +BR	Decouple Trauma Memories and Affective Arousal, Startle Response
Stankovic, 2011	Pre-post	iRest	Combat Veterans	Qualitative: ±Rage, ±Anxiety, ±Emotional reactivity, ±Relaxation, ±Self-efficacy & ±Awareness	None Identified
Staples et al., 2013	Single group, pre-post	KHYF-inspired yoga	Veterans with PTSD	PTSD, Anger, ±QoL, ±Sleep	Neurotransmitter increases affect arousal > affects sleep > affects daytime function
Stoller et al., 2012	RCT, Treatment as usual	Sensory-enhanced yoga	Military deployed in Iraq	+QoL, +Anxiety	Increased PNS Activation
Telles et al., 2012 (review)	Review	Yoga (meditation inclusive)	Survivors of combat, terrorism, natural disaster	Trauma-related depression, Anxiety, PTSD	Neurotransmitter Increases (GABA, Serotonin, Dopamine)

Note. + indicates significant findings between groups, - indicates lack of significant findings between groups, ± indicates client perceived improvement, ❖ indicates mechanisms empirically tested, SKY=Sudarshan Kriya Yoga, BWS=Breath Water Sound, HRV=Heart Rate Variability, BR=Breath Rate, TIR=Traumatic incident reduction (exposure), ANS=Autonomic nervous system, PNS=parasympathetic nervous system, iRest=integrative restoration, QoL=Quality of Life, HRV=Heart rate variability, KHYF= Krishnamacharya Healing and Yoga Foundation, OEF=Operation Enduring Freedom, OIF=Operation Iraqi Freedom.

Table 1 (continued)

Proposed Mechanisms of Change from Yoga and CAM Studies for Persons Exposed to Trauma (alphabetical by author)

Source	Study type	Intervention	Population	Outcome	Proposed Mechanism
Telles, et al., 2010	RCT, Waitlist control	Breath-focused yoga (Pantajali yoga)	Male flood survivors in Bihar, India	+Sadness, +Anxiety, -HRV, -BR	None Identified
❖van der Kolk et al., 2014	RCT, Women's health education control	Trauma-informed hatha yoga	Women with Treatment Resistant PTSD	+PTSD, -Affect Regulation, -Depression	Interoceptive awareness, Tension Reduction, Affect Regulation, ANS Function

Note. + indicates significant findings between groups, - indicates lack of significant findings between groups, ± indicates client perceived improvement, ❖ indicates mechanisms empirically tested, SKY=Sudarshan Kriya Yoga, BWS=Breath Water Sound, HRV=Heart Rate Variability, BR=Breath Rate, TIR=Traumatic incident reduction (exposure), ANS=Autonomic nervous system, PNS=parasympathetic nervous system, iRest=integrative restoration, QoL=Quality of Life, HRV=Heart rate variability, KHYF= Krishnamacharya Healing and Yoga Foundation, OEF=Operation Enduring Freedom, OIF=Operation Iraqi Freedom.

Correlates of change. There are many challenges to empirical research on yoga given its scope. Yoga is a broad set of practices for physical and psychological wellbeing that include meditation, breathing techniques, yogic postures, and principled living (Gard, Noggle, Park, Vago, & Wilson, 2014). Yoga incorporates many practices that separately and in combinations may contribute to wellbeing. The precise mechanisms of these changes are only partially understood. Further, dosage effects in yoga studies are difficult to control thus further contributing to limitations (Williams et al., 2011). A greater understanding of mechanisms of change in stress and trauma will help identify who in particular may benefit from yoga as well as help clarify which aspects of yoga should receive greater emphasis in yoga classes for veterans.

Gard and colleagues (2014) offer a comprehensive top-down and bottom-up self-regulatory framework to describe the mechanisms by which yoga contributes to psychological health. This framework incorporates six brain networks as well as several cognitive, affective, and physiological processes potentially affected by yoga practice. The three low-level brain networks consist of the dorsal attention network, parasympathetic nervous system/vagal complex, and striatopalladil-thalamocortical network which collectively inhibit inflammation, vaso-/pulmonary contraction, muscle tension and pain. The three high-level cognitive processes consist of the central executive, frontoparietal control network, and moral cognition, which collectively inhibit negative appraisal, emotional reactivity, and rumination. Gard and colleagues propose that yoga contributes to the efficiency, flexibility, and integration of these brain and body systems that in turn inform behavior. These many mechanisms are too broad to address in the present study; this study will focus instead on two functions of the high-level cognitive processes of attentional control and reappraisal, shown in Figure 1, given Ehler & Clark's cognitive model for PTSD symptom onset and maintenance.

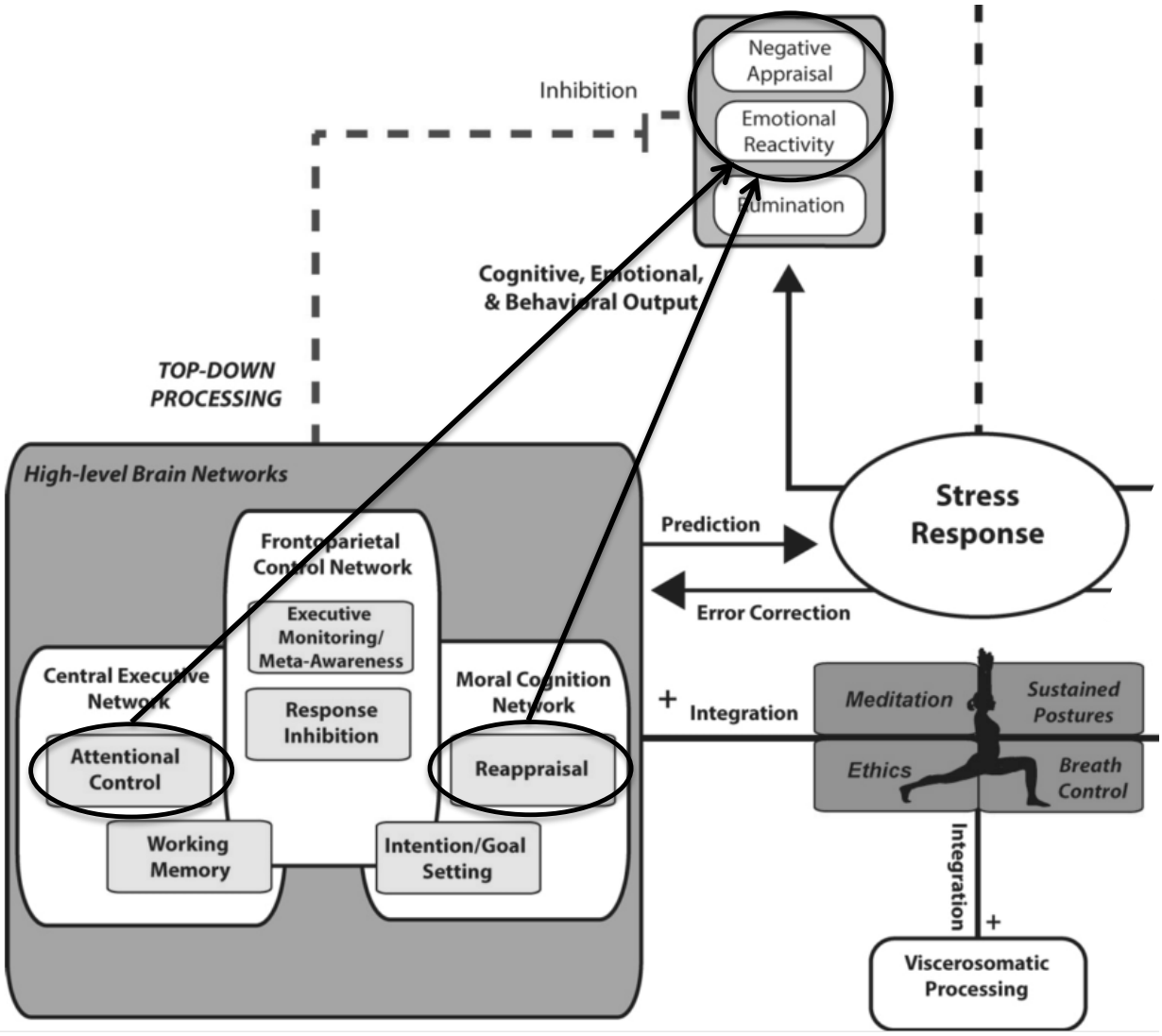

Figure 1. Gard et al. (2014) system network model with cognitive model of PTSD circled.

Further, one must permit and not suppress emotional experience in order for reappraisal to occur (Dick et al., 2014). Psychological flexibility is therefore a potential mechanism in that it includes lack of experiential avoidance and appraisal.

Hypotheses

This study examines five hypotheses regarding predictors of change in PTSD and stress among veterans participating in yoga.

Hypothesis 1. We expect to replicate findings from other studies showing that PTSD and stress will improve over time among veterans participating in yoga.

Hypothesis 2. Greater psychological flexibility and attentional control at baseline will predict improvements in PTSD (hypothesis 2a) and stress (hypothesis 2b). Those who are most flexible and with greater attentional control will be able to attend to and incorporate lessons learned form experiences in yoga class.

Hypothesis 3. Improvements in psychological flexibility and attentional control earlier in yoga (by week 6) will predict improvements in PTSD by week 12 (hypothesis 3a) and stress (hypothesis 3b). As found in Dick et al. (2014), changes in psychological flexibility will be associated with improvements in PTSD. As found in Walter and colleagues' (2010) review of multiple treatments for PTSD, decreases in PTSD severity will be associated with improvements in AC. These early improvements will be associated with better outcomes.

Hypothesis 4. Early improvements in PTSD and stress (by week 4) will predict later changes in flexibility (hypothesis 4a) and attentional control (by session 6) (hypothesis 4b). This hypothesis is the converse of hypothesis 3; hypothesis 4 posits that early reductions in PTSD and stress will be associated with improved flexibility and attentional control.

Hypothesis 5. Openness to experience at intake and prior experience with yoga will predict changes in PTSD (hypothesis 5a) and stress (hypothesis 5b).

CHAPTER II

METHOD

Study Design and Procedures

This is a longitudinal observational study over twelve weeks within an ongoing clinically-based yoga program. This study sought to quantify the benefits of this program for patients with PTSD and other sources of stress, and to examine potential mechanisms of change. Participation in this evaluation did not affect the clinical treatment received. This study was reviewed by the VA Palo Alto Healthcare System Scientific Review Subcommittee and is approved and overseen by the Stanford University Institutional Review Board.

Research Participants

Potential participants were Veterans referred to the yoga program by clinicians at the VA Palo Alto Health Care System (VAPAHCS). They included formerly enlisted or commissioned veterans of the US Armed Forces between the ages of 18 and 89. To be eligible for inclusion in the study potential participants had to have an adequately stable condition and environment to enable attendance at scheduled clinic visits. They had to be able to read, verbalize understanding and voluntarily sign the Informed Consent Form prior to performance of any study-specific procedures or assessments. Those on a psychotropic medication regimen needed to be stable on that medication for at least 4 weeks prior to entry to the study and willing to not change that regimen during the 12-week acute ‘treatment’ phase of the study. Patients were excluded if they were unable to visit the site for study visits and were unable to stand or walk. Participants at risk for suicide were required to establish a written safety plan involving their primary psychiatrist and the treatment team before entering the study.

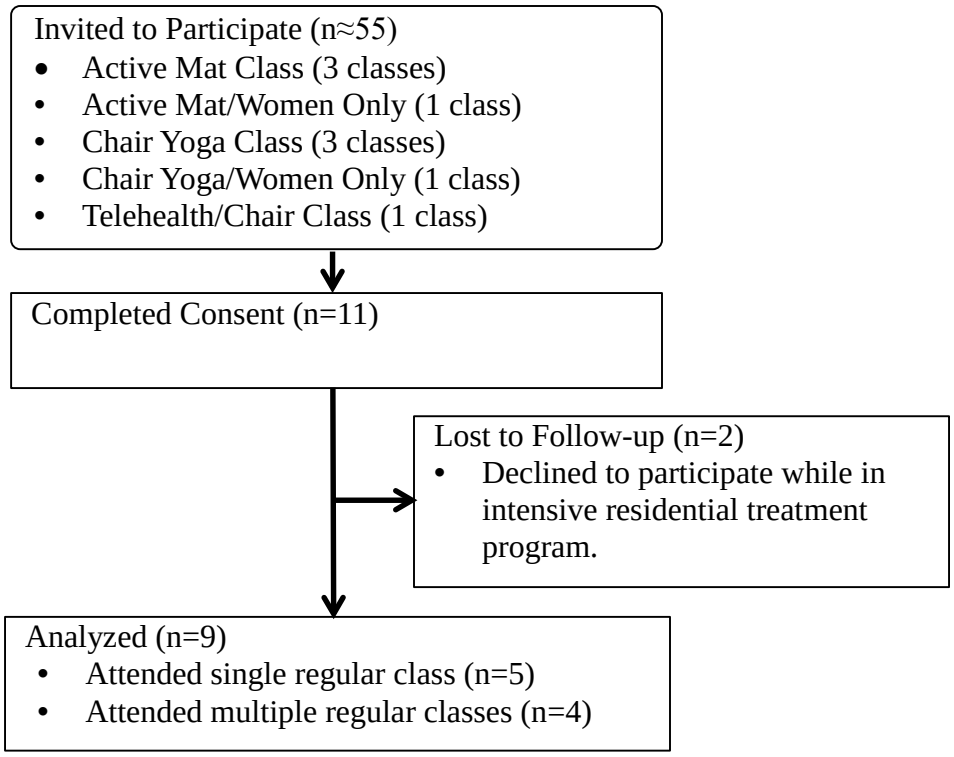

Figure 2. Recruitment and participation consort diagram.

Procedures

The intervention was provided by existing practitioners in the clinical program, and was provided to Veterans regardless of whether they agreed to participate in the research study. Yoga classes were provided at multiple times and locations for veterans receiving services from VAPAHCS. Each class lasted 60 minutes and with typically 5-11 students. Veterans were encouraged to attend as many classes as they like; typical participation is one class per week. However, as depicted in Figure 2 several participants attended different classes from week to week or multiple classes within a single week. Classes are offered five days per week by VAPAHCS and, over the course of the study from time point 1 to time point 5, study participants could attend as few as zero and as many as approximately 60 classes (e.g., five classes per week for 12 weeks). The class was taught by a certified instructor and one assistant and was customized for the veteran by adapting poses for yoga novices. Techniques of controlled

breathing, posture, and meditation are chosen for their potential ability to address physical and psychological issues commonly addressed in yoga traditions. Instructors provided instruction on correct posture, increasing core strength and physical condition. Participants are supplied with props and yoga instructional material to use at home if they so desire.

Consent was acquired and baseline measures were collected at baseline in person. All measures were collected again in person at six weeks. Dependent variable measures are also collected via postal mail at four, eight, and twelve weeks from baseline; the checkmarks in Table 2 indicate the time points for measure collection. Classes were available to participants since before the study began, throughout the study, and after the study completed.

Table 2

Measure Collection Schedule

Measure	Baseline (T1)	Week 4 (T2)	Week 6 (T3)	Week 8 (T4)	Week 12 (T5)
PCL-5	✓	✓	✓	✓	✓
PSS	✓	✓	✓	✓	✓
AAQ-II	✓		✓		
TMT	✓		✓		
NEO Openness	✓		✓		
Exit Questionnaire					✓

Measures

Measures were selected to assess pertinent constructs and to minimize participant burden.

Stress

Stress was measured with the Perceived Stress Scale, a 10-item self-report measure (PSS; Cohen, Kamarck, & Mermelstein, 1983). It is a widely used measure of the perception of stress and indicates the degree to which a person appraises one's life as stressful (e.g., unpredictable,

uncontrollable)(Boals & Banks, 2012). The PSS is reliable (Cronbach's α = .78) and valid (Cohen & Williams, 1988).

Posttraumatic Stress Symptoms

The PTSD Checklist-5 (PCL-5) is a 20-item self-report measure with a total score range of zero to 80, designed to assess the DSM-5 symptoms of PTSD. A cut point of 38 is recommended for a diagnosis of full PTSD (Weathers, Litz, Keane, Palmieri, Marx, & Schnurr, 2013). The PCL-5 has good internal consistency (α = .96), test-retest reliability (r = .84), and convergent and discriminant validity (Bovin, Marx, Weathers, Gallagher, Rodriguez, Schnurr, & Keane, 2015). The Life Events Checklist (LEC), a widely used measure of exposure to potentially traumatic events, will be used in conjunction with PCL-5 to assess criterion 'A' events for PTSD (Weathers, Blake, Schnurr, Kaloupek, Marx, & Keane, 2013).

Psychological Flexibility

Psychological flexibility was measured with the Acceptance and Action Questionnaire – II (Bond et al., 2011). The AAQ-II measures constructs of experiential avoidance and appraisal of one's ability to cope (Meyer et al., 2013). AAQ-II has incremental validity in explaining depression, anxiety, and positive mental health beyond mindfulness measures (Fledderus et al, 2012). This measure also explains variance in PTSD severity above the avoidance symptoms of PTSD (Meyer et al., 2013). The AAQ-II is a psychometrically improved version of the AAQ (Bond et al., 2011). Studies have shown good test-retest reliabilities at three and twelve months with α = .81 and α = .79, respectively, and convergent and discriminant validity (Bond et al., 2011).

Attentional Control

Attentional control was measured with the Trail Making Test (TMT), a valid measure of the executive function of set-switching (Arbuthnott & Frank, 2000). This test consist of two parts, TMT A and TMT B, in which a participant must first connect numbers sequentially without lifting the pencil from the page, then connect numbers and letters sequentially, alternating between them (i.e., switching set). The summary score for comparison purposes was the ratio of TMT B time-to-complete by TMT A time-to-complete (Arbuthnott & Frank, 2000).

Openness to Experience

The Revised NEO Personality Inventory (NEO-PI-R) contains separate scales for each of the "Big Five" personality factors, one of which is Openness to Experience. It is widely used and has significant empirical support (Widiger, 2002). This scale measures aspects of personality that include creativity and curiosity; low openness in personality may present as dogmatic thinking or poor social adaptability (Costa & McCrae, 1992).

Exit Questionnaire

A customized exit questionnaire was provided with the final measures via postal mail to capture additional subjective experiences of participants. The questionnaire consisted of one question and space for free text. The question was, "How much have you benefited from the yoga program?" and included a line to mark from "Very negative impact" to "neutral" to "Very positive." The free text space included the prompt, "Please use the space below to provide any comments, suggestions or feedback about the yoga program." Participants in extant studies reported subjective positive experiences and perceived changes even when measured changes were not significant (e.g., Reddy et al., 2014; Stankovic 2011). Subjective statements may

support greater understanding of the value of this clinical yoga program and reveal benefits not represented in more objective data.

Statistical Analysis

All analyses were conducted using SPSS version 22 (IBM, 2013). Regression analyses were planned to analyze relationships between the predictor and outcome variables. We calculated individual patients' slopes of improvement in stress and PTSD from intake (T1) to the end of twelve weeks (T5). For hypothesis one, the overall effect of yoga, we used regression (with a significance value derived from the t distribution) to test whether the average slopes of improvement over time for stress and for PTSD are significantly different from zero.

For hypothesis 2, effects of initial psychological factors in response to yoga, we initially planned to use regression modeling to predict the slope of PCL changes across time (Hypothesis 2a) (Figure 3a) and PSS changes across time (Hypothesis 2b) (Figure 3b). Predictors in the two regression models were to include the baseline measure of the dependent variable (either baseline PCL or baseline PSS), and TMT T1, AAQ-II T1, and participation (i.e., number of yoga sessions attended). We planned to specifically test whether baseline TMT and AAQ-II have significant effects after adjusting for participation level and baseline scores on the outcome.

Due to having a smaller than anticipated sample size, the analysis plan for hypothesis 2 and subsequent analyses had to be changed. Rather than using linear regression, we conducted multiple pair-wise correlations between each separate pair of predictor and dependent variables. Spearman rank-order correlations were used as a conservative statistical analysis given the low subject count and non-normality of some variables. Spearman calculations indicate significant

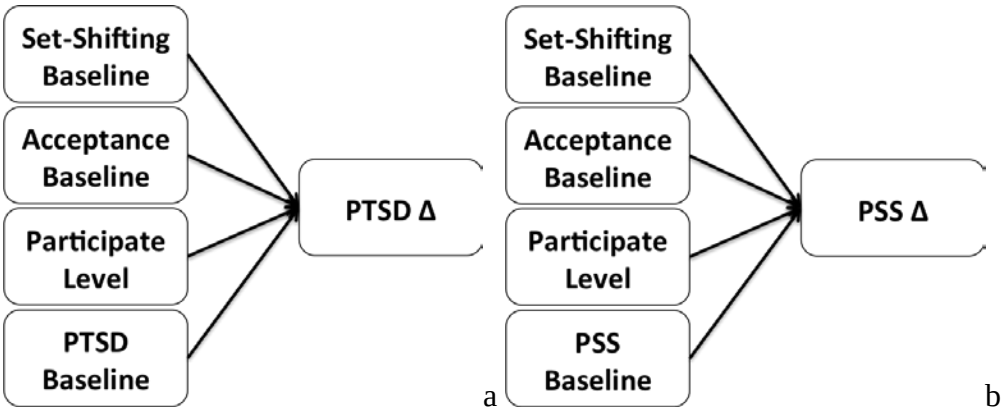

Figure 3. Hypothesis 2 - baseline predictors of change in PTSD and perceived stress.

correlation between variables if, on average, the rank position of the dependent variable for each subject is similar to the rank order of the predictor variable for that subject. Spearman correlation has less statistical power than parametric tests and therefore larger effect sizes must be present to reveal statistically significant results.

We planned two regression models to test hypothesis three, that changes in acceptance and set shifting early in yoga predict the overall rate of improvement in PTSD and stress. The two dependent variables were again PCL change across time (Hypothesis 3a)(Figure 4a) and PSS change across time (Hypothesis 3b)(Figure 4b); calculations utilized both change slope and total change to detect hypothesized signal in this smaller sample. The predictors were T1 TMT, T1 AAQ-II, change in TMT from T1 to T3, change in AAQ-II from T1 to T3, participation level, change in the other DV, and baseline for the DV of interest. The key test was whether change in TMT or AAQ-II scores incrementally adds to either model after adjusting for the baseline covariates and number of yoga sessions attended. As with Hypothesis 2, Spearman rank-order correlations was used to compare each predictor and the DV combination.

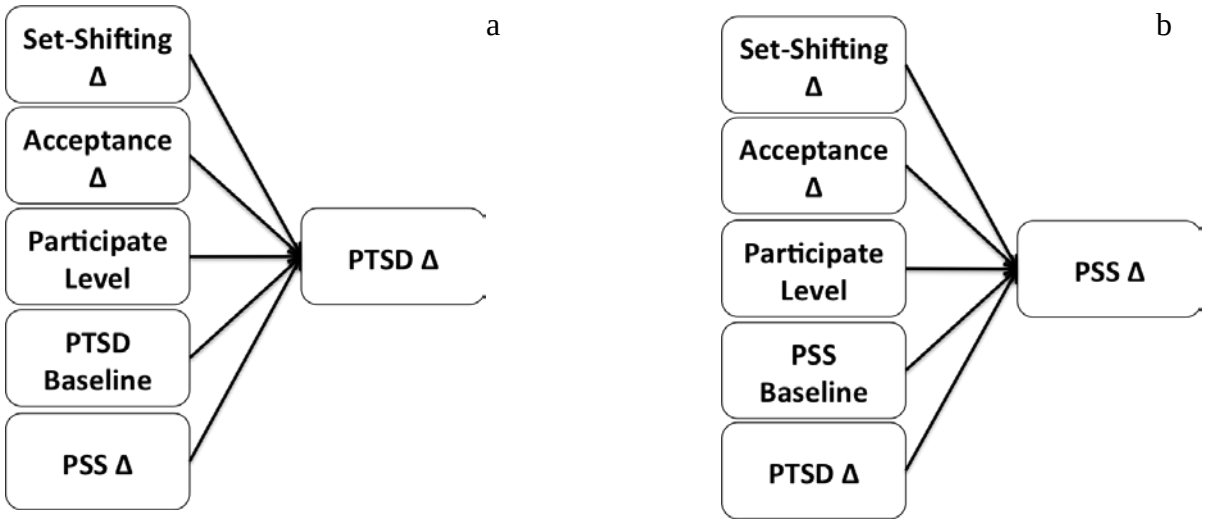

Figure 4. Hypothesis 3 - predictors of PTSD and perceived stress change.

An additional exploratory analysis included a planned regression analysis, ultimately tested with Spearman correlations, with the predictors of early change (T1-T2) and baseline (T1) of PCL and PSS, baseline of TMT, and the dependent variable of change in TMT (T1-T3)(Hypothesis 4a). The same analysis was conducted for AAQ-II, with the predictors of early change (T1-T2) and baseline (T1) of PCL and PSS, baseline of AAQ-II, and the dependent variable of change in AAQ-II (T1-T3)(Hypothesis 4b).

Finally, two regression models were planned to test hypothesis five, that patients with less initial openness to experience and less prior participation in yoga would experience the most improvement in PTSD symptoms and stress; Mann-Whitney non-parametric rank-order comparison was used. Mann-Whitney was selected to compare participants grouped by each of these predictors to identify if subjects respond to yoga differentially based on predictor-group. The DVs were again PCL change (Hypothesis 5a) and PSS change (Hypothesis 5b)). Predictors included yoga participation in the past year, NEO Openness to Experience, and baseline value of

the DV each dichotomized by appropriate delineations or cutoff scores. Participants were dichotomized for prior participation based on relatively naïve, below 10 hours of practice in the past year, compared to non-naïve, 50 or more hours of practice in the past year. Participants were dichotomized by NEO Openness to Experience at or below a T score of 50 compared to above a T score of 50. In terms of PTSD, participants were dichotomized by initial PTSD above or below the recommended PTSD cutoff score of 38 on the PCL-5 (Weathers et al., 2013. Finally, participants were dichotomized by initial stress at above or below the mean PSS-10 score of around 13 (Cohen et al., 1983). Given that participants were in different groups (i.e., participants were taught by different teachers), if there were enough participants in each group it would have been worthwhile to assess group effects as additional predictors. For missing data in the predictor variables, last observation carried-forward (LOCF) was used.

CHAPTER III

RESULTS

Descriptive Analyses

Of the eleven subjects who signed consent forms for this study, ten completed baseline measures, and nine completed at least some measures post baseline. The analyses were conducted on the sample of participants who completed at least one post-baseline measure (n = 9, 82%). The sample characteristics are described below in Table 3. As noted in Table 3, the mean number of yoga sessions during the study was 10.8 with a standard deviation of 7.1.

Shown below in Table 4 are scores on outcome measures for each subject from baseline to the end of the study. Scores for the PCL-5, PSS-10, AAQ-II, Trail Making Test ratio of TMT A to TMT B, and NEO-PI-R Openness scale are provided. Six participants had current or previous diagnoses of PTSD; however, not all participants had PTSD. Therefore, the PCL-5 here served as measure of general distress focused on symptom clusters pertinent to PTSD.

Table 5 includes mean scores and mean change scores for the variables of interest averaged across subjects. The average change slope for PTSD and perceived stress are also provided.

Table 3

Sample Characteristics (n = 9)

Characteristics	Total (%)	Mean (SD)
Male/Female	7 (77.8)/2 (22.2)	
Age (years)		59.8 (11.0)
Education (years)		16.4 (3.1)
Race		
White	5 (55.6)	
Black/African American	1 (11.1)	
Asian	3 (33.3)	
Ethnicity (Hispanic/Latino)	0 (0)	
Life Events Checklist (count of event types)		
"Happened to me"		8.1 (3.4)
"Witnessed event"		2.8 (3.8)
"Learned about it"		.67 (1.1)
"Part of Job"		1.6 (3.9)
Time Between Observations (Days)		30.5 (20.1)
Sessions Between Observations		2.7 (2.9)
Sessions Total During Study		10.8 (7.1)
Prior Year Yoga (hours)		57.7 (46.9)
Prior Year Yoga (days)		54.9 (43.0)
Psychiatric Diagnoses		
Current PTSD Diagnosis	4 (44)	
History of PTSD	2 (22)	
Mood Disorder	3 (33)	
Anxiety Disorder	3 (33)	
Substance Use Disorder	2 (22)	
ADHD	1 (11)	
Sleep-Related Disorders	4 (44)	

Table 4

Changes in Trauma, Stress, and Types of Flexibility Scores for Individual Subjects in Yoga Study

	PCL-5							PSS							AAQ-II		TMT		Open	
Subj.	T1	T2	T3	T4	T5	Δ_{tot}	r	T1	T2	T3	T4	T5	Δ_{tot}	r	T1	T3	T1	T3	T1	T3
1	25	13	7	9	--	-16	-.18	19	15	15	5	--	-14	-.14	44	39	.42	.61	57	56
2	21	12	14	--	9	-12	-.08	11	11	13	--	15	4	.04	51	56	.27	.39	56	54
3	33	30	30	24	40	7	.03	23	21	19	16	29	6	.02	50	48	.43	.21	64	64
4	53	49	51	--	--	-2	-.03	29	33	31	--	--	2	.03	22	22	.53	.75	50	51
5	2	1	2	1	1	-1	-.01	1	4	0	2	4	3	.01	69	70	.58	.52	59	64
6	13	6	7	6	14	1	.01	7	5	8	1	12	5	.02	63	65	.54	.18	44	40
7	8	--	43	11	9	1	-.02	7	--	17	11	12.5	5.5	.04	55	54	.44	.33	76	80
8	54	36	19	22	21	-33	-.26	25	21	13	17	16	-9	-.07	24	26	.33	.44	42	52
9	27	30	17	19	31	4	-.12	21	19	19	18	21	0	-.03	35	33	.60	.38	32	38

Note. PCL = PTSD Checklist for DSM-5, PSS = Perceived Stress Scale 10, AAQ-II = Acceptance and Action Questionnaire II, TMT = Trail Making Test Ratio of TMT A to TMT B tests, Open = NEO PI-R Openness scale T-score, Δ_{tot} = Total change from baseline to final measurement, r = change slope for each participant.

Table 5

Mean Scores and Standard Deviations by Measure for Subjects Across the Yoga Study (n = 9)

	Baseline (T1)	T2	T3	T4	T5	Total Change	Slope Tot.†	T2-T1	T3-T1
PCL	26.2 (18.2)	22.1 (16.6)	21.1 (16.9)	13.1 (8.7)	17.9 (13.7)	-5.7 (12.6)	-.07 (.10)	-5.7 (6.6)	-5.1 (18.5)
PSS	15.9 (9.7)	16.1 (9.6)	15.0 (8.5)	10.0 (7.3)	15.6 (7.8)	.278 (7.04)	-.01 (.06)	-.78 (2.8)	-.89 (6.0)
AAQ	45.9 (16.3)	--	45.9 (17.0)	--	--	0.0 (2.9)	--	--	.00 (2.9)
TMT A/B	.46 (.11)	--	.42 (.18)	--	--	-.04 (.20)	--	--	-.04 (.20)
Open	53.3 (13.0)	--	55.4 (12.9)	--	--	2.2 (4.5)	--	--	2.1 (4.5)

Note. PCL = PTSD Checklist for DSM-5, PSS = Perceived Stress Scale 10, AAQ = Acceptance and Action Questionnaire II, TMT = Trail Making Test Ratio of TMT A to TMT B tests, Open = NEO PI-R Openness scale T-score. † Slope Tot. is mean change over mean time between measures, 30.5 days (i.e., approximately one month). Data missing for one subject, last observation carried forward used.

Primary Analyses

For hypothesis one, the overall effect of yoga, a single-sample t-test revealed a statistically significant change in PTSD symptoms as measured by the regression slopes on PCL-5 over time (t = -2.31, p = .049, df = 8, Cohen's d = .32). This represents a small to medium effect size compared to zero. The individual trajectories (solid lines) and overall average slope (dashed line) are depicted in Figure 5.

The change in overall perceived stress was near zero and not significant (t = -.43, p = .68, df = 8, Cohen's d = .03). Slopes were calculated using average days between outcome measurements. The average time between outcome measurements was 30.5 days (SD = 20.1). The average number of sessions between primary outcome measures was 2.69 (SD = 2.88).

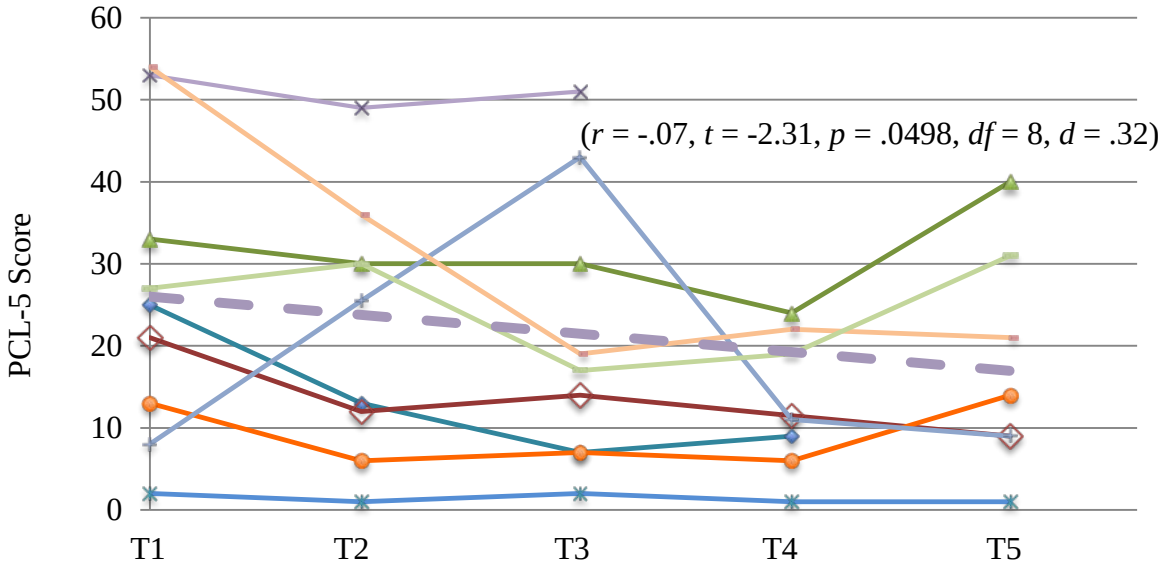

Figure 5. PCL-5 change over time for participants in yoga with washed regression line. Each symbol represents an individual participant.

For hypothesis two, effects of initial psychological factors in response to yoga as measured by PCL-5 and PSS-10, no significant correlations were identified. Of the 4 predictors

none showed significant relationship to the outcome measures based on Spearman ρ calculations. Changes in PTSD scores on the PCL (hypotheses 2a) were not predicted by initial PCL-5 (ρ = -.43, p = .24, df = 8), initial set-shifting (ρ = .37, p = .33, df = 8), initial psychological flexibility (ρ = .62, p = .08, df = 8), nor number of sessions of participation (ρ = -.32, p = .41, df = 8). Similarly, predictors were not significant for changes in perceived stress (Hypothesis 2b). Neither initial PSS-10 (ρ = -.17, p = .67, df = 8), initial set-shifting (ρ = -.08, p = .83, df = 8), initial psychological flexibility (ρ = .28, p = .49, df = 8), nor participation (ρ = -.37, p = .33, df = 8) predicted changes in perceived stress. Test results for Spearman correlations for this and subsequent analyses are represented in Table 6.

Table 6

Spearman Rank Correlations and Probability for Predictor and Dependent Variables (n = 9)

	PCL Slope▯	PCL T5-T1	PCL T5-T3	PSS Slope▯	PSS T5-T1	PSS T5-T3	TMT T3-T1	AAQ T3-T1	AAQ T1
PCL T1	-.43 (.24)	-.23 (.56)	.47 (.20)				.28 (.46)	-.13 (.75)	-.92 (.00)*
PCL T2-T1							-.45 (.24)	-.37 (.33)	
PCL T3-T1						.08 (.83)			
PSS T1				-.17 (.67)	-.34 (.37)	-.10 (.80)	.36 (.34)	-.20 (.61)	-.95 (.00)*
PSS T2-T1							.21 (.58)	.26 (.49)	
PSS T3-T1			-.65 (.06) †						
AAQ T1	.62 (.08) †	.31 (.42)	-.32 (.40)	.28 (.49)	.57 (.11)	.35 (.35)			
AAQ T3-T1		-.36 (.34)	-.39 (.30)		-.36 (.34)	.33 (.39)			
TMT T1	.37 (.33)	.60 (.09) †	.33 (.39)	-.08 (.83)	.07 (.87)	.19 (.62)	-.43 (.24)		
TMT T3-T1		-.78 (.01)*	-.49 (.19)		-.60 (.09) †	-.64 (.06) †			
Open T1	.52 (.15)			.47 (.21)					
Participation	-.32 (.41)	-.49 (.18)	-.02 (.97)	-.37 (.33)	-.38 (.31)			.72 (.03)*	

Note. PCL = PTSD Checklist for DSM-5, PSS = Perceived Stress Scale 10, AAQ = Acceptance and Action Questionnaire II, TMT = Trail Making Test Ratio of TMT A to TMT B tests, Open = NEO PI-R Openness scale T-score. ▯ Slope Tot. is mean change over mean time between measures, 30.5 days (i.e., approximately one month). * Indicates $p < .05$. † Indicates $p < .10$.

For hypothesis three, participation, initial and early acceptance change, and initial and early set-shifting change were partially supported as predictors of change in PTSD and perceived stress. Later changes on the PCL, from time point three to time point five (Hypothesis 3a), were not significantly predicted by initial TMT ratio A/B (ρ = .33, p = .39, df = 8), change in TMT ratio (ρ = -.49, p = .19, df = 8), initial psychological flexibility (ρ = -.32, p = .40, df = 8), change in psychological flexibility (ρ = -.39, p = .30, df = 8), participation (ρ = -.02, p = .97, df = 8), changes in PSS from time points one to three (ρ = -.65, p = .06, df = 8), nor initial PCL (ρ = .47, p = .20, df = 8).

Moreover, later changes in the PSS from time point three to time point five (Hypothesis 3b) were not significantly predicted by initial TMT ratio A/B (ρ = .19, p = .62, df = 8), change in TMT ratio A/B (ρ = -.64, p = .06, df = 8), initial psychological flexibility (ρ = .35, p = .35, df = 8), change in psychological flexibility (ρ = .33, p = .39, df = 8), participation (ρ = .39, p = .30, df = 8), changes in PCL from time points one to three (ρ = .08, p = .83, df = 8), nor initial PSS (ρ = -.10, p = .80, df = 8).

Hypotheses 3a and 3b were also tested using the difference between the baseline and latest available scores (i.e., time point five) on variables of interest to support signal detection in this smaller than planned sample. Spearman ρ showed a significant relationship between total change in PTSD, PCL-5 total at time point 5 minus PCL-5 total at time point 1, and set-shifting, Trail Making Test ratio of TMT A to TMT B at time point 3 minus the ratio at time point 1 (ρ = -.78, p = .01, df = 8). This indicates that an early improvement in set-shifting was associated with an overall decrease in PTSD. Total change in PTSD, at time 5 compared to baseline, was not predicted by initial set-shifting (ρ = .60, p = .09, df = 8), initial psychological flexibility (ρ

= .31, p = .42, df = 8), change in psychological flexibility (ρ = -.36, p = .34, df = 8), participation (ρ = -.49, p = .18, df = 8), nor initial PCL (ρ = -.23, p = .56, df = 8).

These variables were also tested and found insignificant as predictors for total change in perceived stress. Total change in perceived stress, time 5 compared to baseline, was not predicted by initial set shifting (ρ = .07, p = .87, df = 8), change in set shifting (ρ = -.60, p = .09, df = 8), initial psychological flexibility (ρ = .57, p = .11, df = 8), change in psychological flexibility (ρ = .16, p = .68, df = 8), participation (ρ = -.38, p = .31, df = 8), nor initial PSS (ρ = -.34, p = .37, df = 8).

Planned Exploratory Analyses

Two sets of exploratory analyses were conducted. The first set of analyses were planned a priori (see Methods section); the second were conducted post hoc. Planned exploratory analyses addressed predictors of change in set-shifting (Hypothesis 4a) and acceptance (Hypothesis 4b) as well as potential effects of openness to experience. The a priori analysis plan is amended to account for the lower than anticipated subject count. Spearman correlations were used to estimate the relationship between predictors and outcome variables. None of our potential predictors of change in set-shifting (Hypothesis 4a) were supported: the associations of change in set-shifting with initial PCL (ρ = .28, df = 8), change in PCL from time one to two (ρ = -.45, df = 8), initial PSS (ρ = .36, df = 8), change in PSS from time one to time two (ρ = .21, df = 8), and initial set-shifting (ρ = -.43, df = 8) were all non-significant. None of our theorized predictors of changes in acceptance (Hypothesis 4b) were supported either. Change in acceptance was not predicted by initial PCL (ρ = -.13, df = 8), change in PCL from time one to two (ρ = -.37, df = 8), initial PSS (ρ = -.20, df = 8), nor change in PSS from time one to two (ρ = .26, df = 8).

For Hypothesis 5, separate Mann-Whitney rank-order independent samples tests were used instead of regression models due to the low subject count. A Mann-Whitney independent samples non-parametric test was conducted to compare changes in PTSD and perceived stress for participants with little yoga practice in the past year with those that had more practice. Participants were split into two groups: treatment naïve (i.e., below 10 hours of yoga in the past year; n = 3) and treatment experienced (i.e., 50 or more hours of yoga in the past year; n = 6). The individual subjects' hours of yoga practice in the past year and class participation during the study are listed below in Table 7. Results indicated reject the null for both PTSD and perceived stress. Yoga naïve participants had, on average, more reduction in PTSD (p = .02) and perceived stress (p = .02) over the course of this study. These aggregate results are shown graphically in Figure 6.

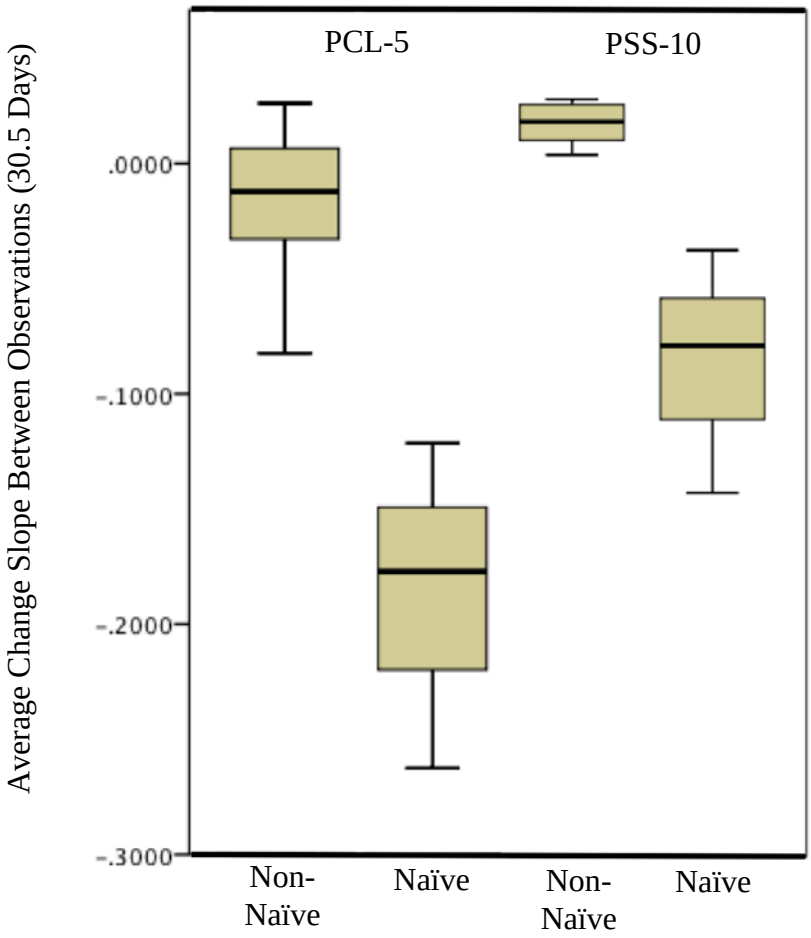

Figure 6. Hypothesis 5 – box plot of naive vs. non-naive changes in PCL-5 and PSS-10.

If we look in more detail at the individual trajectories depicted in Figure 7, we see that the significantly greater improvements among yoga-naïve participants are driven largely by subjects 1 and 8. Of all the study participants, Subject 1 had by far the largest dose of mental health care other than yoga (see Table 7). It is therefore unclear how much that person's improvement in PTSD symptoms can be attributed to yoga specifically. In contrast, subject 8 had only two sessions of psychotherapy, so most of the treatment that person received was yoga.

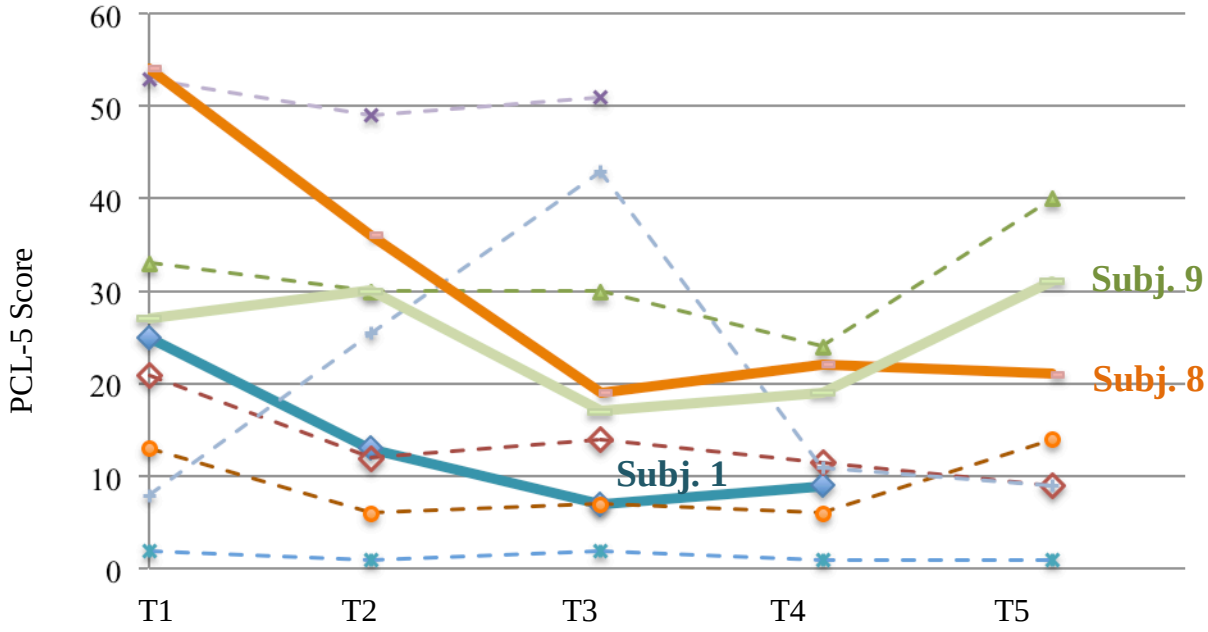

Figure 7. Change in PCL-5 scores with yoga-naive participants solid lines.

The other anticipated predictors of changes in PTSD (Hypothesis 5a) were not supported; NEO Openness to Experience (fail to reject the null), and baseline PTSD (fail to reject the null) were not significantly associated with change in PTSD. Subjects were dichotomized by a T-score at or below 50 versus a T-score above 50. The other anticipated predictors of changes in perceived stress were also not supported; these are NEO Openness to Experience (fail to reject the null), and baseline PSS (fail to reject the null).

There were not enough participants in each teacher group to assess group effects as potential additional predictors.

Table 7

Subjects' Prior Yoga Experience and Participation During Yoga Study

Subj.	Yoga Hrs Prior	Naïve	Study Days	Class Count	Psychotherapy		Mental Health Diagnoses
					Individual Sessions	Group Sessions	
1	4	Y	76	6	0	56	PTSD, Social Phobia, Nicotine Use Disorder, Alcohol Dependence
2	110	N	157	13	0	1	Insomnia
3	60	N	137	3	0	0	PTSD, Insomnia, Mood Disorder NOS, MCI
4	50	N	44	7	2	4	PTSD, GAD Hx, Alcohol Dependence, Mood Disorder NOS, Anxiety Disorder NOS
5	100	N	106	21	0	0	None
6	60	N	101	12	0	0	PTSD Hx, OCD, Hoarding Disorder
7	125	N	99	1	0	0	PTSD, Bipolar I Disorder in Full Remission, Claustrophobia
8	9	Y	110	23	2	0	GAD, Insomnia, ADHD
9	1	Y	115	11	3	0	PTSD Hx, GAD Hx, Parasomnia, MCI, Depression NOS Hx

Note. Yoga Hrs Prior = Number of hours of yoga practice in the past year. Naïve = Yes/No client has practiced less than 10 hours of yoga in the past year. Study Days = Total time between baseline measures and final measures. Class Count = Total number of yoga classes between baseline and final measures. Psychotherapy Sessions = total sessions during period of study observation. Mental Health Diagnoses = diagnoses listed in medical chart from 4 weeks prior to baseline measure to final measure (T5). PTSD = Posttraumatic Stress Disorder. MCI = Mild Cognitive Impairment. OCD = Obsessive Compulsive Disorder. GAD = Generalized Anxiety Disorder, ADHD = Attention-Deficit/Hyperactivity Disorder. Hx = "history of".

Post Hoc Analyses

Post hoc analyses were conducted to explore understanding of the relationships between multiple variables identified in the a priori hypotheses. These post hoc analyses were developed based on findings and recommendations from previous research discussed above. Previous

research demonstrated that improvements in PTSD for yoga participants, and not for an assessment control condition, were associated with increases in psychological flexibility (Dick et al., 2014). Further, in the present study yoga-naïve participants experienced greater improvements in PTSD (i.e., Hypothesis 5a). Level of yoga experience and practice, therefore, may be predictive of PTSD through psychological flexibility, both at baseline and changes over time. The absence of a control condition in the present study along with evidence of overall decreases in PTSD suggest additional analyses are necessary to identify potential effects of psychological flexibility. To that end, Spearman ρ was used to compare psychological flexibility with yoga experience, initial PTSD and perceived stress, and amount of yoga participation during the study. Greater prior yoga practice predicted greater psychological flexibility (ρ = .70, p = .04, df = 8). Greater psychological flexibility at baseline (i.e., AAQ at time point 1) also predicted lower PTSD (ρ = -.92, p < .01, df = 8) and lower perceived stress (ρ = -.95, p < .01, df = 8) at baseline. Finally, higher participation in yoga across the period observed predicted greater improvement in psychological flexibility (i.e., AAQ-II at time point 3 minus time point 1)(ρ = .72, p = .03, df = 8). These correlations suggest more yoga practice is associated with psychological flexibility, and more psychological flexibility is associated with lower stress and PTSD for veterans participating in yoga.

Post-hoc analyses were also conducted to elaborate effects of set-shifting. Hypothesis 3a analysis revealed that early changes in set-shifting predicted overall changes in PTSD. At the same time, Hypothesis 2a analysis indicated baseline set-shifting did *not* predict overall changes in PTSD. Any effects of baseline set-shifting as a predictor of changes in PTSD, therefore, should be accounted for and may be revealed at different time points other than between baseline and final. To that end, Spearman ρ was conducted for baseline set-shifting as a predictor of

changes in PTSD from baseline to each of the other time points (i.e., T2, T3, and T4). Lower initial set-shifting predicted greater PTSD improvement between the first two time points (ρ = .75, p = .02, df = 8); the four cases with lower baseline set-shifting are highlighted in Figure 8 and each demonstrated PCL-5 improvements T1 to T2. Initial set-shifting did not predict changes in PTSD from baseline to time point three (ρ = .40, p = .27, df = 8) or time point four (ρ = .44, p = .24, df = 8). Post-hoc analyses revealed that early changes in PTSD, from time point one to time point two, were predicted by baseline set-shifting.

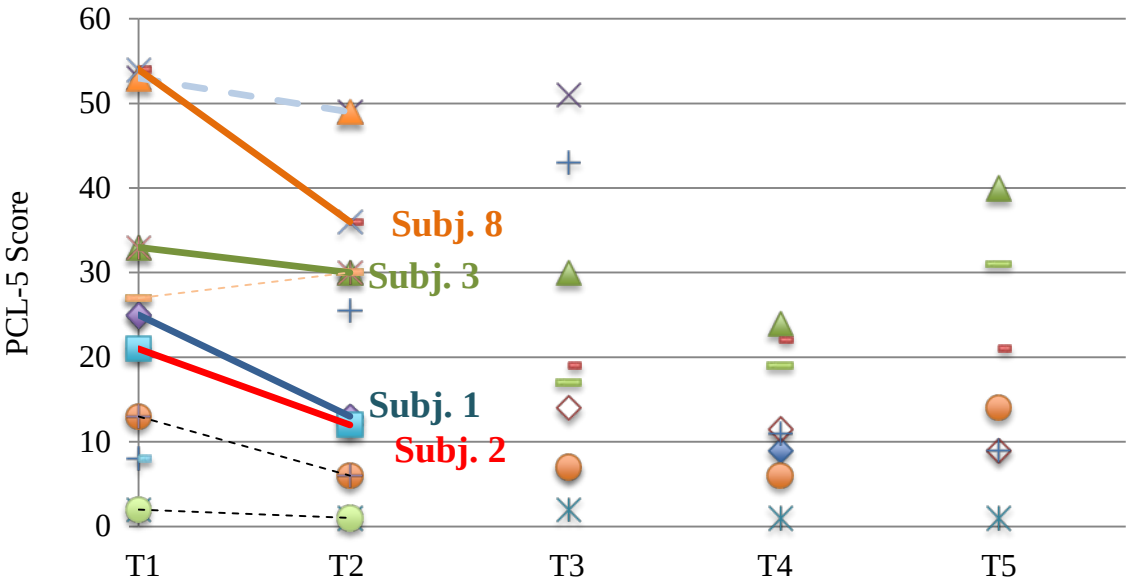

Figure 8, Post hoc hypothesis 7: PCL-5 change by T2 (lower baseline set-shifting solid lines).

Exit Questionnaire Results

Finally, the exit questions revealed generally positive responses from veterans. Subjects used a pen to mark a line from 'very negative' to 'neutral' to 'very positive' impact in response to the question, "How much have you benefited from the yoga program?" The average response, as depicted in Figure 9, was 80% of the distance from neutral towards the "very positive impact"

(*n* = 7) with no responses below neutral.

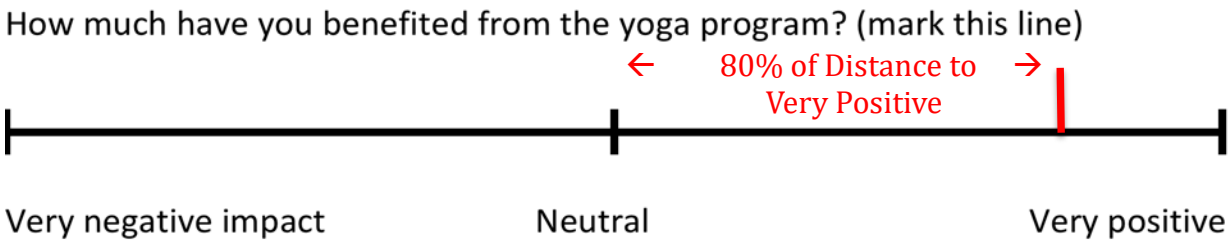

Figure 9. Exit questionnaire average response.

Two subjects did not respond to the final questionnaire; one could not be reached, possibly due to a transfer to unstable housing after discharge from a residential program, and the other continued in the yoga program but did not respond to study correspondences – no reason was provided. The written response included the following (n = 6): "Yoga is the most relaxing life activity that I've done so far," "Physical injury has kept me from yoga for 2 months," "I look forward to each session of yoga because of its calming effect," "Yoga has restored my zest for life health, and peace of mind," "Yoga is helping me move in the right direction by relaxing and slowing down," and "It help [sic] me to be more calm and concentrate. I hope they will keep this program, for our veterans like me." The overall perceptions of yoga by veterans in this study were very positive.

Case Examples

A closer look at a few cases provides a means to identify how individuals are affected by participation in yoga. Subject 1 had multiple diagnoses, to include PTSD, and was undergoing intensive residential treatment for substance abuse. He attended 56 group therapy sessions while in this program and received support from an individual case manager and a therapeutic milieu. He was yoga-naïve with four hours of yoga in the past year and he attended 6 yoga sessions during this study. He experienced the second-highest decrease in PTSD symptom measurement

and the highest decrease in perceived stress. While we cannot separate that effects of yoga from other treatment, yoga may have supplemented his psychotherapy and produced greater improvements through the combination of yoga along with psychotherapy. Another possibility is that the yoga enhanced his ability to endure or participate in the residential treatment program through mindfulness and exercise. This person's psychological flexibility decreased while set-shifting improved. The decreased psychological flexibility is not explained by theories presented herein whereas the improved set-shifting is explained. This case is a good example of the acceptability of yoga along with other treatments.

Subject 5 represents a distinctly different case. This person had no psychiatric diagnoses and received no other treatments during the study. He was experienced in yoga with 100 hours of practice in the past year and he attended 21 sessions during the study. His responses to PTSD and perceived stress measures remained low throughout. Set-shifting and psychological flexibility were relatively stable compared to other participants. He marked the exit questionnaire line at 88% towards "very positive impact" on his life and did not provide additional comments. This case demonstrates that a veteran can have a very positive experience from yoga even when formal symptom measures do not reflect change. Further, veterans with and without diagnoses perceive benefits from yoga.

The case with the second highest decrease in perceived stress was subject 8. She also had the greatest change in PCL-5 although she did not have a PTSD diagnosis. She did have multiple other anxiety and sleep-related psychiatric diagnoses, so it is likely that in her care case the PCL-5 served as a measure of general distress. Like subject 1, she was yoga-naïve with nine hours of practice in the past year. She participated the most in yoga at 23 sessions during the study. Her psychotherapy during the study was limited: individual psychotherapy with one therapist ended

the week she entered the study and therapy began with another therapist the week of final measurement. During this time, she improved in set-shifting and psychological flexibility. In her exit questionnaire response she wrote, “Yoga is helping me move in the right direction by relaxing and slowing down.” Her case is an example of improvement in a veteran without PTSD.

CHAPTER IV

DISCUSSION

In the present study, self-reported PTSD symptoms decreased on average while participating in yoga while perceived stress did not change on average. Further analysis revealed that changes in PTSD and perceived stress may be predicted by level of yoga participation such that yoga naïve participants had more reduction in PTSD symptom-related distress and perceived stress over the course of the study. These significant results were found despite the small sample size. These veterans were in a voluntary clinical yoga program and continued participation in psychological and physical health care activities outside of the yoga program. The improvements in PTSD symptoms are therefore only *possibly* related to participation in yoga. However, the present improvements in PTSD are congruent with previous outcomes from randomized-controlled trials on non-veterans (van der Kolk et al., 2014) and veterans (e.g., Carter et al., 2013; Reddy et al., 2014; Seppälä et al, 2014) in which measured and subject-perceived PTSD decreased.

These results are incongruent with an RCT with a sample that included both veterans and non-veterans, with at least sub-threshold PTSD, which did not find changes in PTSD (i.e., Mitchell et al., 2014); however, the follow-on study to Mitchell et al. (2014) demonstrated that changes in PTSD were associated with changes in psychological flexibility for those participating in yoga (Dick et al., 2014). These findings are supported by the present study in which subjects with more yoga practice in the prior year reported higher psychological flexibility. Further, subjects with greater flexibility at baseline had lower levels of PTSD and perceived stress at baseline. Further still, more yoga participation over the period observed was associated with greater psychological flexibility. A convergence of evidence tentatively supports the

hypothesis that psychological flexibility is a mechanism of change for improvements in PTSD for those participating in yoga. These findings lend credence to the theory that participation in yoga contributes to decreased experiential avoidance and reappraisal of one's ability to endure distress.

Set-shifting also predicted changes in PTSD but across a different temporal sequence. Lower initial set-shifting predicted greater PTSD improvement, but only between the first two time points. Additionally, greater improvements in set-shifting predicted greater overall improvements in PTSD. These results may be related to the fact that those with lower initial set-shifting had the most room for improvement in set-shifting. However, previous controlled studies with non-veteran samples demonstrated that participants in yoga conditions demonstrated better performance on set-shifting (Gothe, Pontifex, Hillman, & McAuley, 2013; Talwadkar, Jagannathan, & Raghuram, 2014). Therefore, if yoga does contribute to improved PTSD through set-shifting, those improvements may largely occur as a result of early improvements in set-shifting related to yoga participation. These findings are particularly important given that set-shifting is a measure of attentional control and, in turn, attentional control is implicated in emotion regulation via top-down inhibition of emotional responses. This process is congruent with Gard and colleagues (2014) regulatory framework for mechanisms of wellbeing through yoga.

In the present study, those who had little yoga practice in the past year had, on average, greater improvements in PTSD when the subjects were dichotomized by relatively naïve versus experienced in yoga practice. This suggests the possibility of greater PTSD reduction over the first twelve weeks of practice for treatment naïve practitioners. Overall, subjects in this study showed an average decrease in self-reported PTSD symptoms while participating in yoga;

findings suggest yoga-naïve status, psychological flexibility, and set-shifting are all possible mechanisms of change.

Perceived stress did not significantly change on average in the current study. The lack of average overall change may be due to some people improving while others worsened. Again, however, there were significant changes in perceived stress associated with yoga-naïve status. When dichotomized by relatively naïve versus experienced in yoga, those who had little yoga practice in the past year had an average improvement in perceived stress. This combination of results is due possibly to a few factors. For instance, scores on the perceived stress scale are influenced by events and circumstances on the days the measure is completed; some subjects may have experienced more stressful events on the days measured. For instance, several subjects completed measures over months leading up to the U.S. holiday season (i.e., November and December) – anecdotal evidence suggests stress tends to increase for veterans over this period. Further, perceived stress consists of a combination of significant events and one's perception of his or her capacity to endure those stressful events. Thus participants' perceptions of capacity may have maintained while objectively stressful events increased. If so, subjects may have scored even higher on perceived stress had they not been participating in yoga, which would suggest a stress inoculation effect. At face value these findings suggest, as with PTSD change, treatment naïve participants experience more benefit in perceived stress when compared to those with more yoga practice (i.e., greater than 50 hours) in the past year.

Baseline scores and early changes in predictors of interests (i.e., psychological flexibility, set-shifting, and participation) were not associated with change slopes in the primary outcomes, PTSD and perceived stress. These non-significant findings may be due to co-variance of predictors that are not revealed in bi-variate analyses. In other words, no single variable in this

model predicts responses to yoga but rather they predict responses as co-variables, congruent with the hypotheses of the present study and as demonstrated by the amended analysis plan. There is less statistical power in the multiple, non-parametric bi-variate correlations used in place of the a priori analysis plan of multiple linear regressions. A single analysis with multiple co-variates would potentially reveal more complex and subtle relationships to the PTSD and perceived stress associated with yoga participation. Additionally, significant findings may not have been found for predictors of perceived stress change because perceived stress did not change, on average, in this sample. Of course, there may not be any relationship between these measures, but supporting theory, previous studies, and other findings in the present study suggest such relationships are possible.

Openness to experience did not predict changes in PTSD or perceived stress. These findings suggest that benefits from yoga may not be related to veteran's lower openness as predicted in the present study. This hypothesis was derived from the author's anecdotal observation that veterans with closed body language and negative perceptions about yoga in their first classes, conceptualized as low openness to experience, tended to quickly engage with yoga and articulate benefits from their participation. These behaviors may be conceptualized more accurately as a reflection of beliefs about mind-body interventions in general or yoga in particular. Openness as a personality trait may therefore not have significant implications in benefits from yoga for veterans. However, the sample is limited in that participants had already elected to participate in a yoga program and in the study; this self-selecting group may be similar in levels of openness to experience thus affecting analyses.

The veterans in this study articulated very positive subjective experiences from participation in yoga. Most comments were about a sense of calmness. One participant had not

attended yoga for two months due to an injury; details of this injury were not provided. However, a physical injury would prevent participation in yoga only if the veteran, due to injury, could not travel to the yoga class or could not remain in the yoga class for any significant period of time. Otherwise, physical injury does not prevent participation in yoga as physical postures are offered but not required by yoga class participants. The other responses were strong endorsements for the value veterans receive from yoga. The enthusiasm conveyed by the veterans suggests, as reported in previous studies, the acceptability of yoga as a treatment.

Clinical Implications

There are several clinical implications if the present findings are replicated in a larger study. First and foremost, yoga is one intervention that can help reduce PTSD symptoms, with or without concurrent other treatments. This treatment option is particularly important given that not all veterans are wiling to participate in currently available PTSD treatments nor do all who participate show improvements. Further, since more gains were observed for yoga-naïve participants, simultaneous prescription or recommendation of yoga may support some symptom relief earlier in treatment for veterans initiating any PTSD treatment. Yoga has broad effects. It may help stress and PTSD symptoms, but it also helps in other ways that were not measured in this study. Hence even people who did not show measurable changes in stress and PTSD often reported finding yoga helpful.

This study suggests yoga as a treatment for stress may be useful, particularly for those with little prior yoga experience. Some veterans may have the misperception that they must "be good" at yoga through long practice to gain benefit. In most yoga traditions, there is no "being good" at yoga – there is only the practice of yoga. Veterans who express uncertainty over the potential for improvements through yoga may be assuaged with this knowledge. They may be

further relieved to know that yoga practice does not require they have any special knowledge or abilities. Therapeutic benefits through yoga are potentially available to any veteran. Further, large improvements in measures of distress occurred for several participants between seeing psychotherapists, which suggests that a veteran might benefit from yoga BETWEEN other episodes of care. Wait times between available services at the VA may therefore be a good time for veterans to be encouraged to participate in yoga.

The current findings may help streamline the broad set of yoga practices for veterans with PTSD and stress by focusing yoga classes more specifically on psychological flexibility. For instance, Acceptance and Commitment Therapy (ACT), a therapy designed to enhance psychological flexibility, leverages six core principles in the service of psychological flexibility. These core principles are Acceptance, Being Present, Cognitive Defusion, Self-as-Context, Committed Action, and Defined Values. Yoga teachings include these principles, among others, in various ways. Given the implications of the present study and previous research, yoga and its broad practices may be more effective for clients referred for PTSD and stress if classes were structured to specifically address these ACT core principles and thus enhance psychological flexibility. One example of the relationship between ACT and yoga principles is depicted in Figure 10; this Venn diagram, or Yoga Hexafoil, shows the overlap of ACT principles with some yoga concepts.

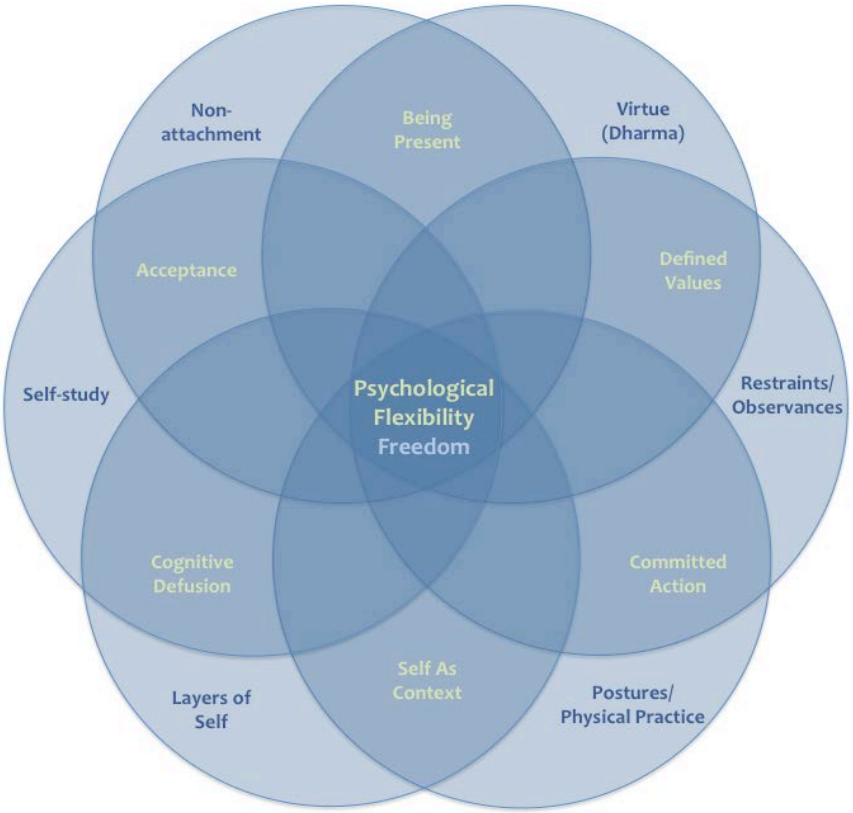

Figure 10. Yoga hexafoil (green/light text = ACT principles, blue/dark text = yoga skills and principles).

ACT therapy guides and yoga texts and training provide means of addressing these principles in yoga classes. Teachers may choose to develop classes with particular attention to these practices for veterans referred for PTSD and stress.

Personality, at least openness to experience, may not be a useful factor to consider in selecting veterans for referral to yoga programs. Openness was not observed as a significant predictor of change in PTSD and perceived stress in the current study. If this finding is replicated in other studies, healthcare providers may choose to refer veterans to yoga regardless of their apparent or measured openness to experience. Openness may not be implicated in participation in yoga nor willingness to participate in yoga.

Yoga, when prescribed, may be prescribed with a recommendation of regular practice instead of sporadic practice for optimal gains. The present study revealed that more prior practice among these subjects predicted greater psychological flexibility, greater psychological flexibility predicted lower baseline PTSD and stress, and more yoga practice predicted greater improvements in psychological flexibility. The optimal yoga dosage was not evaluated but, in general, more appears to be better. Clinicians referring to yoga may encourage more frequent yoga practice as opposed to less. The findings in the present study, if replicated in a larger randomized trial, support healthcare providers in informed referrals for veterans to yoga as well as clinical yoga programs in selecting content for veteran yoga classes.

Limitations and Recommendations for Future Research

Existing research and theory offer many potential mechanisms through which yoga may contribute to wellbeing. The current study, while it supports some previous findings, is not controlled and therefore observed changes may be completely due to treatment and circumstances outside of yoga classes. Observed benefits from yoga may result, for instance, from a therapeutic space in which healing processes are facilitated. While there is been greater yoga research in the past decade there are still more questions than answers. In particular, mechanisms might be elaborated through a trial with randomized assignment to comparison conditions of exercise, existing empirically supported psychotherapy, or both. This would provide greater ability to attribute gains and mechanisms of change to yoga specifically.

Future research should incorporate lessons learned from the present research. For instance, a follow-on study should have less restrictive criteria and expand recruiting to include those not currently in the clinical yoga program. Further, gains related to yoga may occur over different periods. For instance, gains in PTSD may be more readily measured with treatment

naïve subjects as suggested in findings of the present study. Further, improvements related to stress may occur over longer periods. Some analyses revealed significant outcomes based on slopes of change (e.g., slope of PTSD change overall) while others reveled significant relationships based on total change from baseline to final measure (e.g., comparison of prior year yoga experience to PCL/PSS). Future studies with few participants may choose to use total change scores in analysis plans instead of change slopes.

Perceived stress should be measured more frequently if change slopes are to be used in analysis. Not only do subjects' coping resources affect perceived stress as measured by the PSS-10 but so do daily hassles and major events (Cohen, 1994). These daily changes may contribute to significant variability in PSS scores on any particular day of measurement. More frequent completion of the PSS-10 may provide a more robust measure of changes in perceived stress across future studies. Additionally, if yoga does contribute to stress inoculation, then measures of perceived stress from subjects in a comparison condition would help clarify such effect.

Because we did not limit this study to people with PTSD diagnoses, and we did not anchor the PCL-5 to a specific traumatic event, the PCL-5 may have served as a measure of general distress and not PTSD per se. Yoga appears to be useful for stress reduction and it is promising that PTSD measurement response showed improvement. Future studies focused more specifically on PTSD may clarify benefits of yoga with larger samples of subjects with current PTSD, a history of PTSD (i.e., not current), and without PTSD diagnosis.

Openness to experience did not capture the beliefs and behaviors observed in yoga classes by the author. The anecdotal behavioral observations of the present author may have been inappropriately conceptualized as lesser or greater openness to experience. Future research may be better served by a measure that more directly addresses veterans' attitudes, such as the

Beliefs About Yoga Scale (Sohl, Schnur, Daly, Suslov, & Montgomery, 2011). These beliefs may be associated with initial engagement with yoga, participation in yoga, and changes in outcomes such as PTSD and stress. Such relationships are important as current findings support the amount of practice as a factor that affects change.

Frequency and duration of yoga practice should continue to be measured in similar studies. One yoga study with military service members found that frequency, but not duration, was associated with improvements in PTSD (Mueller, 2013). The present study used the variable 'hours of practice', instead of days or frequency, before baseline and during the period observed to test hypotheses. Different measures of participation may have yielded different results. Further, yoga may be practiced in a clinical program, at a community facility, or at home. Yoga practice outside of the clinical yoga program was not measured in the present study. This yoga practice outside the clinical program, if any, should be recorded in future studies since yoga dosage appears to be implicated in treatment outcomes. Future research may also evaluate the optimal yoga practice frequency for PTSD and stress treatment.

This study on potential mechanisms of change in PTSD and stress for veterans participating in yoga resulted in some significant findings despite the small sample size. The present findings in the context of the presented theories and prior research suggest additional research is warranted. Particular attention should be paid to psychological flexibility as a mechanism of change. Lessons learned may assist future researchers in improved specificity as they extend clinical utility for referring clinicians and yoga instructors.

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