

Psychological Flexibility and Set-Shifting Among Veterans Participating in a Yoga Program: A Pilot Study

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ABSTRACT Introduction: 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. This study identifies preliminary correlates of change in PTSD and perceived stress for veterans participating in yoga. Materials and methods: Nine veterans (seven males and two females) were recruited from an existing clinical yoga program and observed over 16 wk. Severity of PTSD symptoms (PCL-5) and perceived stress (PSS-10) were collected at baseline and weeks 4, 6, 8, and 16. Psychological flexibility (AAQ-II) and set-shifting (ratio of trail making test A to B) were collected at baseline and at week 6. Subjects attended yoga sessions freely, ranging from 1 to 23 classes over the 16 weeks. The Stanford University Institutional Review Board approved this research protocol. Results: Self-reported PTSD symptoms significantly reduced while perceived stress did not. Lower baseline set-shifting predicted greater 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. Conclusions: In a small uncontrolled sample, psychological flexibility and set-shifting predicted changes in PTSD symptoms in veterans participating in a clinical yoga program, which supports findings from prior research. Future research should include an active comparison group and record frequency of yoga practiced outside formal sessions.

INTRODUCTION

Yoga is a complementary and integrated health (CIH) modality that has demonstrated positive effects on overall stress and has shown some promise as an acceptable and possibly efficacious treatment for post-traumatic stress disorder (PTSD) in veterans.¹ Further, the U.S. Department of Veterans Affairs, in a memorandum signed on May 18, 2017, requires VA medical facilities make yoga available to their veterans.² Per this policy, VA practitioners are to integrate CIH approaches, including yoga, as clinically appropriate as a complement to conventional medicine. The preliminary findings in the current study contribute to improved understanding of the factors that facilitate change for these veterans.

The diagnosis of PTSD is a set of symptoms, including intrusive thoughts, hyperarousal, avoidance, and negative mood and thoughts, in response to an experienced or directly or indirectly observed traumatic event.³ Mental health consumers including veterans and active duty personnel frequently request yoga and other CIH interventions to manage stress and stress-related symptoms. Such interventions are perceived as

less invasive and as having fewer side effects than other evidence-based therapies.¹ Therefore, yoga may provide an additional option in pursuit of stress-related treatment goals. Although studies suggest likely improvement in PTSD symptoms as a result of yoga practice, treatment mechanisms have not yet been confirmed.⁴ This study is a proof of concept and serves as hypothesis generation for future studies into mechanisms of change in yoga. Funding for this work was provided by the U.S. Department of Veterans Affairs, War Related Illness and Injury Study Centers (WRIISC), which is part of Post-Deployment Health Services.

PTSD symptoms are predicted and maintained by several factors.⁵ One factor is psychological flexibility, the capacity to persist, or change behavior in the face of stressors and in the service of long-term valued goals, which predicts PTSD severity.⁶ Set-shifting is also implicated in the development and maintenance of PTSD.⁷ It refers to a property of attention allowing shifts between two different tasks or strategies. Some studies have reported that set-shifting is impaired in those with PTSD.⁷ Further, one study demonstrated attentional control improved over the course of treatment using empirically based interventions for PTSD.⁸

Multiple randomized, controlled trials with non-veterans⁹ and veterans^{10,11} have shown significant improvements in PTSD associated with participation in yoga. Further, findings suggest that psychological flexibility and set-shifting play a role in these improvements. In one pilot study, yoga participants reported improvement in PTSD symptoms and alcohol use disorder.¹² A larger randomized control study including subjects with at least sub-threshold PTSD demonstrated insignificant

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differences in improvements in PTSD symptoms for both yoga and the group assessment control conditions;¹³ however, further analysis revealed that decreased PTSD symptoms were associated with increases in psychological flexibility only for the yoga participants.¹⁴ In terms of set-shifting, a meta-analysis of yoga RCTs for subjects without PTSD report improvements in executive function, which includes set-shifting.¹⁵ There have not been studies investigating set-shifting as a mechanism of action in yoga participants with PTSD to the knowledge of the authors. This pilot study was not powered for hypothesis testing and results are used for hypothesis generation. The goal of this study is to elaborate cognitive-behavioral correlates of change, namely psychological flexibility and set-shifting, involved in the positive effects of yoga on stress and PTSD in addition to potential change contributions from the amount of yoga practice.

MATERIALS AND METHODS

This was a longitudinal observational study over 16 weeks within an ongoing clinical yoga program provided by the Veterans Affairs (VA) Palo Alto Health Care System. The VA Palo Alto Health Care System Scientific Review Subcommittee and Stanford University Institutional Review Board approved this study. Participation in this study did not affect any other clinical treatments received. Veterans were encouraged to attend as many of the multiple weekly 60-min classes as they wanted and counts of classes attended ranged from 1 to 23 (average = 10.8 classes [SD = 7.1]). Techniques of controlled breathing, posture, and meditation were chosen for their potential ability to address physical and psychological issues commonly found in veteran populations. Yoga instructors did not teach a predefined yoga sequence. They typically provided a Hatha style yoga involving a series of breathing, posture, and meditation exercises appropriate to the participants.

Participants included nine veterans (78% men; mean age 59.8 yr [SD = 11.0]; 56% Caucasian, 11% African American, 33% Asian American). Psychiatric diagnoses per chart reviews included current PTSD (44%), a history of PTSD (22%), mood disorder (33%), anxiety disorder (33%), substance use disorder (22%), ADHD (11%), and sleep-related disorders (44%). Subjects included military veterans between the ages of 18 and 89 yr with adequately stable condition and environment to enable attendance at scheduled clinic visits. Those on a psychotropic medication regimen were stable on that medication for at least 4 weeks before entry to the study and were willing to not change that regimen during the 16-wk period observed. Patients were excluded if they were unable to visit the site for study visits and were unable to stand or walk.

Stress was measured with the Perceived Stress Scale (PSS-10), a reliable (Cronbach’s $\alpha = 0.78$) and valid 10-item self-report measure.^{16,17} PTSD was measured with the PTSD Checklist-5 (PCL-5), a 20-item self-report measure with a total score range of 0–80, designed to assess the DSM-5 symptoms of PTSD. It has good internal consistency ($\alpha = 0.96$), test–retest reliability ($r = 0.84$), and convergent and discriminant validity.¹⁸ The

PCL-5 served as a measure of general distress focused on symptom clusters pertinent to PTSD for the three participants without a current or previous PTSD diagnosis. The Life Events Checklist (LEC), a widely used measure of exposure to potentially traumatic events, was used in conjunction with PCL-5 to assess criterion “A” events for PTSD.¹⁹

Psychological flexibility was measured with the Acceptance and Action Questionnaire-2 (AAQ-2).^{20,21} This measure also explains variance in PTSD severity above the avoidance symptoms of PTSD.²¹ AAQ-2 has demonstrated good test–retest reliabilities at 3 and 12 mo with $\alpha = 0.81$ and $\alpha = 0.79$, respectively, and convergent and discriminant validity.²⁰

Attentional control was measured with the trail making test (TMT), a valid measure of the executive function of set-switching.²² The summary score for comparison purposes was the ratio of TMT B time-to-complete by TMT A time-to-complete (TMT A:B).²² All measures were collected at baseline and at 6 weeks, and PCL-5 and PSS-10 were collected all time points, baseline and approximately weeks 4, 6, 8, and 16. This schedule enabled analysis of temporal relationships between variables.

Regression slopes for stress and PTSD from baseline (T1) to the end of 16 weeks (T5) were compared with zero for to test the overall effect of yoga. Bivariate correlations were conducted for the remaining comparisons of baseline and change values. With a sample size of nine, the study is powered to only detect large effect sizes (e.g., 0.70 and higher).²³ To compare the effects of levels of yoga experience, participants were dichotomized by yoga naïve (below 10 hr of practice in the past year) versus non-naïve (50 or more hours of practice in the past year), above or below the recommended PTSD cutoff score of 38 on the PCL-5,¹⁹ and above or below the mean PSS score.¹⁷ For missing data in the predictor variables, last observation carried-forward (LOCF) was used. All analyses were conducted using SPSS version 22.²⁴

RESULTS

Regarding the overall effect of yoga, a single-sample *t*-test revealed a statistically significant change in PCL-5 ($t = -2.31$, $p = 0.049$, $df = 8$, Cohen’s $d = -0.32$), a small to medium

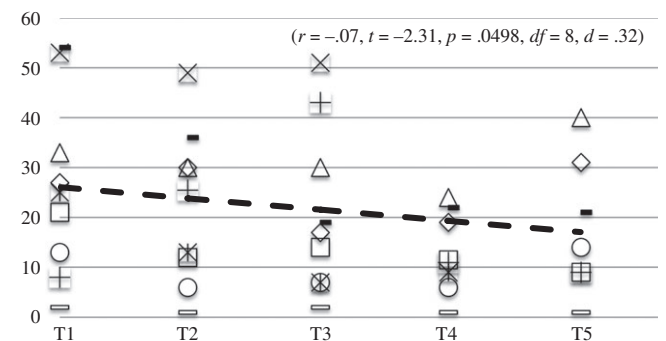


FIGURE 1. PCL-5 change over time for participants in yoga with dashed regression line. Each symbol represents an individual participant.

effect size compared with zero, as depicted in Figure 1. Slopes were calculated using average days of 30.5 d (SD = 20.1) between outcome measurements. The average number of sessions between primary outcome measures was 2.69 (SD = 2.88). The change in overall perceived stress was not significant ($t = -0.43, p = 0.68, df = 8, \text{Cohen's } d = 0.03$). The baseline measures (i.e., PCL-5, PSS, trails A:B ratio, AAQ-2) and

participation level were not significantly correlated with change in PCL-5 or PSS scores from baseline to study end.

Comparisons of PCL-5 and PSS changes for yoga naïve and non-naïve are presented in Figure 2. Table I presents individual subjects' hours of yoga practice and class participation during the study. Results indicated significant group differences for changes in both PTSD and perceived stress. Yoga-naïve participants had, on average, more reduction in PCL-5 ($p = 0.02$) and PSS ($p = 0.02$), as shown in aggregate in Figure 2.

In terms of psychological flexibility, total change in PCL-5 was not predicted by initial AAQ-2 or change in AAQ-2. However, greater baseline AAQ-2 predicted lower baseline PCL-5 ($\rho = -0.92, p < 0.01, df = 8$) and lower baseline PSS ($\rho = -0.95, p < 0.01, df = 8$). Greater prior yoga practice over the previous year predicted higher baseline AAQ-2 scores ($\rho = 0.70, p = 0.04, df = 8$). Higher participation in yoga across the period observed predicted greater improvement in AAQ-2 ($\rho = 0.72, p = 0.03, df = 8$).

In terms of set-shifting, lower initial TMT A:B ratio predicted greater decreases in PCL-5 between baseline and T2 ($\rho = 0.75, p = 0.02, df = 8$) but did not predict changes in PCL-5 at any other time intervals. Changes in TMT A:B ratio (i.e., T1–T3) did not predict later changes (i.e., T3–T5) in PTSD ($\rho = -0.49, p = 0.19, df = 8$) and PSS ($\rho = -0.64, p = 0.06, df = 8$). The trail making test A:B ratio was tested again as a predictor using the PCL-5 and PSS differences between T1 and T5 to support signal detection in this small sample. Early improvement in TMT A:B ratio was associated with an overall decrease in PCL-5 ($\rho = -0.78, p = 0.01, df = 8$) and was not significantly associated with a decrease in PSS ($\rho = -0.60, p = 0.09, df = 8$).

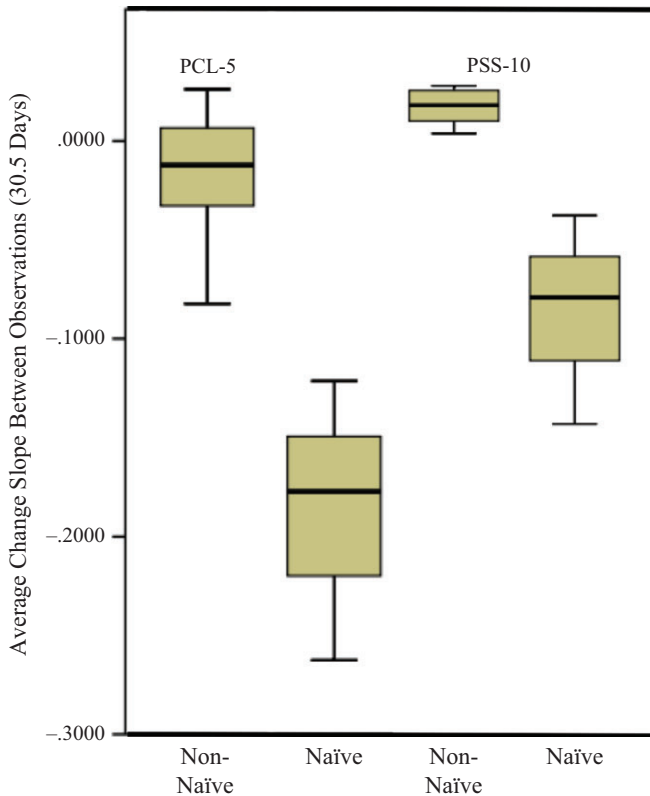


FIGURE 2. Box plot of Mann–Whitney means comparison for naïve versus non-naïve changes in PCL-5 and PSS-10.

CONCLUSIONS

In the present study, self-reported distress as measured by PTSD symptom severity decreased on average while participating in

TABLE I. Subjects' Prior Yoga Experience and Participation During Yoga Study

Subjects	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

Yoga hrs prior, number of hours of yoga practice in the past year; naïve, Yes/No client has practiced less than 10 hr 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 before baseline measure to final measure (T5); PTSD, post-traumatic stress disorder; MCI, mild cognitive impairment; OCD, obsessive compulsive disorder; GAD, generalized anxiety disorder; ADHD, attention-deficit/hyperactivity disorder; Hx, "history of."

yoga while perceived stress did not. Further analysis revealed that changes in PTSD and perceived stress were predicted by the level of prior yoga experience such that yoga-naïve participants had more reduction in PTSD symptom-related distress and perceived stress over the course of the study. These results were very promising given the small sample size.

In many ways, these preliminary findings replicate what has been seen in previous studies and this confirms acceptability of these measures in this setting. First, 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. Most significantly, more yoga participation over the period observed was associated with greater increases in psychological flexibility, similar to findings in previous studies.¹⁴ These pilot results support future hypothesis testing of psychological flexibility as a mechanism of change for improvements in PTSD for those participating in yoga. These findings also lend credence to the theory that participation in yoga contributes to decreased experiential avoidance and improved reappraisal of one's ability to endure distress.²⁵

Set-shifting also predicted changes in PTSD across an unanticipated 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-related symptoms. These results may be due to those with lower initial set-shifting having the most room for improvement in set-shifting. However, previous controlled studies with non-veteran samples demonstrated that participants in yoga conditions demonstrated better executive function.^{26,27} 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 for those participating in yoga. 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.⁷

Those who had little yoga practice in the past year had, on average, greater improvements in PTSD-symptom-related distress and perceived stress compared with those with greater prior yoga practice. This suggests the possibility of greater PTSD reduction over the first 16 weeks of practice for treatment-naïve practitioners. Perceived stress did not significantly change overall. However, treatment-naïve participants experience more benefit in perceived stress when compared with those with more yoga practice (i.e., greater than 50 hr) in the past year. Overall, subjects in this study showed an average decrease in self-reported PTSD symptoms while participating in yoga; findings suggest that yoga-naïve status, psychological flexibility, and set-shifting are all possible mechanisms of change.

These findings should be confirmed with larger controlled studies. Limits of the current study include subjects with heterogeneous mental health diagnoses, a small sample without a

control group, and lack of long-term follow-up. A larger sample would enable a single analysis with multiple covariates, thus potentially revealing more complex and subtle relationships between PTSD, perceived stress, set-shifting, and psychological flexibility associated with yoga participation. Further, yoga practice outside of the clinical yoga program was not measured. Future research should record yoga practice outside the clinical program, if any, as yoga dosage appears to be implicated in treatment outcomes. Frequency, duration, and total hours of yoga practice should also be measured to evaluate the optimal yoga practice for PTSD and stress treatment. Finally, yoga instructors did not use a class manual and therefore critical components of yoga contributing to change mechanisms and outcomes could not be evaluated. Future studies would benefit from an intervention manual to facilitate study of potential critical components.

There are several clinical implications if the present results are replicated in a larger hypothesis-testing study. First and foremost, yoga is one intervention that may help reduce PTSD symptoms. Veterans who express uncertainty over the potential for improvements through yoga may be reassured by preliminary findings that more gains were observed in yoga-naïve participants. 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. Periods between other episodes of care may therefore be an appropriate time for veterans to be encouraged to participate in yoga. In light of previous findings and results herein, yoga and its broad practices may be more effective for clients referred for PTSD and stress if classes foster psychological flexibility and set-shifting. Teachers may therefore choose to develop classes with particular attention to practices that support these abilities. The present study suggests that more yoga practice, over the prior year and during the period observed, is implicated in greater 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 and more total yoga practice as opposed to less. One yoga study with military service members found that frequency, but not duration, was associated with improvements in PTSD.²⁸ The present study measured dosage by "hours of practice," instead of days or frequency, before baseline and during the period observed. Altogether, yoga appears to be useful for stress reduction and it is promising that PTSD measurement response showed improvement.

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