

Effects of Sensory-Enhanced Yoga on Symptoms of Combat Stress in Deployed Military Personnel

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KEY WORDS

- anxiety
- combat disorders
- sensation
- sensation disorders
- stress disorders, post-traumatic
- yoga

OBJECTIVE. We examined the effects of sensory-enhanced hatha yoga on symptoms of combat stress in deployed military personnel, compared their anxiety and sensory processing with that of stateside civilians, and identified any correlations between the State-Trait Anxiety Inventory scales and the Adolescent/Adult Sensory Profile quadrants.

METHOD. Seventy military personnel who were deployed to Iraq participated in a randomized controlled trial. Thirty-five received 3 wk (≥ 9 sessions) of sensory-enhanced hatha yoga, and 35 did not receive any form of yoga.

RESULTS. Sensory-enhanced hatha yoga was effective in reducing state and trait anxiety, despite normal pretest scores. Treatment participants showed significantly greater improvement than control participants on 16 of 18 mental health and quality-of-life factors. We found positive correlations between all test measures except sensory seeking. Sensory seeking was negatively correlated with all measures except low registration, which was insignificant.

CONCLUSION. The results support using sensory-enhanced hatha yoga for proactive combat stress management.

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According to a 2008 RAND Center for Military Health Policy Research study, nearly 20% of combat troops returning from Iraq or Afghanistan met criteria for either posttraumatic stress disorder (PTSD) or depression. Of the estimated 300,000 returning troops, only 53% sought help from a provider in the year of the study. Fear of adverse consequences and stigma were frequently cited reasons for not seeking help (RAND Center for Military Health Policy Research, 2008).

Consequences of not obtaining treatment may include substance abuse, domestic violence, divorce, job loss, financial difficulties, homelessness, and suicide and can be devastating to the individual military member, the family unit, and society (National Center for PTSD, 2006). To avert these outcomes, the RAND Center for Military Health Policy Research (2008) report recommended finding ways to allow deployed military members to receive mental health care off the record.

Unfortunately, traditional mental health care may be insufficient to address these problems, because studies have shown that talk therapies alone have limited success in treating PTSD (Ogden, Minton, & Pain, 2006; van der Kolk, 2006) and can even increase dysregulation (Ford, Courtois, Steele, van der Hart, & Nijenhuis, 2005; Ogden et al., 2006). Imaging studies have shown that Broca's area, a major language center of the brain, can become deactivated in response to traumatic reminders, a finding that may explain why PTSD sufferers are often at a loss for words to discuss their trauma (Shin et al., 1999).

Many experts now believe that people with PTSD need physical experiences to counter the chronic sense of emotional and physical helplessness that frequently results from trauma (Levine, 1997; Ogden et al., 2006; van der Kolk, 2004). According to Levine (1997), the residue of undischarged energy from the freeze response during a traumatic event may lead to the debilitating symptoms of PTSD, which fall into three clusters: (1) reexperience of the phenomenon (e.g., flashbacks), (2) avoidance and numbing, and (3) autonomic hyperarousal (American Psychiatric Association, 2000). Newport and Nemeroff (2003) believed that disturbances in sensory processing play an important role in the hyperarousal symptoms of PTSD, hypothesized by Rothschild (1998) to be at the core of the disorder.

According to van der Kolk (2006), people with PTSD need to learn that internal feelings and sensations are safe and continuously change, unlike the freeze state, when everything seems to stand still. He further asserted that by achieving control over their physiological states through breathing and movement, these people may avoid overwhelming emotions when recalling their traumas.

Yoga, which incorporates both breath work and movement, is becoming increasingly recognized as an effective treatment modality for reducing symptoms of PTSD (Miller, 2009; Pollack, 2010; van der Kolk, 2006; Wills, 2007). Van der Kolk (2006) found that hatha yoga significantly increased heart rate variability (an indicator of increased parasympathetic tone) in typical participants. In the same study, the PTSD group showed a significant reduction in PTSD symptoms as measured by the Clinician-Administered PTSD Scale, a clinical PTSD assessment tool (Blake et al., 1995; van der Kolk, 2006).

A pilot study at Walter Reed Medical Center found that yoga nidra (a form of deep relaxation) resulted in a reduction in symptom severity on the Posttraumatic Stress Disorder Checklist; among the symptoms reduced were insomnia, depression, anxiety, and fear (Miller, 2009; Weathers, Litz, Herman, Huska, & Keane, 1993). In their yoga pilot studies with PTSD, Carter and Byrne (2004) found that Iyengar-style yoga asanas (poses) decreased depression but did not improve hyperarousal symptoms of PTSD until certain pranayama (breathing) techniques and meditation were added. People with PTSD have also been found to benefit from Sudarshan Kriya yoga training, a type of yoga emphasizing particular pranayama practices (Brown & Gerbarg, 2005a, 2005b).

We found no published studies that examined the effect of yoga on sensory processing in military personnel or veterans. However, a small pilot study investigated

the effect of kripalu yoga on sensory overresponsivity in adults (Mollo, Schaaf, & Benevides, 2008). The intervention followed a traditional kripalu yoga class format, which included centering, warmup, an asana series, pranayama, final relaxation, and meditation. Three-stage diaphragmatic breathing was used throughout the practice. Results included a significant increase in cardiac baseline vagal tone, lower low-registration scores on the Adult Sensory Profile (ASP; Brown, Tollefson, Dunn, Cromwell, & Fillion, 2001), and a decrease in state anxiety scores on the State-Trait Anxiety Inventory (STAI; Spielberger, 1983) after treatment. Pretest scores on the ASP were significantly higher ($p = .001$) than the established population norm in three of the four quadrants: low registration, sensory sensitivity, and sensory avoiding. Mollo et al. (2008) suggested that the enhanced proprioceptive input (heavy work) provided by the yoga increased parasympathetic nervous system activity, leading to improved feelings of well-being. However, they acknowledged that the pranayama techniques could have produced this effect. The use of therapeutically enhanced sensation to improve self-regulation is a cornerstone of sensory integration intervention (Koomar & Bundy, 2002).

Finally, Stoller and Cimini (2008) administered the Adolescent/Adult Sensory Profile (AASP; Brown & Dunn, 2002) to 12 older combat veterans diagnosed with PTSD. Results indicated a similar pattern; that is, scores were significantly higher in the quadrants of low registration, sensory sensitivity, and sensory avoiding than in the published norms. In addition, scores were lower in the quadrant of sensory seeking. Given the results from Mollo et al. (2008) and Stoller and Cimini (2008), we predicted that at pretest the deployed military population would demonstrate a sensory processing pattern similar to that of combat veterans and sensory-overresponsive adults and that a sensory-enhanced hatha yoga program would help to normalize sensory processing and reduce other symptoms of combat stress.

Study Objectives

Our specific research questions were as follows:

1. For each of the four quadrants of the AASP—sensory sensitivity, sensory avoidance, low registration, and sensory seeking—is the mean amount of normalization from pretest to posttest in the treatment group significantly greater than that in the control group? (The terms *normalize* and *normalization* indicate scores moving toward the standardized norms on the AASP.)

2. For each of the two state–trait scales of the STAI, does the mean change from pretest to posttest in the treatment group indicate a significantly greater decrease in anxiety than the mean change from pretest to posttest in the control group?
3. With consideration of the AASP’s four quadrants, is the mean for the deployed military personnel less than the mean for the established norm for sensory seeking and greater than the mean for the established norms for sensory sensitivity, sensory avoidance, and low registration?
4. For each of the STAI’s two scales, is the mean for the deployed military personnel higher than the established population norm?
5. For deployed military personnel, with consideration of the STAI’s two scales and the AASP’s four quadrants, are sensory sensitivity, sensory avoidance, low registration, state anxiety, and trait anxiety positively correlated with one another, and is sensory seeking negatively correlated with these other five measures?

Method

Research Design

We used a randomized controlled trial (RCT) to evaluate the effect of sensory-enhanced hatha yoga on combat stress, our primary study objective. The secondary study objectives were achieved using the RCT’s pretest results. Written informed consent was obtained from all participants after they received a detailed description of the study, which was approved by the institutional review board of the Brooke Army Medical Center, San Antonio, TX.

Participants

Participants were recruited by e-mail solicitation and flyers. Inclusion criteria included status as any military personnel deployed to Forward Operating Base Warrior, Kirkuk, Iraq. Excluded from the study were any active-duty military personnel deployed to Forward Operating Base Warrior who would not be able to complete or participate fully in the study because of redeployment or operational requirements, any active-duty military personnel who took yoga during the month before the onset of the study, all pregnant women, and all civilians. Computer randomization occurred during initial data collection, and participants were informed of their group assignment on completion of their paperwork. Initially, we sought 80 participants, but because of time constraints, the final sample consisted of 35 treatment and 35 control participants.

Instruments

We used two standardized instruments: the AASP and the STAI. In addition, we used the Quality of Life Survey to seek additional information on each participant (Stoller, Greuel, & Cimini, 2009).

The AASP includes frequency measurements on 60 sensory processing questions, which are sorted into four quadrants, yielding a score for each quadrant. Norms were established on the basis of an initial pilot study of 615 adults and a standardization study of 950 adolescents and adults. Coefficient α s for each pattern ranged from .66 to .82 in the pilot study (Brown et al., 2001) and from .64 to .78 in the standardization study (Brown & Dunn, 2002). Each item on a subscale was also correlated with the total score for the subscale, yielding Pearson product–moment item-to-total pattern correlations that ranged from .11 to .56 (Brown et al., 2001). These and other standardization tests (described in the test manual) have established satisfactory reliability and validity of this test tool for clinical assessment of sensory processing (Brown & Dunn, 2002).

The STAI consists of two self-report scales for measuring state and trait anxiety. The inventory contains 40 Likert-scale questions, 20 on each scale. According to Spielberger (1983), state anxiety tends to fluctuate and vary in intensity over time in response to situational stress, and trait anxiety is a relatively stable personality trait. Construct validity and high internal consistency have been well established for both scales; median α coefficients are .92 for the State Anxiety scale and .90 for the Trait Anxiety scale for Form Y (Spielberger, 1983). Stability of the testing tool was measured by test–retest coefficients and, as expected, is relatively high for the Trait Anxiety scale and low for the State Anxiety scale (Spielberger, 1983). This study used the norms for working adults.

We developed the Quality of Life Survey to explore occupational performance, hyperarousal, mood, interpersonal relations, and cognitive functioning issues not assessable by standardized measures. Eighteen questions were formatted as follows: “In the last 2 weeks, I am having difficulty _____” (e.g., sleeping, concentrating), with choices of *never* (5), *rarely* (4), *sometimes* (3), *frequently* (2), or *always* (1). Validity and reliability tests have not yet been conducted on this tool. The Results section contains the 18 questions and participant response analysis.

Treatment Procedures

The treatment—sensory-enhanced hatha yoga classes—was scheduled for 3 consecutive weeks, 7 times/wk.

Treatment participants were to attend a minimum of two sessions/wk and a minimum of nine sessions for the entire 3-wk period. Each class was 75 min long and was taught by the principal investigator, Jon H. Greuel, who is a certified yoga instructor. The classes were held in a gym constructed of rubber mat flooring, aluminum beams, and plastic fabric walls. The control participants did not participate in any yoga classes, and both groups were expected to continue to participate in military physical training activities.

The experimental group received intervention by means of a specialized sensory-enhanced hatha yoga program. Cimini developed a yoga program in 2005 to reduce veterans' symptoms of combat stress or PTSD. Stoller observed the program, noted sensory elements, and realized the power of enhancing them. The treatment protocol was described in *General Principles of the Yoga Warrior Method* (Cimini & Stoller, 2009) and includes both bottom-up and top-down approaches. To ensure treatment fidelity, the *Yoga Warrior Lesson Plan* (Cimini, Stoller, & Greuel, 2009) was developed to delineate these principles and was followed with disciplined adherence by Greuel. Highly structured and detailed, the lesson plan was inspired by sensory integrative and sensorimotor treatment approaches for autonomic nervous system dysfunction, which were introduced to the program by Stoller. Specifically, the protocol outlines both required and suggested elements for the initial centering, pranayama techniques, asanas, meditation, and savasana (final relaxation). These elements are designed to provide a therapeutic threshold of enhanced proprioceptive (muscle) input, deep touch pressure, some slow rhythmical movement, carefully selected pranayama techniques that promote calming, and a series of asanas that are chosen to balance the nervous system for a more relaxed and steady state.

Deep touch pressure and enhanced proprioceptive input were provided through particular asanas as well as through the use of props, including a strap and wood blocks. Although a stateside sensory-enhanced yoga class typically involves the use of other props (e.g., bolster, 10-lb weighted bag) during the final restorative pose to provide additional deep touch pressure, a traditional savasana pose was substituted because of the limitations of the deployed environment. Nonetheless, enhanced sensation was provided during the yoga treatment in many ways. For example, a slow, rhythmical dynamic flow between the downward dog and upward dog asanas, coordinated with breath, provided enhanced proprioceptive input throughout the torso and all four limbs; deep touch pressure through both palms and feet (which are highly represented in the sensory

homunculous); and slow, rhythmical vestibular input while facilitating a slower, deeper breathing pattern, all of which are thought to inhibit the sympathetic nervous system. In essence, the asanas were chosen according to their sensory effects on the autonomic nervous system in addition to their widely acknowledged neuromuscular and interoceptive effects on the body. Although many of the techniques can be found in various styles of yoga, how the techniques are uniquely adapted makes this form of yoga powerful for those in extremely stressful environments.

Readings from yoga masters were selected to contribute a sense of peace and calm, and positive affirmations were paired with particular asanas to address the nervous system from a top-down approach. To promote a sense of safety, setting and performance variables were carefully selected. Zen meditation music was played to decrease auditory challenges, such as electrical generators, air conditioners, helicopters, and machine-gun fire.

Data Collection

Participant recruitment and data collection took place 1 wk before the study. Jon H. Greuel collected all data. After informed consent, study volunteers received numbered envelopes containing self-administered assessment materials. Computer randomization occurred while participants filled out the forms. Once the forms were completed, the participants returned to Greuel, who immediately sealed the envelopes for stateside scoring and informed the participants of their group assignment (i.e., treatment or control). Thus, blinding Greuel to group assignment was unnecessary. The entire procedure took approximately 25 min, and Greuel was available to answer any questions. Follow-up data were collected in the same manner as the baseline data in the week after the last sensory-enhanced hatha yoga intervention session.

Data Analysis

We used a power analysis to determine sample size for the RCT. According to the power calculations, a sample size of 80 provides 85% power to detect a difference in the true means of major outcome variables of 0.68 standard deviation. A sample of size of 60 provides 85% power to detect a difference in the true means of major outcome variables of 0.77 standard deviation (Lenth, 2006–2009). Thus, we selected 80 participants as our recruitment goal to allow for a 25% attrition rate.

Analysis of Treatment Effect on Sensory Processing. Our primary research question was whether the sensory-enhanced hatha yoga program would help normalize sensory processing in each of the four sensory processing quadrants, defined as the deviation (distance from the

normative mean of a quadrant in absolute values) at pretest minus the deviation at posttest. We used one-sided, two-independent-sample *t* tests with equal variances not assumed.

Analysis of Treatment Effect on Anxiety. To determine whether yoga had an effect on anxiety, we compared the change in anxiety in the treatment group with the change in the control group using one-sided (because of our assumption of only decreasing anxiety), two-independent-sample *t* tests with equal variances not assumed (Michalsen et al., 2005; Streeter et al., 2010).

Comparison of Test Scores With Established Norms. We compared the mean anxiety and sensory processing scores for the military group with the established means for the normative population by means of single-sample *z* tests with a significance level of $\alpha = .05$. We used one-tailed tests because we predicted that the military group would have higher levels of anxiety, sensory sensitivity, sensory avoidance, and low registration and lower levels of sensory seeking than the normative population.

Following the scoring guidelines, we compared our participants' scores with the appropriate gender norms for the anxiety tool and the appropriate age norms for the sensory processing tool. Except for the female military subsample, the sample sizes were large ($n \geq 30$) for all the anxiety and sensory processing tests; therefore, we produced a normal probability plot that reasonably confirmed that the female sample was from a normal population.

Correlational Analysis. We used a one-tailed Pearson correlation coefficient to test whether every pair of the five measures—state anxiety, trait anxiety, sensory sensitivity, sensory avoidance, and low registration—was positively correlated and whether sensory seeking was negatively correlated with these five measures.

Quality of Life Survey Analysis. We defined improvement between pretest and posttest on the Quality of Life Survey as the posttest score minus the pretest score. To determine whether the treatment group improved more than the control group, we used one-sided, two-independent-sample *t* tests, equal variances not assumed.

All statistical tests were carried out with Minitab 14 and SPSS 17 software (Minitab, Inc., State College, PA; SPSS, Inc., Chicago).

Results

Only 70 of the 80 planned participants enrolled; however, the attrition rate was much lower than expected, mitigating the impact of fewer participants. All participants who met the inclusion criteria and filled out a study packet

at a study briefing were enrolled in the study. Of the 70 participants, 20 were in the U.S. Army and 50 were in the U.S. Air Force; 22 were women and 48 were men. The group's mean age was 32 (standard deviation [*SD*] = 8.05; Table 1). Although 25 participants met or exceeded the attendance requirements for the study, 10 did not. The statistical findings are based on the 35 control participants and 35 treatment participants. We used best practices intention-to-treat analysis, regardless of whether the participants actually met the stated minimum treatment criteria (Gutman, 2010).

Research Questions 1 and 2 required comparisons between pretest and posttest measurements. Sixty-nine participants completed both the pretest and the posttest for the STAI. For the AASP, all questions in a quadrant must be completed to obtain a quadrant score. Only participants who had a score in a quadrant were included in the analysis for that quadrant. For the AASP, 66 participants completed all the sensory sensitivity questions, 64 completed all the sensory avoidance questions, 64 completed all the low registration questions, and 66 completed all the sensory seeking questions on both the pretests and the posttests. In addition, analyses were conducted of the Quality of Life Survey results; 69 participants completed both the pretest and the posttest.

Research Questions 3, 4, and 5 required analyses of only the pretests of the standardized measures. Of the 70 participants, all 70 completed the STAI, 68 completed all the sensory sensitivity questions, 66 completed all the sensory avoidance questions, 67 completed all the low registration questions, and 68 completed all the sensory seeking questions on the pretests.

Effect of Treatment on Sensory Processing

The AASP data did not yield evidence to support that a sensory-enhanced hatha yoga program would help increase normalization of sensory processing (Table 2). In examining the data, at pretest the 6 participants who had scores indicating high sensory sensitivity were all randomized to the control group; therefore, one would not expect to see significant normalization from the yoga program.

Effect of Treatment on Anxiety

The data yielded evidence that the sensory-enhanced hatha yoga program helped significantly reduce both state and trait anxiety, as determined by comparing the treatment group with the control group ($p < .001$; Table 2). For state anxiety, the control group experienced a mean increase of 1.38 ($SD = 8.52$), and the treatment group experienced a mean decrease of 8.23 ($SD = 8.55$),

Table 1. Demographics

Group (<i>n</i>)	Age		Service Branch		Gender	
	Mean	Standard Deviation	U.S. Army, <i>n</i> (%)	U.S. Air Force, <i>n</i> (%)	Female, <i>n</i> (%)	Male, <i>n</i> (%)
Total treatment participants (<i>n</i> = 35)	32.11	9.09	11	24	14	21
Treatment completed (<i>n</i> = 25)	34.68	9.31	6	19	8	17
Treatment not completed (<i>n</i> = 10)	25.70	4.11	5	5	6	4
Control (<i>n</i> = 35)	31.46	6.97	9	26	8	27
Total group (<i>N</i> = 70)	31.8	8.05	20 (28.6)	50 (71.4)	22 (31.4)	48 (68.6)

yielding a difference between the two groups of 9.61 with a standard error of the difference of 2.055, $t(67) = 4.677$, $p < .001$. For trait anxiety, the control group experienced a mean increase of 1.21 ($SD = 7.18$), and the treatment group experienced a mean decrease of 6.86 ($SD = 6.99$), yielding a difference between the two groups of 8.06 with a standard error of the difference of 1.71, $t(67) = 4.727$, $p < .001$. When the treatment and control groups were partitioned by gender, the results for both state and trait anxiety were unchanged.

Military Test Scores Compared With Established Norms

The AASP results indicate that for the four quadrants (low registration, sensory sensitivity, sensory avoidance, and sensory seeking), the data do not provide evidence of a difference between the mean values of the deployed military personnel population and the normative civilian population (Table 3). The data from the STAI did not yield evidence that either the female or the male military

participants had levels of state anxiety or trait anxiety higher than those of the normative population (see Table 3).

Correlation Results

A one-tailed Pearson correlation coefficient test yielded evidence of a significant positive correlation between state anxiety, trait anxiety, sensory sensitivity, sensory avoidance, and low registration. Sensory seeking was negatively correlated with all measures except low registration; this correlation was insignificant (see Table 4).

Additional Results

Treatment participants showed significantly greater improvement than control participants on 16 of 18 variables of the Quality of Life Survey at the .05 significance level. Items reaching the .001 significance level, showing a decrease over the course of the study and thus indicating improvement in functioning, were “having difficulty concentrating,” “feeling irritable,” “having difficulty performing daily tasks,” “avoiding socializing,” “not

Table 2. Change in Sensory Processing and Anxiety: Control Versus Treatment

Measure	Sample Size	Sample Mean	Standard Deviation	Estimate of Difference	<i>T</i>	<i>df</i>	<i>p</i>
Adolescent/Adult Sensory Profile normalization from pretest to posttest							
Sensory sensitivity				1.82	1.73	54	.96
Control	32	0.15	4.92				
Treatment	34	-1.67	3.41				
Sensory avoidance				1.32	1.54	60	.94
Control	31	0.47	3.20				
Treatment	33	-0.92	3.96				
Low registration				1.16	0.92	51	.82
Control	31	0.48	5.68				
Treatment	33	-0.68	3.93				
Sensory seeking				-0.38	-0.39	61	.35
Control	32	-0.30	4.21				
Treatment	34	0.08	3.65				
	Sample Size	Mean Change	Standard Deviation	Difference	<i>T</i>	<i>df</i>	<i>p</i>
Trait anxiety				8.06	4.73	67	<.0001
Control	34	1.21	7.18				
Treatment	35	-6.86	6.99				
State anxiety				9.61	4.68	67	<.0001
Control	34	1.38	8.52				
Treatment	35	-8.23	8.55				

Table 3. Comparison of Military Adolescent/Adult Sensory Profile and Anxiety Scores With the Normative Population

Measure	Established Mean	Established <i>SD</i>	Sample Size	Sample Mean	Sample <i>SD</i>	<i>Z</i>	<i>p</i>
Adolescent/Adult Sensory Profile							
Sensory sensitivity	33.71	7.63	68	32.22	7.49	-1.61	.947
Sensory avoidance	34.57	7.34	66	33.71	7.16	-0.95	.829
Low registration	30.29	6.25	67	31.40	7.61	1.46	.072
Sensory seeking	49.91	6.83	68	49.24	7.30	-0.81	.208
State-Trait Anxiety Inventory							
Trait anxiety							
Female	36.15	9.53	22	39.27	11.36	1.54	.062
Male	36.54	10.22	48	37.40	9.70	0.58	.281
State anxiety							
Female	36.17	10.96	22	39.09	11.88	1.25	.106
Male	36.54	9.76	48	37.29	11.44	0.53	.297

Note. *SD* = standard deviation.

feeling real interested in things,” and “experiencing feelings of boredom.”

Items reaching the .01 significance level, indicating improvement in functioning, were “having difficulty sleeping” ($p = .002$), “feeling ‘down in the dumps’” ($p = .002$), “not attending to my self-care needs” ($p = .002$), “having outbursts of anger” ($p = .003$), “always ‘on guard’ or ‘watching my back’” ($p = .003$), “experiencing feelings of loneliness” ($p = .004$), “experiencing intrusive thoughts or images” ($p = .005$), and “having bouts of sadness or crying” ($p = .007$). Items reaching the .05 significance level, indicating improvement in functioning, were “blaming myself for things” ($p = .011$) and “experiencing distressing ‘mini-dreams’” ($p = .023$). Experiencing feelings of guilt/shame and getting along with others were both nonsignificant.

Optional written comments by the yoga participants support the results of the standardized measurement tools. Strikingly, 54% of the participants reported sleep improvements despite ongoing environmental disruptions to sleep from gunfire and helicopter sounds. Improvements were experienced specifically during or after yoga sessions (“fell asleep at end”; “I sleep better on nights with class than without”). In addition, 37% of participants commented that they felt more calm or relaxed, 26% commented on other physical benefits, and 11% reported reduced frustration and anger or better anger management.

Discussion

Sensory-enhanced hatha yoga was shown to be effective in reducing both state and trait anxiety in deployed military personnel, despite normal pretest scores. One possible explanation may be that the intervention triggered an inhibitory effect on the autonomic nervous system, which in turn may have contributed to improvements in health

and quality-of-life indicators. Pairing positive affirmations with the neurophysiological effects of the asanas may have helped participants reframe negative thinking patterns that may have developed in response to stressors inherent in a deployed location. The readings may have helped orient participants to the present moment rather than replay past or anticipate future events. The systematic study of each of these elements may be needed to fully determine their contributions to the results. However, the combination of these bottom-up and top-down methods may ultimately be the critical feature of the sensory-enhanced hatha yoga.

Direct evidence was lacking to support the use of sensory-enhanced hatha yoga to improve sensory processing in deployed military personnel. Because all treatment participants tested within normal limits on pretest measures, this finding was expected. However, considering that almost 9% of the total study population showed sensory sensitivity at pretest, a larger study would likely provide a sufficient number of participants with sensory differences to more adequately study this research question. Given the correlation results, future PTSD treatment protocols may be informed by also investigating whether anxiety symptoms tend to precede or follow sensory processing symptoms.

Finally, the positive effect of the yoga treatment on quality of life suggests implications that may be immediately applied in military environments. Specifically, using sensory-enhanced hatha yoga in deployed environments for those with sleep difficulties may provide the most practical, nonpharmaceutical alternative for military personnel.

Implications for Occupational Therapy Practice

Occupational therapists have developed effective tools for reducing hyperarousal and improving self-regulation

Table 4. Summary of Results for Correlation Hypothesis

Measure	State Anxiety	Trait Anxiety	Sensory Sensitivity	Sensory Avoidance	Low Registration	Sensory Seeking
State anxiety						
Hypothesis		+	+	+	+	-
Result		+***	+***	+**	+***	-**
Pearson's <i>r</i>	—	.851	.517	.356	.420	-.271
<i>p</i> (1-tailed)		.000	.000	0.002	0.000	.013
<i>N</i>		70	68	66	67	68
Trait anxiety						
Hypothesis			+	+	+	-
Result			+***	+***	+***	-**
Pearson's <i>r</i>	—		.584	.449	.502	-.310
<i>p</i> (1-tailed)			.000	.000	.000	.005
<i>N</i>			68	66	67	68
Sensory sensitivity						
Hypothesis				+	+	-
Result				+***	+***	-*
Pearson's <i>r</i>			—	.696	.679	-.231
<i>p</i> (1-tailed)				.000	.000	.029
<i>N</i>				66	67	68
Sensory avoidance						
Hypothesis					+	-
Result					+***	-**
Pearson's <i>r</i>				—	.592	-.225
<i>p</i> (1-tailed)					.069	.035
<i>N</i>					65	66
Low registration						
Hypothesis						-
Result						<i>ns</i>
Pearson's <i>r</i>					—	-.049
<i>p</i> (1-tailed)						.346
<i>N</i>						67

Note. + = positive correlation; - = negative correlation.
 p* = .05. *p* = .01. ****p* = .001.

in a variety of diagnostic groups using principles from sensory-based theories (e.g., Bundy, Lane, & Murray, 2002; Farber, 1982). Sensory-enhanced hatha yoga can be an effective and age-appropriate method of application in adult populations. Addressing symptoms before they develop into full-blown PTSD may help prevent occupational dysfunction, which frequently accompanies this disorder (American Psychiatric Association, 2000).

Yoga has been accepted by the occupational therapy profession as an evidence-based treatment modality that, with proper training, can be incorporated into the therapeutic process as a preparatory or purposeful activity (American Occupational Therapy Association, 2005; Casaneda & Jacobs, 2010). This study's results validate the inclusion of sensory-enhanced yoga within the domain of occupational therapy for people with combat stress and may be generalizable to other populations. To summarize,

- Sensory-enhanced hatha yoga can be an effective treatment modality for reducing hyperarousal and improving self-regulation in adult populations,

- The treatment shows potential to effectively address symptoms of combat stress before they develop into full-blown PTSD, and
- The proactive treatment of combat stress may prevent the onset of the occupational dysfunction that can accompany PTSD.

Study Limitations

One study limitation is the lack of clear data on length of deployment and combat exposure, including ongoing exposure during the course of the study, which would likely affect symptomatology and outcomes. Also, the short study duration prevented gathering information about the sequence and timing of symptom onset and treatment sustainability. The skewed randomization of all high-sensory-sensitivity participants to the control group affected the study results as well. Moreover, we relied solely on the participants' subjective reports, which would have been bolstered by the addition of objective physiological measures.

Future Research

On the basis of the results, the question arises as to whether sensory-enhanced yoga can proactively manage traumatic stress sufficiently to preclude the development of PTSD. A prospective study showed that people who developed PTSD 6 mo after a precipitating trauma showed typical scores on the STAI's State Anxiety scale immediately after the traumatic event but atypical scores at the 6-mo mark (Bonne et al., 2001). Because sensory-enhanced yoga has been shown to decrease scores on this scale, a prospective study incorporating this tool may help identify an association between sensory-enhanced yoga and an attenuated emergence of PTSD at a later time.

Despite some limitations, this study provided strong evidence that a sensory-enhanced hatha yoga program successfully reduced symptoms of combat stress and improved occupational performance in deployed military personnel. Additional studies are needed to corroborate these findings, address the limitations, and answer further questions raised by the results. However, on the basis of the results, sensory-enhanced yoga appears to be an effective, low-risk approach to proactive combat stress management. ▲

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References

American Occupational Therapy Association. (2005). Complementary and alternative medicine (CAM) position paper. *American Journal of Occupational Therapy, 59*, 653–655. doi: 10.5014/ajot.59.6.653

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: Author.

Blake, D. D., Weathers, F. W., Nagy, L. M., Kaloupek, D. G., Gusman, F. D., Charney, D. S., et al. (1995). The development of a clinician-administered PTSD scale. *Journal of Traumatic Stress, 8*, 75–90.

Bonne, O., Brandes, D., Gilboa, A., Gomori, J. M., Shenton, M. E., Pitman, R. K., et al. (2001). Longitudinal MRI

study of hippocampal volume in trauma survivors with PTSD. *American Journal of Psychiatry, 158*, 1248–1251. doi: 10.1176/appi.ajp.158.8.1248

Brown, C. E., & Dunn, W. (2002). *Adolescent/Adult Sensory Profile: User's manual*. San Antonio, TX: Psychological Corporation.

Brown, C., Tollefson, N., Dunn, W., Cromwell, R., & Filion, D. (2001). The Adult Sensory Profile: Measuring patterns of sensory processing. *American Journal of Occupational Therapy, 55*, 75–82. doi: 10.5014/ajot.55.1.75

Brown, R. P., & Gerbarg, P. L. (2005a). Sudarshan Kriya yogic breathing in the treatment of stress, anxiety, and depression: Part I—Neurophysiologic model. *Journal of Alternative and Complementary Medicine, 11*, 189–201. doi: 10.1089/acm.2005.11.189

Brown, R. P., & Gerbarg, P. L. (2005b). Sudarshan Kriya yogic breathing in the treatment of stress, anxiety, and depression: Part II—Clinical applications and guidelines. *Journal of Alternative and Complementary Medicine, 11*, 711–717. doi: 10.1089/acm.2005.11.711

Bundy, A., Lane, S., & Murray, E. (2002). *Sensory integration—Theory and practice* (2nd ed.). Philadelphia: F. A. Davis.

Carter, J., & Byrne, G. (2004). *A two year study of the use of yoga in a series of pilot studies as an adjunct to ordinary psychiatric treatment in a group of Vietnam War veterans suffering from post traumatic stress disorder*. Retrieved August 16, 2010, from www.therapywithyoga.com/Vivekananda.pdf

Casaneida, S., & Jacobs, K. (Producers). (2010). *Living life to its fullest, Episode 18: Yoga* [Audio podcast]. Retrieved August 29, 2010, from www.aota.org/Consumers/consumers/Health-and-Wellness/Yoga.aspx

Cimini, L., & Stoller, C. (2009). *General principles of the Yoga Warrior method*. West Boylston, MA: Lucy Cimini.

Cimini, L., Stoller, C., & Greuel, J. (2009). *The Yoga Warrior lesson plan*. West Boylston, MA: Lucy Cimini.

Farber, S. (1982). *Neurorehabilitation: A multisensory approach*. Philadelphia: W. B. Saunders.

Ford, J. D., Courtois, C. A., Steele, K., van der Hart, O., & Nijenhuis, E. R. S. (2005). Treatment of complex post-traumatic self-dysregulation. *Journal of Traumatic Stress, 18*, 437–447. doi: 10.1002/jts.20051

Gutman, S. A. (2010). Reporting standards for intervention effectiveness studies. *American Journal of Occupational Therapy, 64*, 523–527. doi: 10.5014/ajot.2010.09644

Koomar, J. A., & Bundy, A. C. (2002). Creating direct intervention from theory. In A. C. Bundy, S. J. Lane, & E. A. Murray (Eds.), *Sensory integration—Theory and practice* (2nd ed., pp. 261–302). Philadelphia: F. A. Davis.

Lenth, R. V. (2006–2009). Java Applets for power and sample size [Computer software]. Retrieved September 10, 2009, from www.stat.uiowa.edu/~rlenth/Power

Levine, P. A. (1997). *Waking the tiger; healing trauma*. Berkeley, CA: North Atlantic.

Michalsen, A., Grossman, P., Acil, A., Langhorst, J., Lütcke, R., Esch, T., et al. (2005). Rapid stress reduction and anxiolysis among distressed women as a consequence of

- a three-month intensive yoga program. *Medical Science Monitor*, 11, CR555–CR561.
- Miller, R. (2009). *Yoga Nidra integrative restoration* [PowerPoint presentation]. Retrieved June 2, 2009, from iayt.fndrl.org/index.cfm?event=c.getAttachment&riid=2013
- Mollo, K., Schaaf, R., & Benevides, T. (2008, September). The use of kripalu yoga to decrease sensory overresponsivity: A pilot study. *Sensory Integration Special Interest Section Quarterly*, 31(3), 1–4.
- National Center for PTSD. (2006). *Returning from the war zone: A guide for families of military members*. Retrieved May 22, 2009, from www.ncptsd.va.gov/ncmain/ncdocs/manuals/GuideforFamilies.pdf
- Newport, D. J., & Nemeroff, C. B. (2003). Neurobiology of posttraumatic stress disorder. *Focus*, 1, 313–321.
- Ogden, P., Minton, K., & Pain, C. (2006). *Trauma and the body: A sensorimotor approach to psychotherapy*. New York: Norton.
- Pollack, N. (2010). Warriors at peace. *Yoga Journal*, 230, 74–77.
- RAND Center for Military Health Policy Research. (2008). *Invisible wounds: Mental health and cognitive care needs of America's returning veterans*. Retrieved May 22, 2009, from www.rand.org/pubs/monographs/MG720/
- Rothschild, B. (1998). Post-traumatic stress disorder: Identification and diagnosis. *Swiss Journal of Social Work*. Retrieved May 25, 2009, from www.healing-arts.org/tir/n-r-rothschild.htm
- Shin, L. M., McNally, R. J., Kosslyn, S. M., Thompson, W. L., Rauch, S. L., Alpert, N. M., et al. (1999). Regional cerebral blood flow during script-driven imagery in childhood sexual abuse–related posttraumatic stress disorder: A PET investigation. *American Journal of Psychiatry*, 156, 575–584.
- Spielberger, C. D. (1983). *State–Trait Anxiety Inventory for Adults* (sampler set). Menlo Park, CA: Mind Garden.
- Stoller, C., & Cimini, L. (2008). [Sensory profiles of older veterans diagnosed with PTSD.] Unpublished raw data.
- Stoller, C., Greuel, J., & Cimini, L. (2009). *Quality of Life Survey*. Unpublished survey.
- Streeter, C. C., Whitfield, T. H., Owen, L., Rein, T., Karri, S. K., Yakhkind, A., et al. (2010). Effects of yoga versus walking on mood, anxiety, and brain GABA levels: A randomized controlled MRS study. *Journal of Alternative and Complementary Medicine*, 16, 1145–1152. doi: 10.1089/acm.2010.0007
- van der Kolk, B. A. (2004). Psychobiology of posttraumatic stress disorder. In J. Panksepp (Ed.), *Biological psychiatry* (pp. 319–344). Hoboken, NJ: Wiley-Liss.
- van der Kolk, B. A. (2006). Clinical implications of neuroscience research in PTSD. *Annals of the New York Academy of Sciences*, 1071, 277–293. doi: 10.1196/annals.1364.022
- Weathers, F., Litz, B., Herman, D., Huska, J., & Keane, T. (1993, October). *The PTSD Checklist (PCL): Reliability, validity, and diagnostic utility*. Paper presented at the Annual Convention of the International Society for Traumatic Stress Studies, San Antonio, TX.
- Wills, D. K. (2007). Heal life's traumas. *Yoga Journal*, 203, 41–44.