A Combined Kundalini Yoga and Cognitive Behavioral Therapy Program for Posttraumatic Stress Disorder: A Pilot Study

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Abstract

Cognitive behavioral therapy (CBT) is one of the standard conventional treatments for posttraumatic stress disorder (PTSD). However, recent studies have reported the benefits of yoga for reducing PTSD symptoms including a Kundalini Yoga (KY) intervention. The purpose of this study was to test the efficacy of a novel combined 8-week CBT and KY program for treating PTSD symptoms and improving sleep quality in a single group trial of 26 adults with PTSD. PTSD symptoms (PTSD checklist-5) and sleep quality (Pittsburgh Sleep Quality Index) were assessed at baseline, post intervention, and at 2-month follow-up. Both CBT and yoga homework compliance were also measured. Total PTSD symptom scores as well as the cluster symptoms (intrusion, avoidance, arousal/reactivity, and negative alterations in cognitions and mood) were significantly improved following the program, all $p < .01$. The improvements in total PTSD scores, intrusion, avoidance, arousal/reactivity were maintained at follow-up, with all values still less ($p < .01$) than baseline. The negative alterations in cognitions and mood symptom cluster continued to improve further at follow-up compared to post-intervention values ($p < .05$). Total sleep score ($p < .05$) and the subscales of sleep disturbance ($p < .01$), daytime dysfunction($p < .05$), and sleep quality ($p < .01$) were significantly improved after the program and these improvements were maintained at follow-up compared to baseline. Sleep medication use was decreased ($p < .05$) and sleep latency was improved ($p < .01$) at follow-up only compared to baseline. There was a significant positive correlation ($p < .05$) between the completion of the yoga home practice and post change in total sleep scores. These results show that a combined KY and CBT intervention resulted in decreased PTSD symptoms and improved sleep quality and suggest this program may constitute an additional treatment option for PTSD.

Keywords: posttraumatic stress disorder, trauma, yoga, cognitive behavioral therapy, insomnia

Posttraumatic stress disorder (PTSD) may follow the experience or witness of a traumatic event. It affects approximately 6% of adults in the United States at some point in their lifetime (National Center for PTSD, n.d.). The American Psychological Association (APA)'s *Clinical Practice Guideline for the Treatment of PTSD* (American Psychological Association, 2017) strongly recommends cognitive behavioral therapy (CBT) for PTSD treatment in adults. CBT focuses on the relationships among thoughts, beliefs, emotions, and behaviors. It helps a patient recognize and change irrational thoughts and beliefs that drive maladaptive thoughts, emotions and behaviors. Two types of CBT, cognitive processing therapy (CPT) and prolonged exposure (PE), have been widely studied and are also recommended treatments by the APA (American Psychological Association, 2017), the Department of Veterans Affairs and the Department of Defense (Management of Posttraumatic Stress Disorder and Acute Stress Disorder Work Group, 2023).

In contrast to CBT's cognitive and behavioral approach to treating PTSD symptoms, yoga is a both a cognitive and body-based approach. Yoga is an ancient practice that utilizes physical postures and exercises, breathing techniques, relaxation practices, and meditation to optimize psychophysiological functioning with the ultimate goal of achieving contemplative states. In addition to improving physical functioning, it also improves self-regulation of stress and emotion, mind-body awareness, mindfulness and overall well-being (Schmalzl et al., 2020). Given the strong presence of both physical and cognitive/emotional symptoms characteristic of PTSD, yoga addresses both physical and cognitive functioning and therefore may have an advantage over primarily cognitive psychotherapeutic interventions (Lanius et al., 2015). The results of several randomized controlled studies (RCTs) found that yoga (Davis et al., 2020; Jindani et al., 2015; van der Kolk et al., 2014) and yogic breathing (Carter et al., 2013; Seppala et al., 2014) significantly reduced PTSD symptoms compared to a wait-list (Carter et al., 2013; Jindani et al., 2015; Seppala et al., 2014), health education (van der Kolk et al., 2014), or wellness lifestyle program (Davis et al., 2020) control. While CBT and yoga both improve PTSD symptoms, they may complement each other by differentially addressing distinct PTSD symptom clusters.

The four PTSD symptom clusters are: intrusion, avoidance, arousal/reactivity, and negative alterations in cognitions and mood, according to the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed: *DSM-5;* American Psychiatric Association, 2013). Note that in some of the earlier studies cited below, PTSD cluster symptoms were categorized according the 4th edition of *DSM* (*DSM-IV)* (American Psychiatric Association, 1994) in which arousal/reactivity was called hyperarousal, and intrusion was called reexperiencing. Both CBT (Beck et al., 2021) and yoga (Chopin et al., 2020) have been shown to improve negative alterations in cognitions and mood. The cognitive and behavioral techniques used in CBT directly target PTSD's negative cognitions and mood by teaching people to identify and change irrational thoughts that lead to negative moods. Yoga practitioners may selectively recruit neurocognitive resources to disengage from negative emotional processing, as shown by studies on the prefrontal cortex and amygdala (Gothe et al., 2019).

CPT (Kelly et al., 2009) and PE (Cox et al., 2023), are highly effective for the avoidance symptom cluster. CPT trains patients to reset distorted thoughts that drive anxiety and avoidant behavior secondary to traumatic memories. PE addresses avoidance through both imaginal and in-vivo exposure to trauma-related stimuli. Exposure promotes adaptive emotional processing and decreases fear in safe situations, resulting in a reduction in avoidant behavior (Foa, 2011; Stevens et al., 2021). Compared to the avoidance symptom cluster, intrusion is not as effectively treated by PE (Stevens et al., 2021) or CBT (Beck et al., 2021). However, yoga and yogic breathing may be effective in treating intrusion symptoms (Quiñones et al., 2015; Seppala et al., 2014). While the mechanisms have not been studied, yoga may decrease intrusion symptoms by increasing self-monitoring and self-awareness.

Arousal/reactivity is the symptom cluster most resistant to treatment with CPT or PE therapy. Twenty-six percent of active duty military who recovered from PTSD following CPT treatment continued to endorse hyperarousal symptoms, and these symptoms were more likely to be present at the end of treatment than any other symptom cluster (Miles et al., 2022). Hyperarousal symptoms were also retained in women following PE therapy (Schnurr & Lunney, 2019). Eighty-two percent still had difficulty sleeping and continued to experience irritability/anger; 71% had difficulty concentrating; and 72% continued to be hypervigilant. Yoga and yogic techniques may be especially helpful for reducing these symptoms as demonstrated by studies on yoga (Chopin et al., 2020; Mitchell et al., 2014; Staples et al., 2013), yogic breathing (Seppala et al., 2014) and mantra (Crawford et al., 2019). Yoga is well-known for its ability to reduce stress and hyperarousal and foster stress tolerance and resilience (Schmalzl et al., 2020).

The arousal/reactivity cluster symptom is particularly relevant in PTSD because it encompasses sleep disturbance (difficulty falling or staying asleep or restless sleep), which is one of the more troubling and life-disrupting symptoms of PTSD. In a study with more than 200 Veterans, 27% cited sleep problems as one of the main symptoms for which they most wanted help (Rosen et al., 2013). Although CPT and PE demonstrate effectiveness in treating PTSD, insomnia commonly persists. Sixty-six percent of active duty military who completed CPT and no longer met criteria for PTSD still reported ongoing insomnia (Pruiksma et al., 2016). Fifty-one percent of female Veterans and soldiers completing PE therapy, who no longer met diagnostic criteria for PTSD, endorsed the “trouble falling or staying asleep” symptom (Schnurr & Lunney, 2019). In addition to improving quality of life related to sleep, effective treatment of insomnia is important because it also predicts the overall improvement in PTSD (Zalta et al., 2020). Yoga interventions for PTSD have been shown to improve sleep in two RCTs (Davis et al., 2020; Jindani et al., 2015) and several uncontrolled studies (Cushing et al., 2018; McCarthy et al., 2017; Staples et al., 2013; Zaccari et al., 2020). One of the RCTs (Jindani et al., 2015) used a similar version of the Kundalini Yoga (KY) protocol used in our study. This protocol incudes a KY meditation (Shabad Kriya) shown to decrease sleep onset latency (SOL) and increase sleep efficiency and total sleep (Khalsa & Goldstein, 2021).

KY is a comprehensive style of yoga incorporating physical postures and exercises, breathing techniques, relaxation, mantra (chanting), and meditation. It emphasizes physical and psychological health as well as spiritual growth, and has shown utility in the treatment of psychological conditions. In addition to reducing PTSD symptoms and improving sleep, the KY protocol has previously been shown quantitatively to decrease perceived stress, negative affect, and anxiety and increase positive affect and resilience (Jindani et al., 2015). In qualitative studies on the KY PTSD program, participants reported heightened energy; spiritual strength; inner peace; enhanced resilience; better self-care; increased centeredness and self-esteem; greater control of thought patterns; and an interrelated connection between spirit and self (Jindani & Khalsa, 2015a; Jindani & Khalsa, 2015b). Two preliminary studies (Gabriel et al., 2018; M. K. Khalsa et al., 2015) and a larger RCT (Simon et al., 2021) have also evaluated the efficacy of KY interventions in the treatment of generalized anxiety disorder.

There have only been a few studies of interventions for PTSD that combine CBT and yoga. One intervention consisted of a 3-week intensive outpatient program with both group and individual CPT, a mindfulness component and yoga (Zalta et al., 2018). The Zalta et al (2018) intensive program also included psychoeducation (including sleep hygiene), nutrition and fitness, art therapy, case management, and optional medication management and acupuncture. The KY/CBT program used in this study differed from the 3-week intensive program (Zalta et al., 2018) in that the KY/CBT program did not include CPT or mindfulness and did not contain the additional elements of the intensive program of Zalta et al. (2018), and KY differed from the style of yoga used in the Zalta et al. (2018) program. Another PTSD intervention utilized an 8-week web-based program of pre-recorded material and a weekly counseling session (Kirk et al., 2022). The online program consisted of eight CBT themed modules, mindfulness meditation and breath practices, and eight 20-minute trauma informed yoga videos. The

KY/CBT intervention in this study was administered in person, included more hours of yoga, and was a different yoga style than the online program.

The KY protocol used in this study has not previously been combined with CBT as a PTSD intervention. The purpose of this study was to test the efficacy of a combined KY/CBT program for treating PTSD symptoms and improving sleep quality.

Method

Participants

The study protocol was approved by the Georgetown University Institutional Review Board. Participants in the Albuquerque, NM area were recruited through: (a) flyers posted at various locations in the community; (b) an electronic bulletin board and community calendar event website; (c) referrals from an outpatient mental health counseling service; (d) an employee assistance program; and (e) counseling centers at a local community college and a university. Fifty subjects provided written informed consent and were screened with a clinical interview using the Life Events Checklist for *DSM-5* (LEC-5) (Weathers et al.,2013b) and the Clinician-Administered Posttraumatic Stress Disorder Scale for *DSM-5* (CAPS-5) (Weathers et al., 2013a). The LEC-5 assesses exposure to 16 events known to potentially result in PTSD or distress and includes one additional item assessing any other extraordinarily stressful event not described in the first 16 items. The LEC-5 has 6 response choices: Happened to me; Witnessed it; Learned about it; Part of my job; Not sure; Doesn't apply. The purpose of the LEC-5 is to establish exposure to a PTSD Criterion A traumatic event. The CAPS-5 assesses the 20 PTSD symptoms as set forth in the *DSM-5* (American Psychiatric Association, 2013). Twenty items are divided into four symptom clusters. Symptom severity is rated on a scale from 0 to 4. To meet a diagnosis threshold an item response must have a rating of 2 or higher. In order to participate in the study, participants needed to meet PTSD diagnostic criteria as determined by the CAPS-5 and set forth in the *DSM-5* (American Psychiatric Association, 2013). Exclusion criteria included: current uncontrolled psychotic or bipolar disorder, significant cognitive impairment, substance dependence, or a significant medical condition that would interfere with safe participation in the yoga practices. Screening for mental health exclusion criteria was done using the EASY Diagnostic System for *DSM-V* (Burns, 2014).

Procedure

The 8-week CBT and yoga intervention was held once a week for 3 hours. Five consecutive group sessions with cohorts of 7 to 15 participants were run for the study. Approximately half of each session was the group CBT intervention and the other half was the yoga protocol.

The CBT protocol followed the testing, empathy, agenda-setting and methods (TEAM) CBT model (Burns, 2013b). This model addresses trauma by: (a) bringing to light self-defeating beliefs about oneself and the world that interfere with present happiness and success; (b) examining motivational factors that have maintained these beliefs and the distorted thinking that flows from them; (c) replacing self-defeating beliefs with adaptive beliefs and rational thoughts; (d) acquiring new behavioral schemas that support and reinforce these new beliefs; and (e) changing relational behavior by learning new self-esteem and conflict resolution skills. All group sessions included: (a) CBT homework reviews; (b) a didactic segment to teach participants how trauma is retained in belief systems and thought patterns; (c) demonstration of one or more cognitive-behavioral techniques for shifting self-defeating beliefs and distorted thinking; (d) practice of these technique(s) in breakout groups or as a demonstration with an individual participant; and (e) troubleshooting obstacles that arose in learning the tools. Due to the nature of group CBT and personal issues that arose during sessions, there was some flexibility in the order that the techniques were presented. The general outline of CBT tools that were taught is shown in Table 1.

The KY protocol for PTSD was developed by a certified KY Therapist and is a component of the International Kundalini Yoga Therapy Professional Training Program of the Guru Ram Das Center for Medicine and Humanology (S. S. K. Khalsa, 2013). The yoga consisted of physical exercises, breathing techniques, relaxation, and meditation. Sessions included: (a) breathing and movement techniques for calming the body; (b) yoga exercises for integrating the body and mind, creating new habits for self-support, and strengthening the nervous system; and (c) meditations for taking charge of one's thinking, reducing unwanted thoughts, and improving sleep. The specific KY sets (sequences) and meditations are listed in Table 1. In order for participants to gain skill and mastery of the yoga sets and meditations, the protocol overlapped material from session to session to include some repetition of practices. All three yoga sets and six specific meditations were practiced in at least two sessions. The time that each yoga set and meditation was practiced was increased incrementally each session.

Homework included a 15-minute meditation practice called Elementary Adjustment of the Brain (Bhajan, Y. 1995). This meditation consists of three 3-minute exercises. Two of the exercises coordinate arm movements with the breath. The third exercise is a static posture. In the KY school/lineage of yoga, this meditation is believed to reset areas of the brain affected by trauma. Homework also included a 15-minute CBT exercise that involved filling out a form called The Daily Mood Log (Burns, 2013a) on which participants wrote down an upsetting event, identified the emotions they felt, recorded their distorted thoughts about the event, identified the cognitive distortions in their thoughts, and wrote down positive thoughts that challenged the negative thoughts. They also rated the intensity of their emotions and their degree beliefs in their negative thoughts before and after the exercise.

Measures

Assessments were conducted at baseline, at the end of the 8-week intervention, and at 2-month follow-up. The PTSD checklist for *DSM-5* (PLC-5) was used to measure PTSD symptoms (Weathers et al., 2013). The PCL-5 contains 20 items corresponding to the *DSM-5* criteria for PTSD. Past-month symptom severity is indicated using a 5-point scale, with higher scores indicating greater symptoms severity. The total score range is 0 to 80. The score range for each of the PTSD symptom clusters is as follows: intrusion (0–20); avoidance (0–8); negative cognitions/mood (0–28); and avoidance (0–24). The PCL-5 has strong internal consistency ($\alpha = .94$), test-retest reliability ($r = .82$) and convergent ($rs = .74$ to $.85$) and discriminant ($rs = .31$ to $.60$) validity (Blevins et al., 2015). In this study $\alpha = .89$ for the baseline sample.

The Pittsburgh Sleep Quality Index (PSQI) was used to measure 7 components of sleep: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction (Buysse et al., 1989). The PSQI has 19 items with each item scored from 0 to 3. The global score is a sum of the component scores and can range from 0 to 21. A score greater than 5 indicates poor sleep quality (Buysse et al., 1989). The PSQI was scored using the Microsoft Access PSQI Scoring Database provided by the authors of the scale at the University of Pittsburgh (Center for Sleep and Circadian Science, 2023). The PSQI has good internal consistency (Cronbach's ($\alpha = 0.83$) (Buysse et al., 1989) and moderate to high convergent validity ($r = .69$ to $.77$) with other sleep quality scales (Carpenter & Andrykowski, 1998). In this study $\alpha = .80$ for the PSQI baseline components.

Yoga homework practice was tracked using a log filled out by participants each week and submitted at the beginning of each session. Participants recorded the starting and ending time of the yoga practice for each day. The total number of home practice yoga sessions for each participant was divided by the total number of weeks of assessment to calculate the average number of yoga sessions practiced per week. Completed CBT homework sessions were documented based on the number of Daily Mood Logs submitted and the average number of completed CBT homework sessions per week was calculated. At follow-up, participants were asked two questions about how much yoga and CBT practice they had done in the 2 months since the program ended. The first question asked how often they had practiced (on average) the Elementary Adjustment of the Brain meditation and any other yoga sets or meditations taught in the program. The second question asked how often they had practiced any of the CBT techniques. An 8-point scale was used with the following choices: never; less than once per month; once per month; twice per month; once per week; 2-3 times per week; 4-6 times per week; and daily.

Statistical Analysis

A power calculation was done using a Monte Carlo simulation run in Stata 18.0. This method involves simulating data using a mixed model where subjects are nested within groups. The simulation generates 1000 sets of results to obtain an estimated *p* value and power with the parameters used in the model. The simulation was run using the baseline mean (*M*), and pre and post standard deviations (*SDs*), from the treatment group of a study using the KY intervention (Jindani et al., 2015). A 15-point pre to post change was used in the simulation based on what is considered a reliable change in PTSD (Marx et al., 2022). The between individuals and between cohort variances were obtained from data from another mind-body group intervention study (Gordon et al, 2015). Baseline and post values in the simulation were *M* (*SD*) of 59.5 (12.0) and 44.5 (12.0), respectively. The simulation used 0.50 as the variance between individuals, .054 as the variance between cohorts, and 0.18 as the residual variance. The results of the simulation showed that three groups with seven participants (21 total subjects) each gave a power level of 0.98 and an average *p* value of 0.005.

There was very little missing data. One participant skipped one question on the PCL-5 at the post timepoint and the same participant skipped another question on the PCL-5 at follow-up. This missing data from the PCL-5 was imputed with SYSTAT (v.12.02) using the Expectation/Maximization (EM) algorithm. For the PSQI, two participants did not give precise times for some of the questions used to calculate sleep efficiency, latency, and duration. These included questions on going to bed and waking times, number of minutes to fall asleep, and total hours of sleep. Total sleep scores were calculated using these subscale scores so there are a few missing data points for these two individuals for both the missing subscales and the total sleep scores, as seen in the footnote of Table 3.

Data analysis was performed using SPSS version 27 (IBM, SPSS). The MIXED procedure in SPSS was used to run a linear mixed model to account for clustering of the cohorts and a repeated measures over time for individuals. Although this 3-level model accounted for all the possible levels of variance in the design, for 5 of the scales or subscales (Negative Cognitions/Mood; PSQI Total; Sleep Disturbance; Sleep Latency; and Use of Sleep Medications) there was not enough variance at the cohort level to give a stable estimate for the variance parameters. When the model would not run with cohort as a random factor, a marginal model was run to account for the repeated measures of individuals over time. An unstructured covariance matrix of the residuals was used in this model. Time was a fixed factor in all the models. In addition, the following were included as fixed factors as well as their interactions with time: time, sex, age category (in 10-year increments), race, ethnicity, highest level graduated (8^{th} grade, high school, college, graduate school), whether they were actively practicing yoga before joining the study (yes/no); and employment status. If any of these fixed factors or their interactions were significant, they were included in the final model. Pairwise comparisons of differences between time points were performed using a Sidak correction.

A Pearson's product-moment correlation assessed the relationship between the number of homework sessions practiced per week and total PTSD scores, PTSD cluster symptoms or total PSQI sleep scores. Before performing the Pearson correlation test, data was visually inspected to determine if a linear relationship existed. If there was a linear relationship, the Shapiro-Wilk test was done to test for the normal distribution of the variables. All variables included in the Pearson correlation test were normally distributed. Follow-up homework data was visually inspected to see if there was a linear relationship between the amount of practice per month and total PTSD or total PSQI sleep scores.

Statistical analysis was performed to test for differences between participants who completed the intervention (n = 26) and those who either stopped attending (n = 14) or never started the program ($n = 5$) (non-completers). There was one outlier in the non-completers group for the PTSD and PSQI total scores and for the number of traumatic events and two age outliers in the non-completers group. Therefore, a Mann-Whitney *U* test was run to determine if there were differences in baseline PTSD and PSQI total scores, number of traumatic events, and age between completers and non-completers. Fisher's Exact test was used to test for differences in sex, ethnicity, employment, and yoga practice between the completers and non-completers. Employment and yoga practice were both condensed into 2 categories (employed: unemployed) (current yoga practice: no current yoga practice). A chi-square test of independence was conducted between education level and completer category. In order to have expected counts less than 5, education levels were condensed to the following 3 graduation levels: up to college; college; graduate school.

Results

Fifty subjects were screened for eligibility. Forty-five subjects (90%) met the inclusion criteria. Five qualified subjects did not begin the program after screening. Fourteen participants attended 3 or fewer sessions. Twenty-six participants attended 4 or more sessions which was designated as the minimum effective dose according to previous guidelines using mindfulness-based CBT for depression (Teasdale et al., 2000). Data from these 26 participants were included in the per-protocol analysis.

Baseline Characteristics and Trauma Exposure

The baseline characteristics of the 26 participants are shown in Table 2. Participants reported an average of 5.7 (*SD* = 2.2) lifetime traumatic experiences, ranging from 1 to 10 traumatic events on the LEC-5. Participants also reported witnessing an average of 1.6 (*SD* = 1.7) lifetime traumatic events, ranging from 0 to 6. Most people (*n* = 19; 73.1%) experienced 4 to 7 types of traumatic events. The most common traumatic experiences were physical assault (*n* = 24; 92.3%); unwanted or uncomfortable sexual experience (other than sexual assault) (*n* = 17; 65.4%); transportation accident (*n* = 16; 61.5%); sexual assault (*n* = 14; 53.8%), and assault with a weapon (*n* = 10; 38.5%). Twenty (76.9%) also endorsed the "other very stressful event or experience" category.

PTSD Outcomes

There was significant improvement in the total PTSD score and the subscales of intrusion, avoidance, arousal/reactivity and negative cognitions/mood as shown in Table 3. There was no significant change from post to follow-up for total PTSD or the subscales of intrusion, avoidance, or arousal/reactivity indicating that these improvements were maintained at follow-up. Negative cognitions/mood continued to improve at follow-up as indicated by a follow-up score that was significantly lower than the post score. All follow-up scores remained significantly lower than baseline.

Employment Status and PTSD

The employment x time interaction was statistically significant for total PTSD scores (p = .01), avoidance scores (p = .001) and arousal/reactivity scores (p = .004). Changes in total PTSD scores between timepoints according to employment status are shown in Table 4. Participants who were employed or retired/unemployed and not looking for work had significantly more improvement in PTSD and the cluster symptoms of avoidance and arousal/reactivity following the program than those who were unemployed and looking for work and these improvements were maintained at follow-up. Those who were looking for work did not have statistically significant improvement in total PTSD, avoidance, or arousal/reactivity scores over time.

Sleep Outcomes

There was significant improvement in total PSQI sleep scores and the subscales of sleep disturbance, daytime dysfunction, and sleep quality from baseline to post and these improvements were maintained at follow-up (Table3). For sleep latency and use of sleep medication, there was significant improvement at the 2-month follow-up only. There were no significant improvements in sleep duration or sleep efficiency.

Employment Status and Sleep

The employment x time interaction analysis showed that there was significant improvement in sleep disturbance and daytime dysfunction from baseline to follow-up in participants who were employed and those who were retired/unemployed and not looking for work (Table 4). From baseline to post, sleep disturbance was significantly improved in those not looking for employment and daytime dysfunction was significantly improved in those who were employed. In contrast, participants who were looking for work had no significant improvement over time for either sleep disturbance or daytime dysfunction

Employment alone as a fixed factor was significant (p = .005) for use of sleep medication. Participants who were looking for work had significantly higher use of sleep medication across all timepoints compared to those who were employed or retired/unemployed and not looking for work. The difference in the scores across all timepoints between those looking for work and those who were employed was (1.6 [95% CI, 0.6, 2.5], p = .002). Between those looking for work and those who were retired/unemployed and not looking for work, the difference was (1.5 [95% CI, 0.5, 2.6], p = .007) .

Homework Practices

The average number of homework sessions practiced per week was as follows: yoga (M = 4.0, SD = 1.9, n = 24); CBT (M = 3.3, SD = 1.9, n = 24). With 7 sessions of homework assigned per week, this is a compliance rate of 57% for yoga and 47% for CBT. There was a statistically significant correlation between the number of yoga homework sessions practiced per week and pre to post improvement in total PSQI sleep scores r(20) = .49, p = .021. There was no significant correlation between the number of yoga homework sessions practiced per week and improvement in total PTSD scores, r(22) = .26, p = .214 or intrusion scores r(22) = .32, p = .127. The pre to post change in the other cluster symptoms had no linear relationship the number of yoga homework sessions practiced per week. There was also no linear relationship between the number of CBT homework sessions per week and the change in total PSQI sleep, total PTSD, or any of the PTSD cluster symptom scores.

The days of home practice per month at 2-month follow-up were as follows: yoga (M = 6.1, SD = 9.7, n = 20); CBT (M = 7.7, SD = 10.0, n = 20). Of the 20 participants who reported on follow-up practices, 5 (25%) did not practice yoga and 2 (10%) did not practice CBT after the program. Of those that practiced yoga or CBT, the days of home practice per month were as follows: yoga (M = 8.1, SD = 10.7, n = 15); CBT (M = 8.5, SD = 10.2, n = 18). There was no linear relationship between the number of days per month of yoga or CBT practiced and post to follow-up change in the total PTSD or PSQI sleep scores.

Completer vs Non-Completer Analysis

There was no significant difference in the baseline scores, demographics, or trauma exposure for completers and non-completers. The median PTSD total scores for completers (50.5) and non-completers (41.0) were not statistically significantly different, U = 116, z = -1.873, p = .063. The median PSQI total scores for completers (12.0) and non-completers (11.5) were also not statistically significantly different, U = 149, z = -.016, p = .987. There was no significant difference in the median number of types of traumatic events experienced by completers (6) and non-completers (5), U = 195, z = -1.214, p = .225. Nor was there a significant difference in the median age for completers (45.5) and non-completers (36.0), U = 165, z = -1.874, p = .061. There was no statistically significant association between sex (p =.681), race (p =1.0), ethnicity (p = 1.0), employment (p = .055), or current yoga practice (p =.224) and the completer category as assessed by Fisher's exact test. There was also no significant association between education and the completer category, $\chi^2(2)$ = .269, p = .874.

Discussion

Participation in the CBT and KY intervention resulted in significant improvements in the total PTSD score and in the subscales of intrusion, avoidance, arousal/reactivity and negative cognitions/mood. The improvements in the total PTSD score, intrusion, avoidance, and arousal/reactivity were maintained at 2-month follow-up. Negative cognitions/mood continued to improve at 2-month follow-up. According to the US Department of Veterans Affairs, a 15 or greater point change on the PLC-5 is a reliable change l (Marx et al., 2022) and the 19.8 point improvement in the total PTSD score in this study easily meets this criterion. There were also statistically significant improvements in total sleep scores and the subscales of sleep disturbance, daytime dysfunction, and sleep quality following the program and these improvements were maintained at follow-up. Sleep latency and use of sleep medication were not improved immediately following the program but both improved significantly at 2-month follow-up. A change of 3 points is considered to be the minimal clinically important difference (MCID) for the total sleep score of the PSQI (Hughes et al., 2009) and the total sleep score improvement in this study of 3.5 points exceeds this criterion. There were no statistically significant differences in the baseline PTSD or PSQI scores or the demographic variables between those who completed the study and those who never began or dropped out.

Employment Status and Improvement

The improvement in total PTSD symptoms, avoidance and arousal/reactivity as well as sleep disturbance and daytime dysfunction due to sleepiness may have been influenced by employment status. Participants who were unemployed and looking for work did not have improvement in these outcomes. On the other hand, those who were either employed or not looking for work had significant improvements in these scores. However, the number of participants in the looking for work category was very small, only 6 people, so these results may not be representative of a larger population.

It is not known whether persistent PTSD interfered with the ability to find work or whether unemployment was a stressor that inhibited PTSD improvement and contributed to poor sleep outcomes. Either reason, or both, may explain these results according to previous studies. PTSD symptoms can interfere with finding employment as demonstrated in a qualitative study where participants described various barriers (Lu et al., 2022). Conversely, unemployment can be a significant predictor of persistent PTSD as shown in a study of adults in New York City 6 months after the September 11th attacks (Nandi et al., 2004). Those who are unemployed are also more likely to have sleep disturbance (Blanchflower & Bryson, 2021; Greissl et al., 2022). The lack of improvement in sleep disturbance and daytime dysfunction in those who were looking for work in our study may be why these participants also had a higher use of sleep medication compared to those who were employed or those who were not looking for work.

Homework Practice and Sleep Improvement

The average number of yoga sessions practiced per week was 57% of the total assigned sessions and for the CBT it was 47% of assigned sessions. This level of compliance is a little lower than what was measured in a study using either group CBT or yoga for generalized anxiety disorder where homework was measured on a scale of 0 – 6 (0 was “no homework completed” and 6 was “all homework completed”) (Szuhany et al., 2022). In that study, the mean homework completed for CBT and yoga combined on the 0–6 scale was 3.8, or about 63%. The only outcome with significant improvement in our study that correlated with the frequency of yoga homework practice was the pre to post change in the PSQI total sleep score. Other studies that measured sleep improvement as a function of the amount of yoga practice showed mixed results. A study using a yoga breathing practice for patients receiving cancer chemotherapy found that an increase in practice, whether in class or at home, resulted in an improvement in sleep disturbance scores (Dhruva et al., 2012). However, a study with participants with major depressive disorder found no difference in the total sleep PSQI score improvement between low and high dosage yoga groups (Scott et al., 2019). Finally, a study of a home practice intervention of a KY meditation (Shabad Kriya) did not find a significant correlation between the amount of daily practice and improvement in sleep efficiency (S. B. Khalsa, 2004).

The correlation between improved total sleep scores and weekly yoga homework is somewhat surprising because the assigned homework meditation was not the Shabad Kriya KY mediation that has been shown to improve sleep (Khalsa & Goldstein, 2021). While Shabad Kriya was practiced during sessions 2-5 in class in this study, the homework assignment was the Elementary Adjustment of the Brain meditation. According to the KY school, this meditation is said to be "effective for relieving loss of memory, loss of feelings, and nightmares" (Bhajan et al., 1995), which are symptoms subsumed under the negative alterations in cognitions and mood and intrusion symptom clusters. The homework results from this study suggest it may also improve sleep as well, although this may not be unexpected given that yoga and meditation practices in general have a positive impact on sleep (Wang et al., 2019).

As noted earlier, difficulty sleeping is a distressing symptom that often remains after CBT treatments for PTSD. An important finding in this study was that the improvements in total sleep scores, sleep disturbance, daytime dysfunction, and sleep quality were maintained 2 months after the program was over. On average, participants were also falling asleep faster and using less sleep medication 2 months following the program than they were before the program. The continued sleep improvements were seen even with a relatively low amount of home practice following the program as compared to during course of the program. These results are encouraging because they suggest that this program may be able to more effectively treat insomnia than CBT alone. Given that Shabad Kriya is part of the program and the amount of yoga homework practiced correlated with better sleep, the KY component may have contributed to these positive sleep outcomes.

There was not a correlation between CBT or yoga homework and a reduction in PTSD symptoms. This is in contrast to some other studies. One study using CPT found that there was a larger decrease in PTSD symptoms in participants who completed more homework but this was only observed in those with higher baseline levels of PTSD (Stirman et al., 2018). Another study using PE found a significant linear regression of homework on PTSD symptoms but only for imaginal exposure and not for in vivo exposure homework (Cooper et al., 2017). A yoga study for PTSD found that the amount of yoga practice from baseline to 1.5-year follow-up was associated with greater decreases in PTSD severity

(Rhodes et al., 2016). It is not known why PTSD improvement was not associated with CBT or yoga homework practice in this study. The CBT homework assignment was the same throughout this study, whereas CPT homework varies according to the session. The CBT homework in this study also did not involve exposure as used in the Cooper et al. (2017) study. The small sample size may have been the reason why the correlation between PTSD improvement and yoga homework was not significant. It may also be that the Elementary Adjustment of the Brain meditation was more effective for sleep than for overall PTSD symptoms.

Mechanisms of Yoga on Arousal/Reactivity and Intrusion

Yoga may be more effective than CBT for reducing arousal/reactivity and intrusion cluster symptoms. While the mechanisms have not been fully studied, arousal/reactivity may be targeted by yoga via the well-known yoga-mediated improvement in self-regulation of the stress response systems, the autonomic nervous system and the hypothalamic pituitary adrenal axis (Pascoe et al., 2017). High frequency-heart rate variability (HF-HRV) is a measure of parasympathetic nervous system function (Ulmer et al., 2018). HF-HRV is reduced in PTSD (Ge et al., 2020) and this reduction is correlated with arousal/reactivity symptoms (Park et al., 2017). Yoga has been shown to increase HF-HRV in healthy adults (Sawane & Gupta, 2015; Pal et al., 2014). HF-HRV is also higher in yoga practitioners compared to sedentary individuals (Satin et al., 2014). Therefore, yoga practice in healthy individuals increases parasympathetic nervous system function as measured by increased HF-HRV. In US Veterans with PTSD, there were greater increases in HF-HRV in participants practicing a yoga breathing technique than in those treated with CPT (Mathersul et al., 2022). Additionally, participants practicing the yogic breathing technique also had larger HF-HRV values overall at the end of the treatment than participants of the CPT intervention. These results suggest that by increasing parasympathetic nervous system activity, yoga and yogic breathing techniques may reduce arousal/reactivity symptoms and may do so more effectively than CBT.

Intrusion symptoms may also be reduced by yoga through the regulation of memory encoding via norepinephrine. Norepinephrine is stress-response hormone that plays a central role in the encoding of memories of stressful or fear-provoking events (Southwick et al., 1999). A meta-analysis of 23 studies showed that norepinephrine levels in plasma and/or urine were higher in individuals with PTSD than in controls (Pan et al., 2018) and increased norepinephrine in PTSD is correlated with reexperiencing (i.e. intrusion) symptoms (Lemieux & Coe, 1995; Yehuda et al., 1992). Yoga can decrease urine norepinephrine as shown in a KY program for stress reduction (Granath et al., 2006). A hypertension study on yoga also measured decreased plasma norepinephrine concentrations (Selvamurthy et al., 1998). The decrease of norepinephrine by yoga practice in people with PTSD may be a mechanism by which yoga reduces intrusion symptoms by better regulation of memory encoding via norepinephrine reduction.

Limitations

The obvious major limitation of this study is that it was a single-group, uncontrolled pilot study with a relatively small sample size. While we did see statistically and clinically meaningful improvement in PTSD symptoms and sleep, the evidence is not as strong without a control group and may have been stronger with a larger sample size. Another study limitation is that exclusion criteria did not include the use of concomitant yoga, cognitive behavioral therapy, or other PTSD treatments during the 8-week intervention. The participant characteristics show that nine participants (35%) had been practicing yoga at least twice a week before the study began. Other than tracking the assigned yoga homework, we did not assess whether participants were engaging in other yoga practices or therapy during the study. Whether or not subjects were practicing yoga before the study was included as fixed factor in the linear mixed models and was not statistically significant. However, it was not possible to determine what additional yoga practices or therapies participants were practicing outside of the assigned intervention that could have contributed to improvement in PTSD or sleep. There is also the limitation that the intervention was delivered by the investigators. This could have introduced bias in the participants' responses, although this potential bias was reduced by having a research assistant who was not otherwise involved in the study collect the data before and after the intervention.

Conclusion

The results of this study suggest that this combined intervention of KY and CBT is effective in reducing PTSD symptoms and improving sleep. One advantage of this program is that it includes CBT, a highly recommended treatment for PTSD, and it addresses sleep problems that are often not typically resolved with CBT alone. Another advantage is that this program has diverse elements and some of the elements may be more appealing and/or more effective depending on the individual's symptoms and preferences. A larger study comparing the effectiveness of the KY and CBT protocols that determined the role that each play in improving different symptom clusters would be helpful in predicting which individuals might benefit the most from each intervention protocol or from both.

Declaration of Conflicting Interests

The Authors declare that there is no conflict of interest.

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Data Availability Statement

The datasets generated during and analyzed during the current study are available from the corresponding author.

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Table 1

Outline of CBT and Kundalini Yoga Taught in Each Session

Session	CBT Concepts and Tools[a]	Kundalini Yoga Kriyas and Meditations[b]
1	Introduce the concept of distorted thoughts and teach how to use the Daily Mood Log worksheet as the CBT homework assignment.	Elementary Adjustment of the Brain Kriya to Still Nerves, Shakes, Anxiety and Tension
2	Explain the difference between healthy and unhealthy emotions. Introduce the Cost Benefit Analysis as an agenda-setting tool to help participants choose which PTSD symptoms they would like to address and which they may prefer to accept.	Elementary Adjustment of the Brain Kriya to Still Nerves, Shakes, Anxiety and Tension Shabad Kriya
3	Present the concept of self-defeating beliefs. Teach and practice cognitive and behavioral tools to identify and install new, adaptive beliefs.	Shabad Kriya Kriya to Still Nerves, Shakes, Anxiety and Tension Gudtkaa Kriya
4	Present and practice additional cognitive and behavioral tools to consolidate new beliefs.	Shabad Kriya Creating Internal Balance Gudtkaa Kriya
5	Teach and practice assertiveness and conflict resolution skills to help participants learn new and effective ways of interacting with others.	Shabad Kriya Creating Internal Balance Jupiter Finger Chakra Meditation
6	Examine the roots of self-esteem. Identify internal and external sources of self-worth and the advantages and disadvantages of each.	Jupiter Finger Chakra Meditation Creating Internal Balance Pauri Kriya

Session	CBT Concepts and Tools[a]	Kundalini Yoga Kriyas and Meditations[b]
7	Present and practice cognitive and behavioral tools to address avoidance and procrastination, two common responses to trauma exposure.	Pauri Kriya Renew Your Nervous System and Build Stamina Meditation into Being
8	Explain the importance of using the CBT tools when PTSD symptoms return. Practice addressing the thoughts and feelings that may reoccur using the CBT tools mastered in the program.	Pauri Kriya Renew Your Nervous System and Build Stamina Meditation into Being

[a]CBT Sessions 2-8 began with a review of the Daily Mood Log homework

[b]A guided deep relaxation was included at the end of Session 1 and before the last meditation in Sessions 2-8

Table 2

Participant Characteristics

	n	%
Sex		
Male	5	19.2
Female	21	80.8
Race		
White	23	88.5
Other (includes mixed race)	3	11.5
Ethnicity		
Hispanic/Latinex	9	34.6
Not Hispanic/Not Latinx	17	65.4
Highest Level of Education		
8th Grade Graduate	1	3.8
High School Graduate	2	7.7
Some College	6	23.1
College Graduate	5	19.2
Some Graduate School	4	15.4
Post Graduate Degree	8	30.8
Employment status		
Employed (full-time or part-time)	12	46.2
Unemployed or retired, and not looking for work	8	30.8
Unemployed or retired, and looking for work	6	23.1
Military status		
None	24	92.3
Veteran	2	7.7
Military Branch (*N*)		
Air Force	1	3.8
Marines	1	3.8

	n	%
Period of Military Service		
Vietnam	1	3.8
Between Gulf War (1991) and War in Afghanistan	1	3.8
Yoga or Meditation Practice		
Never	2	7.7
In the past only	10	38.5
Current practice – less than once a month	1	3.8
Current practice – once a month	3	11.5
Current practice – twice per month	1	3.8
Current practice – 2-3 times per week	4	15.4
Current practice – daily	5	19.2

Note. N = 26. Participants were on average 46.0 years old (*SD* = 2.5) with an age range of 19 – 73 years.

Table 3

Results of PTSD and Sleep Measures

Outcome Measure	Mean Score[a] [95% Confidence Interval] Baseline (T1) (n = 26)[b]	Post Treatment (T2) (n = 24)[c]	Follow-up (T3) (n = 21)[d]	*p* value[e]	Score Change [95% Confidence Interval] Pairwise Comparisons[f]
PCL-5 Total Score	50.3 [42.4, 58.2]	30.5 [23.1 37.9]	26.1 [17.9, 34.4]	< .001	T1 vs T2: -19.8 [-29.5, -10.1], *p* < .001 T1 vs T3: -24.2 [-33.4, -14.9], *p* < .001 T2 vs T3: -4.4. [-11.6, 2.8], *p* = .342
Intrusion	11.2 [8.4, 13.9]	7.4 [4.7, 10.1]	7.2 [4.5, 9.9]	.002	T1 vs T2: -3.8 [-6.5, -1.1], *p* = .005 T1 vs T3: -3.9 [-6.6, -1.2], *p* = .003 T2 vs T3: -0.2 [-2.4, 2.2], *p* = .998
Avoidance	5.5 [4.5, 6.6]	3.1 [2.2, 4.2]	2.6 [1.6 ,3.6]	< .001	T1 vs T2: -2.4 [-3.7, -1.0], *p* < .001 T1 vs T3: -3.0 [-4.0, -2.0], *p* < .001 T2 vs T3: -0.6 [-1.3, 0.2], *p* = .184
Arousal/Reactivity	13.4 [9.6, 17.2]	7.9 [4.1, 11.6]	6.6 [2.7, 10.5]	< .001	T1 vs T2: -5.5 [-8.5, -2.5], *p* < .001 T1 vs T3: -6.7 [-9.8, -3.7], *p* < .001 T2 vs T3: -1.2 [-4.2, 1.8], *p* = .645
Negative Cognitions/Mood	19.9 [17.7, 22.0]	11.7[9.8, 13.5]	9.2 [7.0, 11.4]	< .001	T1 vs T2: -8.2 [-12.0,- 4.4], *p* < .001 T1 vs T3: -10.7 [-14.4, -7.0], *p* < .001 T2 vs T3: -2.5 [-4.9, 0.6], *p* = .044

	Mean Score[a] [95% Confidence Interval]				Score Change [95% Confidence Interval]
Outcome Measure	Baseline (T1) (n = 26)[b]	Post Treatment (T2) (n = 24)[c]	Follow-up (T3) (n = 21)[d]	*p* value[e]	Pairwise Comparisons[f]
PSQI Total Score	11.5 [9.6, 13.4]	8.1 [6.2, 9.9]	6.5 [4.6, 8.3]	< .001	T1 vs T2: -3.5 [-6.4, -0.6], $p = .016$ T1 vs T3: -5.0 [-7.5, -2.6], $p < .001$ T2 vs T3: -1.5 [-3.6, 0.4], $p = .154$
Sleep Duration	1.3 [0.7, 1.9]	0.9 [0.3, 1.5]	0.8 [0.3, 1.4]	.152	No pairwise comparisons Change over time was not significant
Sleep Disturbance	2.0 [1.7, 2.3]	1.5 [1.3, 1.7]	1.2 [0.9, 1.4]	< .001	T1 vs T2: -0.5 [-0.9, -0.2], $p = .001$ T1 vs T3: -0.9 [-1.2, -0.5], $p < .001$ T2 vs T3: -0.3 [-0.7, 0.6], $p = .119$
Sleep Latency	1.7 [1.2, 2.2]	1.2 [0.7, 1.6]	0.9 [0.5, 1.3]	.004	T1 vs T2: -0.6 [-1.2, 0.1], $p = .090$ T1 vs T3: -0.9 [-1.4, -0.3], $p = .003$ T2 vs T3: -0.3 [-0.9, 0.2], $p = .426$
Daytime Dysfunction	1.8 [1.5, 2.2]	1.3 [0.9, 1.6]	1.0 [0.7, 1.4]	< .001	T1 vs T2: -0.6 [-1.1, 0.05], $p = .030$ T1 vs T3: -0.8 [-1.1, -0.5], $p < .001$ T2 vs T3: -0.2 [-0.6, 0.2], $p = .416$
Sleep Efficiency	1.2 [0.6, 1.9]	1.1 [0.4, 1.7]	1.1 [0.4, 1.7]	.744	No pairwise comparisons Change over time was not significant

	Mean Score[a] [95% Confidence Interval]				Score Change [95% Confidence Interval]
Outcome Measure	Baseline (T1) (n = 26)[b]	Post Treatment (T2) (n = 24)[c]	Follow-up (T3) (n = 21)[d]	*p* value[e]	Pairwise Comparisons[f]
Sleep Quality	2.0 [1.6, 2.4]	1.3 [0.9, 1.7]	1.0 [0.6, 1.4]	.001	T1 vs T2: -0.7 [-1.2,- 0.3], *p* = .002 T1 vs T3: -1.0 [-1.6, -0.4], *p* = .001 T2 vs T3: -0.3 [-0.7, 0.2], *p* = .318
Use of Sleep Medication	1.8 [1.3, 2.3]	1.4 [0.9, 1.9]	0.9 [0.4, 1.4]	.018	T1 vs T2: -0.4 [-1.1 0.3], *p* = .388 T1 vs T3: -0.9 [-1.6, -0.2], *p* = .016 T2 vs T3: -0.5 [-1.2, 0.2], *p* = .247

[a] Mean scores are Estimated Marginal Means from the repeated measures linear mixed models.

[b] for PSQI Total Score and Sleep Latency, n = 25

[c] for PSQI Total Score, Sleep Duration and Sleep Efficiency, n = 22; for Sleep Latency, n = 23

[d] for PSQI Total score and Sleep Latency, n = 19; for Sleep Efficiency n = 20

[e] *p* value is for differences across the three timepoints

[f] Change scores calculated using the T1, T2, and T3 values on the table may vary slightly compared to those shown in pairwise comparisons due to rounding of the mean scores

Table 4

PTSD and Sleep Improvement Based on Employment Status

	Mean Score[a] [95% Confidence Interval]			Score Change [95% Confidence Interval]
PTSD or Sleep Outcome and Employment Category	Baseline (T1)[b]	Post Treatment (T2)[c]	Follow-up (T3)[d]	Pairwise comparisons[e]
Total PTSD				
Employed	46.6 [37.4, 55.8]	18.5 [10.6, 26.4]	18.2 [8.3, 28.1]	T1 vs T2: -28.1 [-41.6, -14.6], *p* < .001 T1 vs T3: -28.5 [-41.3, 15.6], *p* < .001 T2 vs T3: -0.4 [-10.4, 9.7], *p* = 1.00
Not Looking for Employment (Retired or Unemployed)	55.1 [44.6, 65.6]	23.1 [13.4, 32.8]	15.4 [2.5 28.3]	T1 vs T2: -32.0 [-49.2, -14.8], *p* < .001 T1 vs T3: -39.7 [-57.0, -22.4], *p* < .001 T2 vs T3: -7.7 [-21.6, 6.2] *p* = .414
Looking for Employment (Retired or Unemployed)	49.2 [37.3, 61.1]	49.9 [40.1, 59.7]	44.9 [32.3, 57.4]	T1 vs T2: 0.7 [-18.4, 19.8], *p* = 1.00 T1 vs T3: -4.3 [-21.9, 13.1], *p* = .893 T2 vs T3: -5.0 [-18.9, 8.3], *p* = .707
Avoidance				
Employed	5.3 [4.1, 6.5]	2.1 [0.9, 3.3]	1.7 [0.6, 2.8]	T1 vs T2: -3.2 [-5.0, -1.3], *p* = .001 T1 vs T3: -3.6 [-4.9, -2.2], *p* < .001 T2 vs T3: -0.4 [-1.5, 0.7] *p* = .723
Not Looking for Employment (Retired or Unemployed)	6.4[5.0, 7.8]	2.0 [0.5, 3.6]	1.2 [-0.2, 2.6]	T1 vs T2: -4.3 [-6.8, -1.9], *p* < .001 T1 vs T3: -5.2 [-7.0, -3.3], *p* < .001 T2 vs T3: -0.8 [-2.3, 0.6], *p* = .394
Looking for Employment (Retired or Unemployed)	5.0 [3.4, 6.6]	5.3 [3.8, 6.9]	4.8 [3.5, 6.3]	T1 vs T2: 0.3 [-2.3, 3.0], *p* = .984 T1 vs T3: -0.2 [-2.1, 1.7], *p* = .995 T2 vs T3: -0.5[-1.9, 0.9], *p* = .758

	Mean Score[a] [95% Confidence Interval]			Score Change [95% Confidence Interval]
PTSD or Sleep Outcome and Employment Category	Baseline (T1)[b]	Post Treatment (T2)[c]	Follow-up (T3)[d]	Pairwise comparisons[e]
Arousal/Reactivity				
Employed	13.1 [9.0, 17.2]	4.4 [0.8, 7.9]	4.8 [0.5, 9.1]	T1 vs T2: -8.8 [-13.0, -4.5], *p* <. 001 T1 vs T3: -8.3 [-12.6, -4.0], *p* < .001 T2 vs T3: 0.4 [-3.7, 4.6], *p* = .992
Not Looking for Employment (Retired or Unemployed)	15.2 [10.7, 19.7]	5.8 [2.0, 9.6]	3.3 [-1.9, 8.6]	T1 vs T2: -9.4 [-14.9, -4.0], *p* = .001 T1 vs T3: -11.9 [-17.8, -6.0], *p* < .001 T2 vs T3: -2.5 [-8.2, 3.3] *p* = .624
Looking for Employment (Retired or Unemployed)	11.8 [6.8, 16.8]	13.5 [9.8, 17.3]	11.9 [6.6, 17.0]	T1 vs T2: 1.7 [-4.3, 7.6], *p* = .857 T1 vs T3: 0.0 [-5.7, 5.7], *p* = 1.0 T2 vs T3: -1.7 [-7.2, 3.8], *p* = .821
Sleep disturbance				
Employed	1.8 [1.4, 2.2]	1.4 [1.1, 1.7]	1.1 [0.8, 1.5]	T1 vs T2: -0.4 [-0.9, 0.3], *p* = .075 T1 vs T3: -0.7 [-1.3, -0.2], *p* = .005 T2 vs T3: -0.3 [-0.8, 0.2], *p* = .372
Not Looking for Employment (Retired or Unemployed)	2.4 [1.9, 2.9]	1.4 [0.9, 1.8]	0.9 [0.4, 1.3]	T1 vs T2: -1.0 [-1.6, -0.4], *p* < .001 T1 vs T3: -1.5 [-2.2, -0.8], *p* < .001 T2 vs T3: -0.5 [-1.2, 0.3], *p* = .267
Looking for Employment (Retired or Unemployed)	1.8 [1.3, 2.4]	1.7 [1.2, 2.1]	1.5 [1.0, 2.0]	T1 vs T2: -0.2 [-0.8, 0.5], *p* = .879 T1 vs T3: -0.3 [-1.0, 0.4], *p* = .558 T2 vs T3: -0.2[-0.9 0.6], *p* = .907

PTSD or Sleep Outcome and Employment Category	Mean Score[a] [95% Confidence Interval] Baseline (T1)[b]	Post Treatment (T2)[c]	Follow-up (T3)[d]	Score Change [95% Confidence Interval] Pairwise comparisons[e]
Daytime Dysfunction				
Employed	1.7 [1.3, 2.2]	0.98 [0.6, 1.4]	1.0 [0.7, 1.4]	T1 vs T2: -0.8 [-1.5, -0.05], *p* = .035 T1 vs T3: -0.7 [-1.2, -0.2], *p* = .003 T2 vs T3: 0.07 [-0.5, 0.6], *p* = .986
Not Looking for Employment (Retired or Unemployed)	2.2 [1.7, 2.7]	1.4 [0.9, 2.0]	0.7 [0.2, 1.1]	T1 vs T2: -0.7 [-1.6, 0.2], *p* =.135 T1 vs T3: -1.5 [-2.1, -0.9], *p* < .001 T2 vs T3: -0.7 [-1.5, 0.02], *p* = .059
Looking for Employment (Retired or Unemployed)	1.6 [1.0, 2.1]	1.4 [0.8 1.9]	1.4 [0.9, 1.8]	T1 vs T2: -0.2 [-1.2, 0.8], *p* = .963 T1 vs T3: -0.2 [-0.8, 0.5], *p* = .876 T2 vs T3: 0.0[-0.8, 0.8], *p* = 1.0

[a] Mean scores are Estimated Marginal Means from the repeated measures linear mixed models.

[b]Participant numbers are as follows: Employed (n= 12), Not looking for employment (n = 8); Looking for employment (n=6)

[c]Participant numbers are as follows: Employed (n= 12), Not looking for employment (n = 6); Looking for employment (n=6)

[d]Participant numbers are as follows: Employed (n= 10), Not looking for employment (n = 5); Looking for employment (n=6)

[e] Change scores calculated using the T1, T2, and T3 values on the table may vary slightly compared to those shown in pairwise comparisons due to rounding of the mean scores