

Examining Mechanisms of Change in a Yoga Intervention for Women: The Influence of Mindfulness, Psychological Flexibility, and Emotion Regulation on PTSD Symptoms

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Objective: This study explored possible mechanisms through which symptoms of posttraumatic stress disorder (PTSD) were reduced in a randomized controlled trial comparing the effect of a yoga intervention with an assessment control. **Method:** We examined whether changes in psychological flexibility, mindfulness, and emotion regulation strategies (expressive suppression and reappraisal) were associated with posttreatment PTSD symptoms for 38 women with Diagnostic and Statistical Manual of Mental Disorders Fourth Edition full or subthreshold PTSD. **Results:** Hierarchical linear regression models revealed that expressive suppression significantly decreased for the yoga group relative to the assessment control. Psychological flexibility increased significantly for the control but not yoga group. However, increases in psychological flexibility were associated with decreases in PTSD symptoms for the yoga but not control group. **Conclusion:** Preliminary findings suggest that yoga may reduce expressive suppression and may improve PTSD symptoms by increasing psychological flexibility. More research is needed to replicate and extend these findings. Published 2014. This article is a U.S. Government work and is in the public domain in the USA *J. Clin. Psychol.* 70:1170–1182, 2014.

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Posttraumatic stress disorder (PTSD) is a detrimental psychological disorder that exerts a significant burden on individuals and society (Kessler, 2000) and is characterized by symptoms of re-experiencing, avoidance, and hyperarousal after exposure to trauma (American Psychiatric Association, 2000). Epidemiological studies have found that 50% to 75% of U.S. residents have experienced at least one traumatic event during their lifetimes (Breslau, Davis, Andreski, & Peterson, 1991; Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995; Norris, 1992). The prevalence of lifetime PTSD among U.S. adults has been estimated at 6.8% (Kessler et al., 2005), with higher rates among women (9.71%) than men (3.59%; Mitchell, Mazzeo, Schlesinger, Brewerton, & Smith, 2012). Moreover, individuals with a lifetime diagnosis of PTSD are more likely to develop anxiety, mood, and substance disorders and are at a higher risk for suicide as compared to individuals without PTSD (Kessler, 2000; Pietrzak, Goldstein, Southwick, & Grant, 2011).

Due to the debilitating nature of PTSD, several empirically supported treatments have been developed and evaluated for this condition (Foa, Keane, Friedman, & Cohen, 2008; Resick, Williams, Suvak, Monson, & Gradus, 2012). In addition, an emergent body of literature suggests that mindfulness-based interventions may enhance existing empirically supported interventions

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for PTSD (Follette, Palm, & Pearson, 2006; Follette, Palm, & Rasmussen Hall, 2004; Lang et al., 2012; Thompson, Arnkoff, & Glass, 2011).

Findings suggest that mindfulness and acceptance-based interventions may alleviate PTSD symptom severity and improve posttraumatic functioning (Boden et al., 2012; Thompson et al., 2011) by decreasing re-experiencing, avoidance, and hyperarousal symptoms (Thompson & Waltz, 2010; van der Kolk, 2006; Vujanovic, Youngwirth, Johnson, & Zvolensky, 2009; Wahbeh, Lu, & Oken, 2011). Perhaps this is because increased mindfulness (i.e., nonjudgmental attention to experiences in the present) is characterized by approaching experiences with curiosity, openness, and acceptance, and is associated with increases in attention regulation, body awareness, and emotion regulation (Bishop et al., 2004; Holzel et al., 2011; Kabat-Zinn, 1990).

Specifically, it is hypothesized that mindfulness-based interventions may exert their effect on PTSD by influencing core avoidance symptoms (Thompson & Waltz, 2011). Avoidance symptoms are the most predictive of PTSD symptom severity and seem to prolong or worsen PTSD symptoms over time (Marshall et al., 2006; Marx & Sloan, 2005; Palm & Follette, 2011; Polusny & Follette, 1995; Rosenthal et al., 2005). Avoidance of aversive internal experiences leads to a narrowing of behavioral repertoires, or psychological inflexibility, which has also been described as not being able to be mindful of the present (Follette et al., 2004; Follette et al., 2006). In addition, evidence suggests that experiential avoidance may account for the observed relationship between cognitive inflexibility and PTSD (Palm & Follette, 2011). Avoidance of internal experiences can manifest as expressive suppression or inhibiting emotion-expressive behavior when emotionally aroused (Gross & Levenson, 1993). This is an unhealthy emotion regulation strategy when used exclusively and is thought to be less healthy than cognitive reappraisal, an emotion regulation strategy that requires attention to experiences so that they can be reappraised (Gross & John, 2003).

Yoga has been suggested as an effective modality for developing mindfulness (Salmon, Lush, Jablonski, & Sephton, 2009; Shelov, Suchday, & Friedberg, 2009), particularly for individuals with PTSD (van der Kolk, 2006). Salmon and colleagues suggested that yoga or other movement practices may stimulate cognitive processes related to meditative awareness and provide a more salient and appealing vehicle for focusing attention than seated meditation due to the enhanced sensory awareness that comes with movement and learning new skills. Van der Kolk (2006) hypothesized that yoga may be a particularly useful tool for individuals with PTSD in facilitating greater tolerance for attending to internal sensations and perceptions and becoming more present oriented. Thus, it is hypothesized that yoga could lead to increased mindfulness, which, combined with a greater tolerance for attending to the present moment in spite of distress, may lead to decreased experiential avoidance and increased acceptance, healthier emotion regulation strategies, and greater cognitive flexibility, in turn reducing PTSD symptoms (Follette et al., 2004).

A small but growing number of studies have examined the effect of yoga on PTSD symptoms (Descilo et al., 2010; Mitchell et al., 2014; Streeter, Gerbarg, Saper, Ciraulo, & Brown, 2012; Telles, Singh, Joshi, & Balkrishna, 2010; van der Kolk, 2006). However, very little is known about possible mechanisms by which yoga may reduce symptoms of PTSD. Most of the studies that have examined yoga as an intervention for PTSD or other psychological disorders have focused on possible biological mechanisms through which it may exert its effect (Streeter et al., 2012; Telles et al., 2010; van der Kolk, 2006); only one investigation measured the effects of yoga on mindfulness (Shelov et al., 2009). Shelov and colleagues found that overall trait mindfulness as well as scores on three of four mindfulness subscales increased significantly after an 8-week yoga intervention. However, to our knowledge, no studies have yet examined the relationships between mindfulness constructs and PTSD before and after a yoga intervention.

The present study represents a secondary analysis of a randomized clinical trial of a yoga intervention, compared to an assessment control, for civilian and veteran women with full or subthreshold PTSD. The parent study found that yoga had a positive effect on participants' PTSD symptoms (Mitchell et al., 2014). Contrary to the study's hypothesis, the assessment control group also had a clinically significant improvement in PTSD symptoms such that there were no significant differences between groups postintervention. The authors proposed several factors that may have contributed to the lack of difference between groups, including the

empathic attention from research staff. The weekly completion of questionnaires may have had a self-monitoring effect, and attending group sessions may have had a behavioral activation effect.

We examined possible mechanisms for PTSD symptom reduction, comparing the two groups. The examined mechanisms of change included mindfulness skills (i.e., nonjudgmental awareness of the present moment; Bishop et al., 2004), psychological flexibility (defined as “the ability to fully contact the present moment and the thoughts and feelings it contains without needless defense” through acceptance, not experiential avoidance; Bond et al., 2011, p.678), and emotion regulation (i.e., “the processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions”; Gross, 1998, p. 275).

Specifically, we examined two emotion regulation strategies: expressive suppression (i.e., inhibiting emotion-expressive behavior while emotionally aroused; Gross & Levenson, 1993) and reappraisal, or cognitively transforming a situation to alter its emotional effect (Gross, 1998). Expressive suppression is thought to not only be an ineffective emotion regulation strategy but also have negative psychological consequences, whereas reappraisal both is a more effective emotion regulation strategy and has positive psychological associations (Gross & John, 2003). We hypothesized that yoga participants would experience increases in mindfulness, psychological flexibility and reappraisal, and decreases in expressive suppression, relative to the control group. We also hypothesized that improved emotion regulation (i.e., increased reappraisal and decreased suppression) and increased psychological flexibility and mindfulness would be associated with decreased PTSD symptoms in the yoga but not control group.

Method

Participants

Participants were veteran and civilian women recruited through flyers at a large northeastern Veterans Affairs (VA) Medical Center, on Craigslist, and through a research participant database. As described by Mitchell et al. (2014), individuals invited to attend a baseline assessment, comprising a diagnostic interview and self-report questionnaires, were aged 18–65 years, screened positive on the Primary Care PTSD screen (PC-PTSD; Prins et al., 2003), had not taken a yoga class within the past 6 months, did not have a substance dependence problem in the past 3 months, were psychiatric medication stable (if applicable), and did not indicate current suicide or homicide risk. Ninety-six women were screened by telephone. Women were excluded at this stage because they did not report significant symptoms of PTSD ($n = 25$), did not complete the screening ($n = 16$), had attended a recent yoga class ($n = 7$), were unable to attend classes ($n = 4$), did not agree to randomization ($n = 2$), or were outside of the eligible age range ($n = 1$). Of the 41 women who were interviewed, 3 were excluded because they did not meet criteria for full or subthreshold PTSD.

The 38 participants (nine veterans and 29 civilians) who met criteria for full or subthreshold PTSD measured by the PTSD Symptom Scale-Interview (PSS-I; Foa, Riggs, Dancu, & Rothbaum, 1993) were randomly assigned to either the yoga condition ($n = 20$) or the assessment only condition (assessment control group; $n = 18$). Subthreshold PTSD was defined by the presence of at least one symptom in each criterion “cluster,” or meeting full symptom criteria for at least two symptom clusters (Mitchell et al., 2012; Pietrzak et al., 2011; Schnurr, Friedman, & Rosenberg, 1993). Random allocation was determined using the Microsoft Excel random numbers function. Fourteen participants completed the yoga group after three participants were lost to follow-up and three withdrew. Of the 18 control participants, two were lost to follow up, four withdrew, and 12 completed.

Procedures

Study procedures have been described in detail elsewhere (Mitchell et al., 2014). Study recruitment occurred from April to June 2011; groups were conducted from June to September 2011. Two master’s-level research assistants conducted both telephone phone screens and assessment interviews. Before completing baseline assessment interviews and questionnaires, participants

were given detailed information regarding the study protocol and provided informed consent for study participation.

In brief, the yoga group attended 12 75-minute sessions of yoga instruction (weekly for 12 weeks or twice-weekly for 6 weeks) and completed weekly questionnaires assessing PTSD, pain, and mood symptoms as well as exercise behaviors outside of the class. In total, two groups completed the intervention: nine were assigned to the weekly group and 11 to the biweekly group, based on their preference.

A registered 200-hour National Yoga Alliance-certified yoga instructor taught both classes, which were held in a large meeting room at a medical center. The style of the class was Kripalu, a form of Hatha yoga that emphasizes connections between mind and body, compassionate self-observation (or nonjudgmental self-study), and focus on the present moment. The teaching style adapts for all body types, is noncompetitive, and emphasizes the individual creating her own practice based on her choices.

Classes also encompassed main tenets of trauma-sensitive yoga (Emerson, Sharma, Chaudhry, & Turner, 2009), emphasizing four key themes: (a) present moment (connecting to the physical cues and noticing); (b) making choices (providing options that allow participants to choose their own experiences); (c) effective action (the opportunity to do something that makes students feel better, safer); and (d) moving in rhythm (synching rhythm of breath and movement with a group and within one's body). The curriculum, which emphasized the foundational yoga principle of kindness to self, was created so that each class had a weekly theme related to Dialectical Behavior Therapy (DBT) skills components (Linehan, 1993), including mindfulness, emotion regulation, distress tolerance, and interpersonal effectiveness (see Table 1).

The control group attended 12 weekly assessment sessions in groups of approximately five participants each and completed the same weekly questionnaires as the yoga group, which were an abbreviated packet of the questionnaires given at baseline, postintervention, and follow-up. Weekly packets included measures of PTSD (the PTSD Checklist-Civilian [PCL-C]; Weathers & Ford, 1996), emotion regulation (the ERQ; Gross & John, 2003), mood, pain, and exercise outside of the yoga study, but not measures of mindfulness (the Mindful Attention Awareness Scale [MAAS]; Brown & Ryan, 2003) or psychological flexibility (the Acceptance and Action Questionnaire [AAQ-II]; Bond et al., 2011). Control group participants were given three times during the week when they could complete questionnaires alongside other control group participants in conference rooms at the same medical center. Questionnaires were handed out and collected by one of the study's research assistants. Participants completed measures, which took approximately 15 to 20 minutes and left upon completion. Both groups completed postintervention and 1-month follow-up questionnaires. Control group participants were offered the opportunity to attend the yoga classes after the study.

Measures

The following measures were administered at baseline, post-intervention and at the 1-month follow-up assessment, except the PTSD Symptom Scale-Interview (PSS-I; Foa et al., 1993), which was administered only at baseline.

The PSS-I (Foa et al., 1993) is a 17-item structured diagnostic interview with prompts that match the 17 Diagnostic and Statistical Manual of Mental Disorders Fourth Edition (DSM-IV) symptom criteria of PTSD. The PSS-I provides a continuous score reflecting frequency of symptoms and can be used to determine a PTSD diagnosis. The PSS-I is strongly associated with other PTSD interviews and has good internal consistency and convergent validity (Foa & Tolin, 2000). The PSS-I was used to determine PTSD diagnoses at baseline assessment.

The PCL-C (Weathers & Ford, 1996) is a 17-item measure of DSM-IV criteria for PTSD. The civilian version, which assesses general problems related to stressful experiences, was used. This measure has been validated as a screening measure for PTSD (Dobie et al., 2002). The PCL is scored by summing responses for each item, and higher scores indicate more severe psychopathology. Changes of 10 or more points on the PCL are considered clinically significant (Monson et al., 2008). Cronbach's alpha for the total scale in the current sample was .87 (at

Table 1
Examples of Yoga Language and DBT Themes

Yoga lesson	DBT theme	Yoga language
Lessons 1: Introduction	Mindfulness	Without judgment, notice the breath coming into your body and leaving your body. Simply observe what is happening on your mat.
Lesson 2: Body awareness	Mindfulness	Take a moment to roll onto the balls of your feet. If comfortable, stay there for a moment. Notice how that feels. Now, if you'd like, roll onto your heels and stay there for a moment. Notice how you feel at this moment.
Lesson 3: Breath awareness	Mindfulness	As you're ready, notice the quality of the breath. Is it ragged? Smooth? What is the temperature of the air? Warm? Cold?
Lesson 4: Mind awareness/mindfulness	Mindfulness	Participating mindfully in yoga involves noticing how you feel in a pose: What do your feet feel like on the floor? How do your arms and hands feel? What emotions are you experiencing?
Lesson 5: Nonjudgmental compassion awareness/mindfulness Part II	Mindfulness	Women face a lot of pressure to look a certain way or change our bodies so that we look more like people on TV. As a result, we judge our bodies as being "good" or "bad." What if you focused instead on how you feel in a yoga pose, instead of how you look?
Lesson 6: Combining ease and edge, doing what works, effectiveness	Mindfulness Interpersonal effectiveness Building mastery	One goal of mindfulness is to "do what works" rather than what is "rightdā per se. But when we worry about the "right way" or what our neighbor is doing, we stop paying attention to what the body feels in that moment.
Lesson 7: Phases of a pose, entry-sustain-release-integrate-transition, distress tolerance	Mindfulness Distress tolerance	Sometimes we can change the situation. When we cannot, we can learn to tolerate the unpleasantness. You always have the option of going to a different yoga pose, or coming out of the pose to rest for a moment. However, there may be days when you want to challenge yourself to stay in a pose longer, even if it is mildly uncomfortable, and practice tolerating the discomfort.
Lesson 8: Balance, emotion regulation	Mindfulness Emotion regulation	We've been talking a lot about noticing emotions and accepting situations for the way they are. This applies to negative emotions as well. Rather than trying not to feel, it may be more effective to try to feel something positive.
Lesson 9: Acceptance, letting go	Mindfulness Effective action	As you come into the fold, take a moment to use this as a restorative posture. It's your choice to create the experience that allows you to release and let go.
Lesson 10: Dance of life	Mindfulness Distress tolerance	Rather than looking to a solid state of bliss that never shifts, we are looking for a means of dancing with our world as it moves, a way of feeling the richness of both joy and sadness, of watching with curiosity as the weather changes.
Lesson 11: Integration	Mindfulness Taking effective action Distress tolerance Emotion regulation	When you come here to the yoga class, you can make the choice to leave your stress at the door—things going on at home or at work—in order to focus on yourself and your yoga practice.
Lesson 12: Celebration	Mindfulness	Today's lesson is celebration. Acknowledge all that you have explored over the past 11 weeks . . .

Note. DBT = Dialectical Behavior Therapy.

baseline assessment). This measure was also administered to both groups weekly; however, the analyses used in this study included only baseline, postintervention, and follow-up scores.

The Emotion Regulation Questionnaire (ERQ; Gross & John, 2003) is a 10-item measure of reappraisal and expressive suppression, two emotion regulation strategies commonly used in everyday life that represent effective (reappraisal) and ineffective (expressive suppression) attempts to influence which emotions individuals have, when they have them, and how they experience and express these emotions (Gross, 1998). Reappraisal is a strategy in which individuals construe a potentially emotion-eliciting situation in a way that changes its emotional effect (Lazarus & Alfert, 1964) and occurs before the emotion response tendencies have been fully generated (Gross & John, 2003). Expressive suppression is a response-focused strategy in which individuals modulate emotional responses by inhibiting ongoing emotion-expressive behavior (Gross, 1998).

Two subscales within the measure produce separate scores for cognitive reappraisal (ERQ-R) and expressive suppression (ERQ-S). Higher subscale scores indicate greater reappraisal (less pathological) and greater expressive suppression (more pathological). The measure's developers reported that this questionnaire demonstrated good convergent and discriminant validity and good internal consistency for both reappraisal (Cronbach's alpha = .75–.82) and expressive suppression (Cronbach's alpha = .68–.76; Gross & John, 2003). In the current sample, Cronbach's alphas for the cognitive reappraisal and expressive suppression subscales were .87 and .54, respectively, at baseline. This measure was also administered to both groups weekly; however, the analyses used in this study included only baseline, postintervention, and follow-up scores.

The MAAS (Brown & Ryan, 2003) is a 15-item measure of awareness and attentiveness to day-to-day experiences. Scores are obtained by summing the responses of each question. A higher score on this measure is related to a higher level of mindfulness. According to its developers, the MAAS has exhibited good internal consistency and temporal stability and measures a unique quality of consciousness that is related to a variety of well-being constructs (Brown & Ryan, 2003). Cronbach's alpha for this sample was .84 at baseline.

The AAQ-II (Bond et al., 2011) is a 10-item measure of psychological flexibility, defined as "the process of contacting the present moment fully as a conscious human being and persisting or changing behavior in the service of chosen values" (Hayes, Luoma, Bond, Masuda, & Lillis, 2006, p. 9). Acceptance, or a willingness to experience and not alter the form, frequency, or sensitivity of unwanted private events in order to pursue one's values and goals, is an example of psychological flexibility, whereas experiential avoidance (i.e., the attempt to alter the form, frequency, or situational sensitivity of private events; Bond et al., 2011) is an example of psychological inflexibility.

The measure's developers reported that the AAQ-II demonstrated good concurrent, predictive, discriminant, and convergent validity (Bond et al., 2011). Lower AAQ-II scores (i.e., less psychological flexibility) may predict future mental illness; AAQ-II scores have also been found to account for unique variance in PTSD symptom severity (Meyer, Morissette, Kimbrel, Kruse, & Gulliver, 2013). In addition, the AAQ-II has exhibited adequate internal consistency (Cronbach's alpha = .76–.87) and temporal stability ($r = .78$ –.80; Bond et al., 2011). In the current sample, Cronbach's alpha for the AAQ was .92 at baseline.

Statistical Analysis

Descriptive statistics and regressions were calculated using PASW Statistics (SPSS) version 18. Hierarchical linear regression models, estimated using Mplus 7.0 (Muthén & Muthén, 1998–2010), were used to examine whether psychological flexibility (AAQ-II), mindfulness (MAAS), and emotion regulation (ERQ) changed significantly over the course of the intervention.

The default approach to these models assumes that measurements were obtained at equidistant time points. However, this was not the case in the current study, given the timing of the baseline, postintervention, and 1-month follow-up assessments in the weekly and biweekly groups. Thus, we created a "time" variable based on the number of days since the baseline session; this variable was included in the models as a time-varying covariate. Time was not centered in these models, as baseline was considered a meaningful zero point. Group was dummy-coded

and group status was assessed as a predictor of change over time for each dependent variable. The direction and significance of slope means indicates the nature of change and whether increases or decreases are significantly different from baseline. Slope means indicate the direction of change over time and whether it was significant. Effect sizes for the between-group effects, analogous to Cohen's *d*, were calculated as:

$$\beta^*(\text{time})/SD_{\text{raw}}$$

Where β = the unstandardized coefficient of the regression of slope onto dummy-coded treatment group, time = the mean number of days since baseline at the 1-month follow up, and SD_{raw} = the baseline standard deviation for the total sample (Feingold, 2009).

In order to test whether mindfulness and emotion regulation contributed to change in PCL scores, we created change scores for the MAAS, AAQ-II, ERQ-R, and ERQ-S by subtracting preintervention variables from postintervention variables. These change scores were used in four separate regression models, with PCL scores at follow-up as the dependent variable and PCL scores at baseline as a covariate. The intent-to-treat sample ($N = 38$) was included in the hierarchical linear models, and data from all available time points were used to estimate change over time using Mplus. Missing data were listwise deleted in SPSS. No missing data were imputed.

Results

Demographics

Thirty-eight participants (nine veterans and 29 civilians) were randomized to the yoga intervention or assessment control condition. Veterans differed significantly from civilians only in age, $t(33.03) = 2.24, p = .03$; on average, veterans were older ($M_{\text{age}} = 49.67$) than civilians ($M_{\text{age}} = 42.72$). There were no significant differences between veterans and civilians in education, ethnicity, whether they had previously practiced yoga, or PCL, MAAS, ERQ, or AAQ-II baseline scores (all $p > .05$). Overall, participant mean age was 44.37 ($SD = 12.37$); 52.6% were Caucasian, 36.8% African American, 5.3% Asian, and 5.3% other racial/ethnic groups. Participants overall had a relatively high level of education: 5.3% had some high school, 39.5% some college, 26.3% had obtained a 4-year degree, and 28.9% had a graduate degree. A total of 29 participants met criteria for a full PTSD diagnosis and nine had subthreshold PTSD, according to the PSS-I (Foa et al., 1993).

A total of 47.4% of participants had done yoga before, however most (70.8%) of these women had never practiced regularly, i.e., taken at least one class every 2 weeks for a given period of time. None had taken any yoga classes in the 6 months preceding the study. There were no significant differences between yoga and control groups on any of the demographic variables measured including age, race/ethnicity, years of education, previous yoga participation, or previous participation in talk therapy ($p > .05$).

Growth Curve Models Testing Change Over Time

For study variable means presented by group, see Table 2. In the full sample, growth curve results indicated that mindfulness, as measured by the MAAS, had marginally significant increases over the study period (mean [M] = .03, $T = 1.91, p = .06$). The effect of group was nonsignificant (unstandardized $B = .01, T = .35, p = .73$), suggesting that the two groups did not differ in mindfulness change scores over the intervention period. The effect size for this comparison was .30. Psychological flexibility, as measured by the AAQ-II, increased significantly over time ($M = .05, T = 3.22, p = .001$); the effect of group was not significant ($B = -.01, T = -.44, p = .66$). The effect size was .47. When change in AAQ-II scores was estimated separately for each group, we observed a significant increase for the control ($M = .05, T = 2.67, p = .01$) but not yoga group ($M = .03, T = 1.50, p = .13$), which was counter to our predictions. The effect size for this comparison was .47.

Table 2
Means of Study Outcomes by Group

Measure	Yoga group (n = 20)			Assessment control group (n = 18)		
	Baseline Mean (SD)	Post yoga Mean (SD)	1-mo follow-up Mean (SD)	Baseline Mean (SD)	Post 12 sessions of assessment Mean (SD)	1-mo follow-up Mean (SD)
PCL total scores	51.94 (14.36)	39.07 (16.01)	40.91 (18.89)	53.44 (10.56)	39.09 (12.65)	42.18 (14.20)
ERQ reappraisal	26.11 (8.10)	24.79 (8.89)	25.67 (11.72)	25.94 (5.12)	27.00 (5.81)	28.27 (5.80)
ERQ suppression	17.65 (3.73)	14.14 (5.25)	13.31 (4.46)	15.06 (4.70)	14.27 (5.29)	14.82 (4.79)
MAAS	51.00 (12.55)	52.21 (17.84)	53.46 (21.19)	55.56 (10.62)	61.00 (11.79)	58.67 (13.41)
AAQ-II	32.90 (16.23)	41.69 (15.50)	43.08 (17.69)	34.67 (11.84)	39.91 (11.67)	38.91 (11.64)

Note. SD = standard deviation; PCL = PTSD Checklist; ERQ = Emotion Regulation Questionnaire; MAAS = Mindful Attention Awareness Scale; AAQ-II = Acceptance and Action Questionnaire, second version.

Expressive suppression, measured by the ERQ-S, decreased significantly over time ($M = -.02$, $T = -2.49$, $p = .01$). The effect of group was significant ($B = -.04$, $T = -3.23$, $p = .001$); scores decreased for the yoga ($M = -.04$, $T = -4.31$, $p < .001$) but not control group ($M = .01$, $T = .06$, $p = .95$) over the course of the intervention. There were no significant changes in reappraisal scores, measured by the ERQ-R ($M = .00$, $T = -.01$, $p = .99$), and the effect of group was not significant ($B = -.03$, $T = -.93$, $p = .35$). Between-group effect sizes for the ERQ-S and ERQ-R were .68 and .40, respectively.

Regression Models Testing Mechanisms of Change

Regression models with change scores for the MAAS, AAQ-II, ERQ-S, and ERQ-R, respectively, were used to determine whether changes from baseline to postintervention were associated with PTSD symptoms as measured by the PCL, at follow-up, while controlling for baseline PCL scores. For the yoga group, increases in psychological flexibility (AAQ-II) scores were associated with lower PTSD symptom scores ($\beta = -.48$, $T = -2.49$, $p = .04$), while change in mindfulness (MAAS; $\beta = -.41$, $T = -1.36$, $p = .22$), expressive suppression (ERQ-S; $\beta = .04$, $T = .16$, $p = .88$), and reappraisal (ERQ-R; $\beta = -.14$, $T = -.51$, $p = .63$) were not associated with PCL scores at follow-up. For the assessment control group, changes in psychological flexibility ($\beta = .11$, $T = .26$, $p = .80$), mindfulness ($\beta = -.03$, $T = -.07$, $p = .95$), expressive suppression ($\beta = .45$, $T = 1.23$, $p = .27$), and reappraisal ($\beta = .75$, $T = 2.48$, $p = .06$) were not associated with PTSD symptom scores at follow-up.

Discussion

This study examined the effect of a yoga intervention on psychological flexibility, emotion regulation (including reappraisal and expressive suppression), mindfulness, and PTSD symptoms. We found that expressive suppression, one of two emotion regulation strategies measured, decreased for the yoga but not control group. The effect of group was significant, meaning that participation in the yoga group was significantly related to a decrease in expressive suppression compared to the control group. This finding was consistent with our hypotheses that yoga would have a positive effect on emotion regulation, possibly because the encouragement of a nonjudgmental attitude toward thoughts and experiences as well as the practice of distress tolerance over multiple sessions resulted in reduced efforts to cope with distressing emotions by attempting to suppress them.

When examined separately for the two groups, we found that psychological flexibility scores increased significantly for the control but not yoga group, which was inconsistent with our hypotheses. As reported in the parent study (Mitchell et al., 2014), also contrary to our hypothesis, the control group had a clinically significant improvement in PTSD symptoms, as measured by the PCL, such that there were no significant differences between groups postintervention. It is possible that weekly completion of questionnaires, attending group sessions, and empathic attention from research staff may have contributed to the lack of difference between groups. Perhaps these factors also contributed to an increase in psychological flexibility in the control group.

Alternatively, it is possible that unmeasured variable(s) accounted for the improvement of the control group participants' symptoms. However, it is not apparent why the control group would improve significantly while the yoga group did not. Of note, a previous study (Shelov et al., 2009) examined the effect of a yoga intervention on trait mindfulness and found that the yoga participants as well as the waitlist control group participants improved in overall mindfulness, as measured by the Freiburg Mindfulness Inventory (FMI; Buchheld & Walach, 2002) and on the Insightful Understanding subscale of this measure.

Notably, increases in psychological flexibility were associated with PCL scores at follow-up for the yoga but not control group, suggesting that for the yoga group, changes in psychological flexibility were related to changes in PTSD symptoms. Thus, increases in psychological flexibility did not have an effect on PTSD symptoms in the control group. It is worth noting that neither the yoga nor the control group sessions contained explicit training pertaining to PTSD symptoms

per se; however, the yoga group did receive instructions regarding emotions and sensations that participants did not want to feel, while the control group received no instructions at all. It is possible that yoga participants were able to apply a framework of psychological flexibility gained from the yoga intervention to their PTSD symptoms, while the control group did not have the same framework. Although this should be interpreted with caution, given that the changes in psychological flexibility scores were not significant in the yoga group, these findings provide preliminary evidence to suggest that yoga may reduce expressive suppression among women with full or subthreshold PTSD and improve PTSD symptoms by increasing psychological flexibility.

Limitations

Several limitations of the study should be noted. This was a pilot study investigating the effect of a novel yoga intervention on PTSD symptoms. Several characteristics of the sample such as some participants with high levels of education, partial PTSD diagnoses, low symptom levels, veteran status, and previous yoga experience may limit generalizability. Time and funding constraints prohibited recruiting a larger sample that might be necessary to detect important differences both between and within groups. Power analyses suggested we had less than 10% power to detect small to medium effect sizes. The lack of power may have precluded a clean pattern for results.

Additionally, although inclusion in the study was based on the PSS-I (Foa et al., 1993), change was measured by the PCL (Weathers & Ford, 1996). Unfortunately, a longer term follow-up assessment to measure the full effect of the intervention compared to assessment group was not feasible. It is possible that greater differences between the yoga and assessment control groups would emerge during a longer term follow-up. Also, we were not able to evaluate which specific aspects of the yoga practice were most effective or to whom they were most beneficial.

Perhaps of greatest relevance to a mechanisms study are limitations in the available measures used to assess the constructs of interest. For example, it has been argued that existing measures of mindfulness may conflate the effect of engagement in a mindfulness practice, i.e., when one becomes more mindful and aware, one realizes how often one is not mindful, and this may lead to lower scores on mindfulness scales (Erisman & Roemer, 2012; Germer, 2005). A new measure developed to account for this inaccuracy in reporting became available after the data were collected for this study (Mindfulness Process Questionnaire; Erisman & Roemer, 2012).

Similar limitations have been identified in the sensitivity of explicit measures to detect group differences in psychological flexibility. A study comparing a thought suppression induction to a mindfulness induction found both groups improved slightly on the AAQ-II, an explicit measure of psychological flexibility, while only the mindfulness group improved significantly on an implicit measure of psychological flexibility (Hooper, Villatte, Neofotistou, & McHugh, 2010). The authors suggested that the discrepancy between an explicit versus implicit measure may highlight limitations in participants' ability to accurately report on their current psychological states. Expectancy effects may also contribute to inflated psychological flexibility scores (Hooper et al., 2010). Control participants in the current study were informed that the purpose of the control group was to provide a comparison for the yoga group. However, they knew that it was a PTSD study and may have expected to experience improvements from attending weekly assessment sessions, which could have contributed to our control group improving more than the yoga group on this measure.

Conclusion

As there is currently little research examining the effect of yoga on PTSD, and a dearth of information regarding "active ingredients" of yoga interventions in general, it is difficult to interpret our results in the context of the broader literature. To our knowledge, this study was the first randomized controlled trial that attempted to investigate these relationships and thus contributes to the field as a first look into possible mechanisms of change. The unexpected finding that psychological flexibility increased for the control group may highlight the need for improved sensitivity in measurement in the areas of mindfulness and psychological flexibility.

The findings that expressive suppression improved significantly in the yoga group and that improved psychological flexibility may be associated with PTSD symptom reduction, suggest that these may be important areas to target when developing future interventions. More research is needed to replicate and extend the findings of this pilot study to determine the extent to which yoga interventions can impart psychological flexibility, mindfulness, and emotion regulation skills, and to further elucidate the effect of these variables on PTSD symptoms.

Additionally, future studies should examine temporal relations between reductions in PTSD symptoms and changes in mindfulness, psychological flexibility, and emotion regulation in response to a yoga intervention to determine whether observed changes are a result of treatment or happen after a decrease in PTSD symptomatology. Further investigation into mechanisms of change through rigorous trials is imperative.

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