Research

A Case Series on the Effects of Kripalu Yoga for Generalized Anxiety Disorder

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Abstract

Generalized anxiety disorder (GAD) is a prevalent psychiatric disorder associated with substantial impairment and poor treatment response. Yoga influences processes that are linked to the maintenance of GAD including mindfulness, anxiety, and heart rate variability, but has yet to be evaluated among people with the disorder. The present study is a first step toward documenting the efficacy of yoga for reducing worry among people with GAD using a single-subject AB design case series and daily ratings of worry. Standardized self-report measures of worry, trait anxiety, experiential avoidance, mindfulness, and heart rate variability were assessed pre- and post-intervention. Three participants with primary GAD received eight twice-weekly Kripalu yoga sessions following a baseline data collection period. All participants showed systematic improvement in daily worry ratings on at least one index and all scores on self-reported measures of worry, anxiety, experiential avoidance, and mindfulness changed in the expected direction following yoga (with one or two exceptions). Participants also showed improved heart rate variability during a worry period from pre- to post-intervention. Yoga has the potential to improve the processes linked to GAD and should stimulate further research in this area.

Keywords: yoga, case series, generalized anxiety disorder, heart rate variability

Introduction

Yoga has increased in popularity in the United States in recent years (Clarke et al., 2015), and people in the US who are interested in practicing yoga often cite mental health benefits as reasons to practice (Birdee, Legedza, Saper, Bertisch, Eisenberg, & Phillips, 2008). The evidence to date supports this reasoning; practicing yoga has been linked to reductions in symptoms of depression and anxiety (Harner, Hanlon, & Garfinkel, 2010; Fan & Chen, 2011; Javanbakht, Hejazi Kenari, & Ghasemi, 2009). Across a variety of high-stress circumstances, people practicing yoga report less anxiety, including breast cancer survivors (Rao, Raghuram, Nagendra, Gopinath, Srinath, Diwakar, Patil, Bilimagga, Rao, & Varambally, 2009), incarcerated women (Harner et al., 2010), and individuals with schizophrenia (Vancampfort, De Hert, Knapen, Wampers, Demunter, Deckx, Maurissen, & Probst, 2011). In a randomized controlled trial of women with high levels of self-reported anxiety, two months of yoga reduced state and trait anxiety to a greater extent than a two-month waitlist control (Javnbahkt et al., 2009). Yoga is associated with more anxiety reduction than other forms of exercise (Berger & Owen, 1988) and has been hypothesized to improve mental health symptoms by reducing allostatic load (i.e., the physiological impact of stress) (Streeter, Gerbarg, Saper, Ciraulo, & Brown, 2012).

A small number of studies have begun to examine yoga for those diagnosed with clinical anxiety disorders. In a small trial, van der Kolk (2006) found that yoga was associated with reduced intrusions and hyperarousal in women with PTSD, whereas a Dialectical Behavior Therapy group treatment did not show these effects. Later, van der Kolk, Stone, West, Rhodes, Emerson, Suvak, and Spinazzola (2014) expanded this work when they published a larger randomized controlled trial; in this study, ten sessions of

Hatha yoga more effectively reduced PTSD symptoms than a ten-session health education group among women with chronic, treatment non-responsive PTSD. In another study, Carter, Gerberg, Brown, Ware, D'Ambrosio, Anand, Dirlea, Vermani, and Katzman (2013) found that yoga reduced depression and symptoms of PTSD significantly more than a waitlist control among veterans diagnosed with PTSD. Finally, Vorkapic and Rangé (2014) found that those diagnosed with panic disorder reported lower anxiety on multiple metrics following a two-month yoga intervention, either alone or in combination with psychotherapy. Although evidence for the treatment of anxiety disorders with yoga is promising, little to no research to date has examined the impact of yoga on Generalized Anxiety Disorder (GAD). The present study systematically examines the impact of yoga on three individuals with GAD.

GAD is a common psychiatric disorder characterized by exaggerated and impairing worry. Worry, the core feature of GAD, is defined as a cognitive, verbal/linguistic attempt to problem-solve an uncertain, potentially negative future event (Borkovec, Robinson, Pruzinsky, & DePree, 1983). Among individuals with GAD, worry has become uncontrollable and is accompanied with a number of physiological symptoms such as fatigue, muscle tension, difficulty sleeping, and a subjective sense of restlessness. GAD is associated with greater rates of impairment and disability than any other anxiety, substance use, or personality disorder (Grant, Hasin, Stinson, Dawson, Ruan, Goldstein, Smith, Saha, & Huang, 2005) and shows the poorest response to psychotherapy of all the anxiety disorders (Brown, Barlow, & Liebowitz, 1994). Theoretical models suggest that yoga could reduce the symptoms of GAD by targeting both psychological and physiological processes associated with this disorder.

The avoidance theory of GAD posits that worry functions as an avoidance strategy (Borkovec, Alcaine, & Behar, 2004) because applying language to emotional experience (i.e., worrying) allows individuals to avoid uncomfortable internal experiences (Borkovec & Hu, 1990). The language-based process of worry is hypothesized to temporarily reduce anxiety because words are indirectly related to fear, whereas images of feared events take on more stimulus properties of the feared event and cause more distress (Borkovec, Alcaine, & Behar, 2004). That is, an individual with GAD may process feared future events through applying language to this experience (e.g., "What if I stumble over my words in my class presentation?") instead of imagery (e.g., mental images of stumbling during the class presentation). Using language rather than imagery to describe an emotionally charged scene is associated with less cardiovascular responsiveness to the scene (Vrana, Cuthbert, & Lang, 1989).

Worry functions physiologically (if somewhat counter-intuitively) to mitigate anxiety by reducing cardiovascular responding in the short term; in the long term, however, it results in physiologic dysfunction, including poor parasympathetic nervous system control (Hoehn-Saric & McLeod, 1988), decreased brain GABA activity (Friedman, 2007), and even heightened risk for myocardial infarction (Martens et al., 2010). One way to target the avoidant function of worry and thereby reduce it has been to increase exposure to and acceptance of internal experiences (Roemer, Orsillo, & Salters-Pedneault, 2008). This is accomplished, in part, by encouraging mindfulness—nonjudgmental awareness of internal experience.

Cultivating mindful awareness is an essential component of yoga. Hatha yoga, by definition, involves mindful awareness while moving through physical posture sequences (Feuerstein, 2001). Brisbon and Lowery (2009) found that advanced Hatha yoga practitioners report significantly higher levels of mindfulness than a sample of yoga beginners. Healthy adults randomly assigned to an eight-week yoga intervention reported greater increases in overall mindfulness, attention to the present moment, acceptance, and open attitudes to experience than those assigned to a waitlist (Shelov & Suchday, 2009). Increasing mindfulness involves increased contact with experiences that arise in the present moment, thereby reducing avoidance of unwanted negative internal experiences (Hayes & Wilson, 2003). The relation between mindfulness and experiential avoidance has been demonstrated experimentally; individuals randomly assigned to a mindfulness condition show lower levels of experiential avoidance than individuals assigned to suppress their thoughts (Hooper, Villatte, Neofotistou, & McHugh, 2010). Yoga may reduce the worry characterized by individuals with GAD by increasing mindfulness and decreasing experiential avoidance.

Yoga may also relieve symptoms of GAD because it improves physiological dysfunctions associated with the disorder. Individuals with GAD consistently show lower levels of heart rate variability (HRV) (Hoehn-Saric & McLeod, 1988; Hoehn-Saric, McLeod, & Zimmerli, 1989), especially high-frequency HRV (HF-HRV). Higher HRV indicates that the heart can more quickly adapt to changing environmental stimuli and generally is considered a more adaptive physiological response to stress (Dishman et al., 2000). Parasympathetic functioning, which is indexed by power in the high-frequency band of HRV (Saul, 1990), is particularly important in this regulatory function of the heart. The parasympathetic nervous system influences an individual's ability to return to baseline heart functioning following a stressful stimulus. Thus, those individuals with greater HF-HRV have greater ability to quickly calm down following a stress reaction (Appelhans & Luecken, 2006).

Yoga has been shown to increase the low levels of heart rate variability typically exhibited by people with GAD, particularly in the high-frequency band. In a randomized, waitlist-controlled trial of prenatal yoga, pregnant women who practiced yoga daily showed significantly greater increases in HF-HRV than controls who engaged in a series of stretching exercises (Satyapriya, Nagendra, Nagarathna, & Padmalatha, 2009); the yoga group showed a 150% increase in the high-frequency band as compared to 97% in the control condition. Khattab, Khattab, Ortak, Richardt, and Bonnemeier (2007) compared HRV between a sample of long-term yoga practitioners and age- and gender-matched controls without meditation or yoga experience. Yoga practitioners showed higher HRV during both a 60-minute yoga practice and a 60-minute walk than control subjects. Finally, van der Kolk (2006) found greater increases in HF-HRV in women with PTSD who were randomly assigned to receive yoga than those who were randomly assigned to receive group dialectical behavior therapy.

The present study uses the single-subject AB design case series method to evaluate the impact of yoga on worry. This design has several advantages over traditional case studies and is thus appropriate for preliminary work. An AB design produces evidence that shows that changes in an outcome variable coincide with the introduction of an intervention. Using this design provides control of several extraneous variables, such as the effects of testing, maturation, and regression to the mean (Kazdin, 2011). We also examined pre- to post-intervention changes in standardized self-report measures of worry, trait anxiety, experiential avoidance, mindfulness, and HF-HRV. We hypothesized the following: (1) participant ratings of daily worry will decline following the onset of the yoga intervention; (2) self-report worry, state anxiety, and experiential avoidance will decrease from pre- to post-intervention; (3) self-report mindfulness will increase from pre-to-post-intervention; and 4) HF-HRV will increase from pre- to post-intervention. Results will be discussed to identify hypothesized mechanisms of change in yoga for GAD.

Method

Participants

Students at a public university in the southeastern United States were recruited for the present study. Participants were required to meet the following inclusion criteria: (1) primary diagnosis of GAD as assessed by SCID-IV, (2) age 18–65, (3) English literacy, and (4) Internet access. Exclusion criteria included the following: (1) history of bipolar disorder or any psychotic disorder, (2) active suicidal ideation, (3) substance use disorder in the last six months, (4) concurrent psychotherapy, (5) recent (in the last eight weeks) or planned changes in psychotropic medications, and (6) a "yes" response to any item on the Physical Activity Readiness Questionnaire. The present study was approved by the university's Institutional Review Board and all participants consented for this study. Pseudonyms are used to protect participants' privacy.

Tamara was a single African-American female aged 19 years and diagnosed with both GAD and Social Anxiety Disorder at the baseline assessment. Consistent with her psychiatric diagnoses, Tamara presented as shy and did not often make eye contact. She spoke little during the screening clinical interview, provided one-word answers to many clinician inquiries, and showed little negative or positive affect. She reported that her worries about everyday life were her primary concern, in concordance with clinician judgment following the SCID-IV. Although social anxiety impacted her social life, it appeared that worry and procrastination were particularly impairing. She often procrastinated in school and worried that she would not succeed in school, in her future career, and in relationships.

Viraj was a single Asian-American 21-year-old male diagnosed with GAD, PTSD, and Social Anxiety Disorder at the baseline assessment. He reported that symptoms of GAD were his primary concern. According to his report, he had also recently been diagnosed with a learning disorder (i.e., Disorder of Written Expression) and an expressive language disorder through a comprehensive neuropsychological evaluation. He noted that he had "always been anxious," but since his evaluation, he worried about the meaning of the results. He often worried that he would perform poorly in school and that it would impact his relationships. Viraj had previously tried acupuncture, meditation, and supportive psychotherapy for his anxiety, but these techniques had reportedly not been effective.

Lindsey was a single 32-year-old African-American female diagnosed with GAD at the baseline assessment and with a history of Major Depressive Disorder. She said that she had struggled with GAD for "all her life" and that she had always found it difficult to "quiet her mind." She noted that she worried about "everything," especially her performance in school, her finances, her relationships, and her future success in her career. She was taking extremely difficult classes during the semester of the intervention, especially Organic Chemistry, and she often worried if she would do well in these classes. Lindsey's history was significant for a previous week-long hospitalization for suicidal ideation and Major Depressive Disorder. She received medication and psychotherapy for several months after this hospitalization but had not had treatment in over 10 years. She did not endorse any current suicidal ideation and did not meet criteria for current Major Depressive Disorder.

Procedure

Recruitment. Students at a university in the southeastern United States were recruited through an online survey, which they completed for course credit. This survey queried inclusion and exclusion criteria screening criteria. Students were invited to provide their email address if they were interested in participating in an eight-session yoga intervention study. Those students who met screening criteria and provided their email addresses were contacted to determine their interest and availability to participate in the yoga intervention.

Of 12 participants who expressed interest and met preliminary inclusion criteria for the study, three participants were enrolled in and completed the yoga intervention. Nine participants were excluded for the following reasons: were no longer interested (*n* = 6), were unable to schedule the pre-treatment assessment (*n* = 1), had primary Major Depression Disorder rather than GAD (*n* = 1), or dropped out of the study and did not respond to further contact (*n* = 1).

Intervention. After at least a two-week baseline assessment period, participants attended a 75-minute yoga class twice per week for four weeks in the Kripalu style of Hatha yoga practice. Kripalu Yoga is based on the Hatha yoga teachings of the ascetic yogi Swami Kripalu and is unique in its particular focus on the importance of moment-to-moment awareness of the self, including awareness of energy and physical sensation, as well as awareness of emotional and cognitive activity. The protocol for the yoga intervention was developed by the first and second authors and was delivered by the first author. The first author received her 200-hour certification in Kripalu Yoga; the second author is an E-RYT and a physical therapist.

Yoga classes were held at the university. Each class began with a five-minute meditation emphasizing mindfulness of breath. Subsequently, participants engaged in beginner-level posture sequences. Each class ended with an exercise in alternate nostril breathing, *nadi shodhana* [a common form of yogic breathing that may be helpful in improving autonomic functioning and heart rate variability (Ghiya & Lee, 2012)] and *savasana*, a ten-minute pose in which participants laid prone on the ground in rest and meditation. Participants were also asked to practice several postures each day between yoga classes; they were provided images of the postures and asked to choose the postures that they would like most to engage in over the next week.

Measures. The following measures were administered to all study participants. All measures were completed pre- and post-intervention, except for daily worry, which was collected on a daily basis throughout the baseline and intervention phases.

Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (First, Spitzer, Gibbon, & Williams, 2002). The SCID-IV is a widely used semi-structured diagnostic clinical interview. The present study utilized the SCID-IV to determine inclusion and exclusion criteria related to diagnoses and to reassess diagnoses post-intervention.

Daily Worry. Participants were asked to track the severity of their worry on a scale from 1 to 10 on a daily basis throughout the baseline and intervention phases. This was defined as a global rating of the severity of their worry for the entire day. A rating of 1 was defined as no worry or anxiety—a relaxed day. A rating of 10 in worry was defined as a day completely filled with worry—the most worried they have ever felt. Participants recorded worry daily on a calendar table that was given to them in the initial interview. They reported these records on a weekly basis online through a survey hosted on www.surveymonkey.com.

Penn State Worry Questionnaire (Startup & Erickson, 2006). Participants completed the PSWQ at pre- and post-intervention. The PSWQ is a 16-item, uni-factorial (Brown, Antony, & Barlow, 1992) measure of pathological worry. The PSWQ has shown acceptable reliability (Dinardo & Brown, 1988), validity (Chelminski & Zimmerman, 2003), and treatment sensitivity (Borkovec & Costello, 1993) as a measure of pathological worry.

State Trait Anxiety Inventory—Trait Scale (Spielberger, Gorsuch, & Lushene, 1970). The 20-item trait scale of the STAI was delivered at pre- and post-intervention. The STAI trait scale has shown excellent internal consistency (Knight, Waal-Manning, & Spears, 1983), test-retest reliability, and discriminative validity between students who experienced a stress condition or did not experience stress (Metzger, 1976).

Acceptance and Action Questionnaire, Second Edition (Bond, Hayes, Baer, Carpenter, Guenole, Orcutt, Waltz, & Zettle, 2011). The AAQ-II is a seven-item measure of experiential avoidance and was collected at pre- and post-intervention. The AAQ-II shows good internal consistency, test-retest reliability, and convergent validity (Bond et al., 2011). Divergent validity has been shown through low correlations with social desirability scales and little to no influence of age, gender, or race on assessment scores (Bond et al., 2011).

Five Facet Mindfulness Questionnaire (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). Participants completed the FFMQ, a measure of mindfulness, at pre- and post-intervention. Alpha coefficients for the subscales of the FFMQ range from .75 to .91, indicating adequate to good internal consistency (Baer et al., 2006). The FFMQ scales have shown convergence with expected variables, including openness to experience, emotional intelligence, and self-compassion (Baer et al., 2006).

Electrocardiogram. At pre- and post-intervention, a Lead I electrocardiogram (EKG) was recorded for each study participant and high-frequency and low-frequency measures of heart rate variability (HRV) were calculated. A BIOPAC MP150 Data Acquisition System and ECG100C amplifier were used to record heart rate data with disposable 1 3/8'' electrodes. These were Ag-Ag Cl electrodes with a 10mm contact area and 35mm total width; they were filled with 7% chloride liquid electrolyte gel. The EKG signal was sampled at 1,000 Hz. The first five minutes of the EKG established the individual's baseline HRV; participants were told to sit still and "simply wait for a little while" during the first five minutes of the EKG. Individuals were instructed to worry for the last five-minute interval. Consistent with Thayer, Friedman, and Borkovec (1996), participants were given a definition of worry and then instructed to worry about a recent life event for the next five minutes. Only EKG data collected during the paradigm were analyzed for HF-HRV. The procedures for measuring HRV followed the guidelines established by the Task Force of The European Society of Cardiology and the North American Society of Pacing and Electrophysiology (Malik, Bigger, Camm, Kleiger, Malliani, Moss, & Schwartz, 1996).

EKG signals were quantified using Acq*Knowledge*® Data Acquisition and Analysis 4 software. The signal was bandpass filtered between 0.5 and 35 Hz. Guided by visual inspection of a tachogram created using a modified Pan and Tompkins (1985) algorithm, data were cleaned through visual inspection of QRS waveforms. Graphic data were evaluated for inconsistency with template-matched QRS waveforms and were corrected according to the recommendations of Berntston, Bigger, Eckberg, Grossman, Kaufmann, Malik, Nagaraja, Porges, Saul, Stone, and van der Molen (1997). Power spectral density analysis was carried out by fast Fourier transform using a Hamming window. The high frequency band was defined between 0.15 and 0.40 Hz.

Data Analysis Plan. Daily worry ratings were plotted for each individual to examine the degree to which changes in worry coincided with the introduction of practicing yoga. Systematic change was evaluated by visually inspecting daily worry ratings for changes in mean, trend, level, variability, and latency, as recommended by Cohen, Feinstein, Masuda, and Vowles (2014). Changes in mean and trend were evaluated using Fisher, Kelley, and Lomas' (2003) conservative dual criterion method. Using this method, a split-middle line and a trend line of the baseline data were moved 0.25 standard deviations in the direction of the expected treatment effect to reduce the likelihood of Type 1 error and were superimposed over the data to improve reliability of visual inspection. Expected changes in mean and trend would be shown if, following the onset of

the intervention, worry ratings fell below the split-middle line and trend line.

Changes in worry level were demonstrated by discontinuity in the data from one phase to the next (e.g., a drop in worry following the onset of yoga is indicative of a change in level). Evaluations of latency can only be made when a change in level has occurred because latency describes how immediately the change in level occurs (e.g., worry ratings decrease following the 1st or 50th day following the onset of yoga). Variability refers to changes in the range of scores from one phase to the next (e.g., fewer visual "spikes" of worry ratings following the onset of yoga would indicate an expected change in variability).

Secondary data were reported with regard to changes in worry (PSWQ), anxiety (STAI), experiential avoidance (AAQ-II), and mindfulness (FFMQ) at pre- and post-intervention. Changes in these variables are reported individually for participants.

Finally, we examined changes in HF-HRV across baseline and worry conditions before and after the yoga intervention. Following the removal of outliers, frequency-domain analyses were calculated using the discrete Fourier transform. Changes in HF-HRV are also reported individually for participants.

Results

Daily worry ratings (the primary outcome measure) are shown in Figure 1. Data for measures collected pre- and post-intervention are presented in Table 1 for each participant, including standardized self-report measures of worry, trait anxiety, experiential avoidance, mindfulness, clinician-rated diagnostic status, and heart rate variability. Electrocardiograms were available only for Participants 1 and 3.

Tamara

Tamara rated the intensity of daily worry (on a scale from 1 to 10) at an average 2.02 (*SD* = 2.47) over her 14-day baseline period. This participant showed decreased mean daily worry ratings at the onset of the intervention but not decreased trend in daily worry ratings according to Fisher et al.'s (2003) criteria for conservative visual inspection. She showed immediate latency of mean change in worry in that her worry level never increased above a rating of 3 as soon as the intervention began, but there was no evidence for change in level as her lines were continuous across baseline and intervention phases. Tamara changed visibly in the variability of her daily reports of worry following the introduction of the treatment. She showed high variability over the baseline phase, with some worry reported on most days, and occasional sharp increases in worry, up to a rating of 8 out of 10. After Tamara began yoga, the variability of daily
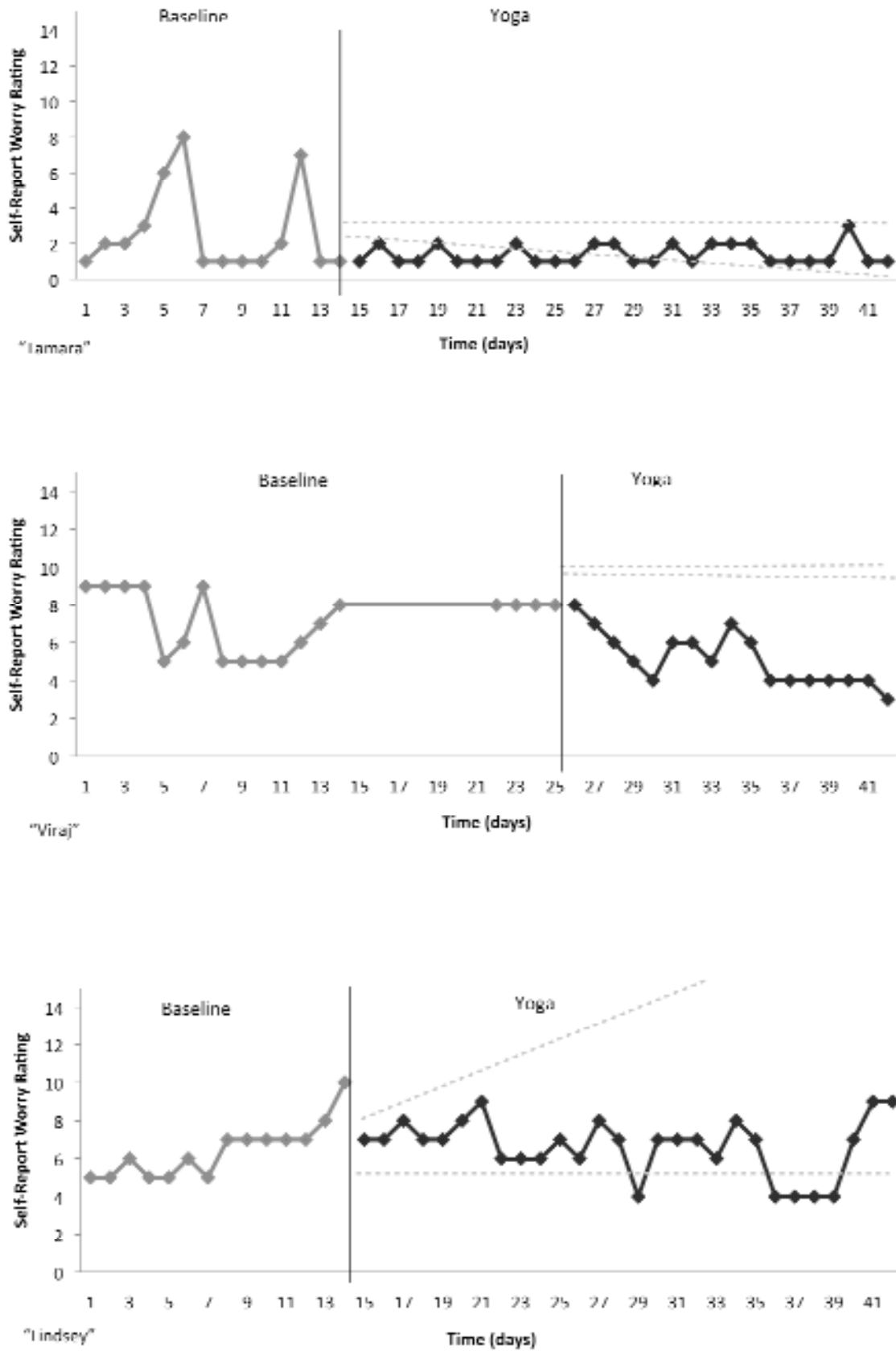
Figure 1. Daily worry ratings over baseline and intervention phases.
Mean Line — — ; Trend Line – – –

	Pre-intervention	Post-intervention
Tamara		
PSWQ	56	23*
STAI	32	25*
AAQ-II	14	8*
FFMQ	112	116*
HF-HRV (baseline)	3.74E-05	3.15E-05
HF-HRV (worry)	3.83E-05	7.05E-05*
Viraj		
PSWQ	64	45*
STAI	57	55*
AAQ-II	38	22*
FFMQ	125	113
HF-HRV (baseline)	NA	NA
HF-HRV (worry)	NA	NA
Lindsey		
PSWQ	66	69
STAI	63	64
AAQ-II	25	22
FFMQ	105	134*
HF-HRV (baseline)	9.24E-05	1.15E-04*
HF-HRV (worry)	1.44E-05	5.54E-05*

Table 1. Scores on measures of worry, trait anxiety, experiential avoidance, mindfulness, and heart rate variability pre- and post-intervention.

PSWQ = Penn State Worry Questionnaire. STAI = State Trait Anxiety Inventory. AAQ-II = Acceptance and Action Questionnaire - II. FFMQ = Five Facet Mindfulness Questionnaire. HF-HRV = high-frequency heart rate variability. * = change in therapeutically desirable direction

worry decreased and she no longer reported sharp increases in worry. The range in her daily worry ratings decreased and her worry ratings were maintained at low levels (1 to 3 out of 10) after the intervention began.

On standardized self-report measures, Tamara generally improved. Her PSWQ scores reduced 33 points from a score of 56 at pre-treatment, a score in the clinical range, to a score of 23, which is not in the clinical range for this measure (Behar et al., 2003). She reduced 7 points on the STAI (Pre-intervention: 32; Post-intervention: 25) and 6 points on the AAQ-II. She increased 4 points on the FFMQ (Pre-intervention: 112; Post-intervention: 116). Tamara's HF-HRV did not improve for baseline measures and was, in fact, lower at post- than pre-intervention (Pre-intervention: 3.74E-05; Post-intervention: 3.15E-05), but this measure improved during the worry period of the EKG (Pre-intervention: 3.83E-05; Post-intervention: 7.05E-05). Tamara no longer met criteria for any psychiatric diagnosis after yoga was concluded when she was re-evaluated using the SCID.

Viraj

Viraj rated the intensity of daily worry at an average 7.17 (*SD* = 1.65) over a 25-day baseline period. Split-middle and trend lines were superimposed over the treatment data to evaluate evidence for changes in mean and trend. Using Fisher et al.'s (2003) criteria, Viraj showed improvement in both mean and trend after the introduction of yoga. That is, his average daily worry was lower during the intervention phase than during the baseline phase and his rate of change in worry was greater than predicted by his baseline data. He showed no change in variability of worry ratings, as his worry only declined over time. He showed no immediate change in level of worry and showed gradual latency of change. In the last week of his participation in yoga, his daily worry averaged 3.86.

On standardized self-report measures, Viraj improved overall. His PSWQ scores reduced 19 points, from a score of 64 at pre-intervention, a score in the clinical range, to a score of 45, which is just at the clinical cutoff score for this measure (Behar et al., 2003). He reduced 2 points on the STAI (Pre-intervention: 57; Post-intervention: 55) and 16 points on the AAQ-II. His mindfulness score, however, was

lower; he dropped 12 points on the FFMQ (Pre-intervention: 125; Post-intervention: 113). Viraj was not available for completion of an EKG or a diagnostic interview at post-intervention.

Lindsey

Lindsey rated the intensity of her daily worry at an average of 6.43 (*SD* = 1.45) over a 14-day baseline period. All of Lindsey's intervention-phase data points were below her trend line, indicating systematic change in trend. By Fisher et al.'s (2003) criteria, however, she did not show evidence for systematic change in mean. Lindsey showed a trend toward increased worry over time during the baseline period. This trend became level—she stopped increasing in worry—after she began yoga. Later in the intervention, she reported some low ratings of daily worry, but did not show decreased or increased variability overall. She showed no immediate change in level of worry after the intervention began. Given that she did not show evidence for change, latency of change was not evaluated.

On standardized self-report measures, Lindsey's results were varied. Her PSWQ scores increased 3 points, from a 66 to a 69, remaining in the clinical range (Behar et al., 2003). She increased 1 point on the STAI (Pre-intervention: 63; Post-intervention: 64), indicating small increases in anxiety. However, her AAQ-II score reduced by 3 points (Pre-intervention: 25; Post-intervention: 22) and her FFMQ score increased by 29 points (Pre-intervention: 105; Post-intervention: 134). She also showed increases in HF-HRV during both baseline (Pre-intervention: 9.24E-05; Post-intervention: 1.15E-04) and worry periods (Pre-intervention: 1.44E-05; Post-intervention: 5.54E-05). Lindsey had no change in diagnostic status at post-intervention.

Discussion

The results of this study show that yoga may improve the symptoms and physiological dysfunctions associated with GAD. All participants showed systematic improvement in daily worry ratings on at least one index, and two participants showed improvement on the majority of indices. All participants' scores on self-reported measures of worry, anxiety, experiential avoidance, and mindfulness changed in the expected direction following yoga (with one or two exceptions). Both participants who completed the EKG assessments at pre- and post-intervention improved in the expected direction.

Tamara responded overall as predicted to the intervention. Her daily worry ratings reduced in both mean and variability, which is consistent with her change in diagnostic status; she no longer met criteria for either GAD or SAD after the intervention. This participant's self-reported

worry, anxiety, and experiential avoidance decreased after completing the yoga intervention, with her self-reported worry falling within the normal range post-intervention (i.e., PSWQ < 45) (Behar et al., 2003). She also showed a small increase in mindfulness following yoga. Qualitatively, she stated that she was "much improved" since she began the intervention and that she would "definitely" recommend yoga to a friend with anxiety. Tamara changed in her demeanor throughout the study; by the final interview, she made eye contact easily, she provided more detail in the clinical interview, and she often smiled and laughed.

Viraj also appeared to respond favorably to yoga. He showed systematic improvement in daily worry ratings. His self-reported worry decreased from 64 to 45, the lower bound of the clinical cut-off for the PSWQ (Behar et al., 2003). His trait anxiety decreased slightly from pre- to post-intervention and his experiential avoidance scores decreased substantially. Unexpectedly, and despite changes in the expected direction on all other measures, his self-reported mindfulness decreased following yoga. Unfortunately, Viraj was not available for an interview or heart rate monitoring at post-intervention; his change in diagnostic status is unknown.

Lindsey's response to yoga is the most difficult to interpret. Her daily worry ratings showed an increasing trend over the baseline phase, which stabilized following the onset of yoga. Although her worry did not improve following the onset of yoga, it also did not continue to worsen, predicted by the baseline data. As expected, she showed a small decrease in experiential avoidance and a substantial increase in mindfulness following the completion of the yoga intervention; in fact, she was the only participant to show a large increase in mindfulness after completing yoga. Unexpectedly, she showed slight increases in self-reported worry and trait anxiety following the completion of the intervention—the improvements in mindfulness and experiential avoidance were not coupled with improvements in anxiety following the intervention. Although Lindsey reported that she used yoga and breathing exercises during times of stress to manage anxiety and that that she would recommend yoga to a friend with anxiety, she did not improve in anxiety over the intervention.

It is interesting to note that across all three participants, the pre-post improvement in mindfulness did not correspond to pre-post improvement in worry or anxiety. Tamara reported improvement in worry and anxiety but showed only slight increases in mindfulness. Viraj reported improvement in worry and anxiety as well but also reported lower levels of mindfulness following completion of the yoga intervention. Lindsey did not report improvements in worry or anxiety but showed the largest improvement in mindfulness of any participant. However, change in mind-

fulness did correspond to change in HF-HRV across the two participants that completed pre-post EKGs. Indeed, Lindsey, who did not improve on any symptom measure, experienced the greatest increases in mindfulness and the greatest improvements in HF-HRV. These findings beg the question of how mindfulness functions among people practicing yoga to relieve GAD.

One possibility is that, regardless of the presence or absence of GAD symptoms, yoga improves the ability to tolerate and regulate emotion and to remain mindful of the present moment. Recent approaches to cognitive-behavioral therapy, especially those emphasizing the cultivation of mindfulness and acceptance, have highlighted that symptom change may not be required to improve quality of life and reduce disability among individuals with psychological difficulties (Hayes, Strosahl, & Wilson, 2012). Instead, mindfulness- and acceptance-based approaches teach individuals the ability to abandon unfruitful attempts to control thoughts and feelings and to focus on living a valued life. Through this process, individuals learn to behave consistently with their values and thus improve their functioning, whether or not they are experiencing psychological symptoms. Consistent with this approach, a recent study identified that higher levels of mindfulness were related to lower functional disability among individuals with GAD (Hoge et al., 2013). Thus, mindfulness, an emotion-regulation strategy (Hayes & Feldman, 2004), may help people with GAD reduce the degree to which their symptoms interfere with their lives.

It may be that in order to reduce the impact of symptoms on everyday life, individuals with GAD must acquire emotion-regulation strategies. Mankus, Aldao, Kerns, Mayville, and Mennin (2013) recently identified that mindfulness was related to better HF-HRV (a physiological index of emotion regulation; Appelhans & Luecken, 2006) only for those with high GAD symptoms. That is, those who experience more severe GAD symptoms might utilize mindfulness as a strategy to aid in the regulation of emotion. Although emotion regulation (i.e., the ability to evaluate and moderate emotional responses) was not directly evaluated in this study, qualitative comments from participants and HF-HRV data suggest that yoga helped improve emotion regulation. Tamara, for example, said her improvement in worry was because she was "better able to let thoughts or stress just come and go" and she showed improvement in HF-HRV. Lindsey did not show signs of improvement in daily worry ratings; however, her HF-HRV improved dramatically when she was worrying. This coincides with her report that, although she did not feel she had improved more than minimally, she utilized techniques she had learned in yoga during times of stress. It is possible that Lindsey utilized these strategies to improve her response to stress, even though she still experienced frequent worry.

Future research on yoga for GAD should also assess functional disability to determine if quality of life improves following yoga practice, even if symptoms do not always change.

The major limitation of the current study is the use of a single-subject AB case series, a quasi-experimental design (Gast, 2009). Because of the use of this design, we could not control for some confounding variables such as history effects. Because the primary outcome variable (i.e., daily worry) was evaluated continuously through a lengthy baseline phase and an intervention phase, we can determine that participant change coincided with the introduction of yoga. Although we cannot say that yoga caused worry to decline for Tamara and Viraj, we can say that their change in worry coincided with the introduction of the yoga intervention and was not simply due to repeated measurement.

Another limitation of this study is that the timing of the yoga intervention introduced history effects. All participants were college students that completed the yoga class during the week prior to final exams. Lindsey specifically commented that her anxiety increased as final exams approached. It is unknown how the timing of the yoga classes affected the findings of the present study. It is possible, for example, that student worry declines over the course of a college semester naturally and that yoga did not cause the observed changes. Similarly, participants' anxiety and worry may have increased in a more pronounced way as they approached final exams had they not practiced yoga as part of the present study.

All participants showed systematic improvement in daily worry ratings on at least one index and two participants showed improvement on the majority of indices. All participants' scores on self-reported measures of worry, anxiety, experiential avoidance, and mindfulness changed in the expected direction following yoga (with one or two exceptions). All participants who completed the EKG assessments at pre- and post-yoga improved in the expected direction during the worry period. These positive findings should encourage continued research using a more methodologically rigorous design to determine the extent to which yoga causes improvement in symptoms and quality of life among people with GAD and to test the mechanisms by which yoga may exert its effects. Currently, those with GAD are in need of improved access to treatment. Only 50% of individuals with GAD access mental health care (Grant et al., 2005), which is likely due in part to the lack of qualified providers in many communities in the United States (Taylor & Chang, 2008). Yoga, however, is widely available in many communities and growing (Clarke et al., 2015), and thus has the potential to reach a wider population of those struggling with GAD and reduce its public health burden.

References

Appelhans, B. M., & Luecken, L. J. (2006). Heart rate variability as an index of regulated emotional responding. *Review of General Psychology, 10*, 229–240.

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment, 13*, 27–45.

Behar, E., Alcaine, O., Zuellig, A. R., & Borkovec, T. D. (2003). Screening for generalized anxiety disorder using the Penn State Worry Questionnaire: A receiver operating characteristic analysis. *Journal of Behavior Therapy and Experimental Psychiatry, 34*(1), 25–43.

Berntston, G. G., Bigger, T. Jr., Eckberg, D. L., Grossman, P., Kaufmann, P. G., Malik, M., Nagaraja, H. N., Porges, S. W., Saul, J. P., Stone, P. H., & van der Molen, M. W. (1997). Heart rate variability: Origins, methods, and interpretive caveats. *Psychophysiology, 34*, 623–648.

Birdee, G. S., Legedza, A. T., Saper, R. B., Bertisch, S. M., Eisenberg, D. M., & Phillips, R. S. (2008). Characteristics of yoga users: Results of a national survey. *Journal of General Internal Medicine, 23*(10), 1653–1658.

Bond, F. W., Hayes, S. C., Baer, R. A., Carpenter, K. C., Guenole, N., Orcutt, H. K., Waltz, T. & Zettle, R. D. (2011). Preliminary psychometric properties of the Acceptance and Action Questionnaire – II: A revised measure of psychological flexibility and acceptance. *Behavior Therapy, 42*, 676–688.

Borkovec, T. D., Alcaine, O. M., & Behar, E. (2004). Avoidance theory of worry and generalized anxiety disorder. In R. Heimberg, C. Turk, & D. Mennin (Eds.), *Generalized anxiety disorder: Advances in research and practice* (pp. 77–108). New York, NY: Guilford Press

Borkovec, T. D., & Costello, E. (1993). Efficacy of applied relaxation and cognitive-behavioral therapy in the treatment of generalized anxiety disorder. *Journal of Consulting and Clinical Psychology, 61*, 611–619.

Borkovec, T. D., & Hu, S. (1990). The effect of worry on cardiovascular response to phobic imagery. *Behaviour Research and Therapy, 28*, 69–73.

Borkovec, T. D., Robinson, E., Pruzinsky, T., & DePree, J. A. (1983). Preliminary exploration of worry: Some characteristics and processes. *Behaviour Research and Therapy, 21*(1), 9–16.

Brisbon, N. M. & Lowery, G. A. (2009). Mindfulness and levels of stress: A comparison of beginner and advanced Hatha yoga practitioners. *Journal of Religion and Health, 50*(4), 931–941.

Brown T. A., Antony, M. M., & Barlow, D. H. (1992). Psychometric properties of the Penn State Worry Questionnaire in a clinical anxiety disorders sample. *Behaviour Research and Therapy, 30*, 33–37.

Brown, T. A., Barlow, D. H., & Liebowitz, M. R. (1994). The empirical basis of generalized anxiety disorder. *American Journal of Psychiatry, 151*, 1272–1280.

Carei, T. R., Fyfe-Johnson, A. L., Breuner, C. C., & Brown, M. A. (2010). Randomized controlled clinical trial of yoga in the treatment of eating disorders. *Journal of Adolescent Health, 46*, 346–351.

Carter, J., Gerbarg, P. L., Brown, R. P., Ware, R. S., D'Ambrosio, C., Anand, L., Dirlea, M., Vermani, M., & Katzman, M. A. (2013). Multi-component yoga breath program for Vietnam veteran post-traumatic stress disorder: Randomized controlled trial. *Journal of Traumatic Stress Disorders and Treatment, 2*(3), 1–10.

Chelminski, I. & Zimmerman, M. (2003). Pathological worry in depressed and anxious patients. *Journal of Anxiety Disorders, 17*, 533–546.

Clarke, T. C., Black, L. I., Stussman, B. J., Barnes, P. M., & Nahin, R. L. (2015). Trends in the use of complementary health approaches among adults: United States, 2002-2012. *National Health Statistics Reports*, (79), 1–16.

Cohen, L. L., Feinstein, A., Masuda, A., & Vowles, K. E. (2014). Single-case research design in pediatric psychology: Considerations regarding data analysis. *Journal of Pediatric Psychology, 39*(2), 124–137.

DiNardo, P. A., & Barlow, D. H. (1988). *Anxiety Disorders Interview Schedule-Revised (ADIS-R)*. Albany, NY: Center of Stress and Anxiety Disorders.

Dishman, R. K., Nakamura, Y., Garcia, M. E., Thompson R. W., Dunn, A. L., & Blair, S. N. (2000). Heart rate variability, trait anxiety, and perceived stress among physically fit men and women. *International Journal of Psychophysiology, 37*, 121–133.

Ebnezar, J., Nagarathna, R., Bali, Y., & Nagendra, H. R. (2012). Effect of an integrated approach of yoga therapy on quality of life in osteoarthritis of the knee joint: A randomized control study. *International Journal of Yoga, 4*(2), 55–63.

Feuerstein, G. (2001). *The yoga tradition: Its history, literature, philosophy and practice.* Prescott, AZ: Hohm Press.

First, M. B., Spitzer, R. L., Gibbon, M., & Williams, J. B. W. (2002). *Structured clinical interview for DSM-IV-TR axis I disorders, research version, patient edition* (SCID-I/P). New York, NY: Biometrics Research, New York State Psychiatric Institute.

Fisher, W. W., Kelley, M. E., & Lomas, J. E. (2003). Visual aids and structured criteria for improving visual inspection and interpretation of single-case designs. *Journal of Applied Behavior Analysis, 36*(3), 387–406.

Gast, D. L. (2009). *Single subject research methodology in behavioral sciences.* London, United Kingdom: Routledge.

Ghiya, S., & Lee, C. M. (2012). Influence of alternate nostril breathing on heart rate variability in non-practitioners of yogic breathing. *International Journal of Yoga, 5*(1), 66–69.

Grant, B. F., Hasin, D. S., Stinson, F. S., Dawson, D. A., June Ruan, W., Goldstein, R. B., Smith, S. M., Saha, T. D., & Huang, B. (2005). Prevalence, correlates, co-morbidity, and comparative disability of DSM-IV generalized anxiety disorder in the USA: Results from the National Epidemiologic Survey on Alcohol and Related Conditions. *Psychological Medicine, 35*, 1747–1759.

Gupta, N., Khera, S., Vempati, R. P., Sharma, R., & Bijlani, R. L. (2006). Effect of yoga based life style intervention on State and Trait Anxiety. *Indian Journal of Physiology and Pharmacology, 50*, 41–47.

Hayes, A. M., & Feldman, G. (2004). Clarifying the construct of mindfulness in the context of emotion regulation and the process of change in therapy. *Clinical Psychology: Science and Practice, 11*(3), 255–262.

Hayes, S. C., & Wilson, K. G. (2003). Mindfulness: Method and process. *Clinical Psychology: Science and Practice, 10*(2), 161–165.

Hayes, S. C., Strosahl, K., & Wilson, K. G. (2012). *Acceptance and Commitment Therapy: The Process and Practice of Mindful Change* (2nd. ed.). New York: Guilford Press.

Hayes, S. C., Wilson, K. G., Gifford, E. V., Follette, V. M., & Strosahl, K. (1996). Experiential avoidance and behavioral disorders: A functional dimensional approach to diagnosis and treatment. *Journal of Consulting and Clinical Psychology, 64*(6), 1152–1168.

Hoehn-Saric, R., & McLeod, D. R. (1988). The peripheral sympathetic nervous system: Its role in normal and pathological anxiety. *Psychiatric Clinics of North America, 11*, 375–386.

Hoehn-Saric, R., McLeod, D. R., & Zimmerli, W. D. (1989). Somatic manifestations in women with generalized anxiety disorder. *Archives of General Psychiatry, 46*, 1113–1119.

Hoge, E. A., Hölzel, B. K., Marques, L., Metcalf, C. A., Brach, N., Lazar, S. W., & Simon, N. M. (2013). Mindfulness and self-compassion in Generalized Anxiety Disorder: Examining predictors of disability. *Evidence-Based Complementary and Alternative Medicine*, Article ID 576258.

Hooper, N., Villatte, M., Neofotistou, E., & McHugh, L. (2010). The effects of mindfulness versus thought suppression on implicit and explicit measures of experiential avoidance. *International Journal of Behavioral Consultation and Therapy, 6*(3), 233–244.

Javanbakht, M., Hejazi Kenari, R., & Ghasemi, M. (2009). Effects of yoga on depression and anxiety of women. *Complementary Therapies in Clinical Practice, 15*, 102–104.

Kabat-Zinn, J., Massion, A. O., Kristeller, J., & Peterson, L. G. (1992). Effectiveness of a meditation-based stress reduction program in the treatment of anxiety disorders. *The American Journal of Psychiatry, 149*(7), 936–943.

Kazdin, A. E. (2011). *Single-case research designs: Methods for clinical and applied settings.* Oxford, UK: Oxford University Press.

Khattab, K., Khattab, A. A., Ortak, J., Richardt, G., & Bonnemeier, H. (2007). Iyengar yoga increases cardiac parasympathetic nervous modulation among healthy yoga practitioners. *Evidence-Based Complementary and Alternative Medicine, 4*, 511–517.

Knight, R. G., Waal-Manning, H. J., & Spears, G. F. (1983). Some norms and reliability data for the State-Trait Anxiety Inventory and the Zung Self-Rating Depression scale. *British Journal of Clinical Psychology, 22*, 245–249

Malik, M., Bigger, J. T., Camm, A. J., Kleiger, R. E., Malliani, A., Moss, A. J., & Schwartz, P. J. (1996). Heart rate variability standards of measurement, physiological interpretation, and clinical use. *European Heart Journal, 17*(3), 354–381.

Mankus, A. M., Aldao, A., Kerns, C., Mayville, E. W., & Mennin, D. S. (2013). Mindfulness and heart rate variability in individuals with high and low generalized anxiety symptoms. *Behaviour Research and Therapy, 51*(7), 386–391.

Martens, E. J., de Jonge, P., Na, B., Cohen, B. E., Lett, H., & Whooley, M. A. (2010). Scared to death? Generalized anxiety disorder and cardiovascular events in patients with stable coronary heart disease: The Heart and Soul Study. *Archives of General Psychiatry, 67*, 750–758.

Metzger, R. L. (1976). A reliability and validity study of the State-Trait Anxiety Inventory. *Journal of Clinical Psychology, 32*, 276–278.

Meyer T. J., Miller M. L., Metzger R. L., & Borkovec T. D. (1990). Development and validation of the Penn State Worry questionnaire. *Behaviour Research and Therapy, 28*, 487–495.

Morris, S. B., & DeShon, R. P. (2002). Combining effect size estimates in meta-analysis with repeated measures and independent-groups designs. *Psychological Methods, 7*(1), 105–125.

Pan, J., & Tompkins, W. J. (1985). A real-time QRS detection algorithm. *Biomedical Engineering, 3*, 230–236.

Rao, M. R., Raghuram, N., Nagendra, H. R., Gopinath, K. S., Srinath, B. S., Diwakar, R. B., Patil, S., Bilimagga, S. R., Rao, N., & Varambally, S. (2009). Anxiolytic effects of a yoga program in early breast cancer patients undergoing conventional treatment: A randomized controlled trial. *Complementary Therapies in Medicine, 17* (1), 1–8.

Roemer, L., Lee, J. K., Salters-Pedneault, K., Erisman, S. M., Orsillo, S. M., & Mennin, D. S. (2009). Mindfulness and emotion regulation difficulties in generalized anxiety disorder: Preliminary evidence for independent and overlapping contributions. *Behavior Therapy, 40*(2), 142–154.

Roemer, L., Orsillo, S. M., & Salters-Pedneault, K. (2008). Efficacy of an acceptance-based behavior therapy for generalized anxiety disorder: Evaluation in a randomized control trial. *Journal of Consulting and Clinical Psychology, 76*, 1083–1089.

Roemer, L., Salters, K., Raffa, S., & Orsillo, S. M. (2005). Fear and avoidance of internal experiences in GAD: Preliminary tests of a conceptual model. *Cognitive Therapy and Research, 29*, 71–88.

Salmon, P., Lush, E., Jablonski, M., & Sephton, S. E. (2009). Yoga and mindfulness: Clinical aspects of an ancient mind/body practice. *Cognitive and Behavioral Practice, 16*, 59–72.

Satyapriya, M., Nagendra, H. R., Nagarathna, R., & Padmalatha, V. (2009). Effect of integrated yoga on stress and heart rate variability in pregnant women. *International Journal of Gynaecology and Obstetrics, 104*, 218–222.

Saul, J. P. (1990). Beat-to-beat variations of heart rate reflect modulation of cardiac autonomic outflow. *News in Physiological Science, 5*, 32–37.

Shelov, D. V., Suchday, S., & Friedberg, J. P. (2009). A pilot study measuring the impact of yoga on the trait of mindfulness. *Behavioral and Cognitive Psychotherapy, 37*(5), 595–598.

Spielberger, C., Gorsuch, R., & Lushene, R. (1970). *The State/Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychology Press.

Startup, H. M., & Erickson, T. M. (2006). The Penn State Worry Questionnaire (PSWQ). In G. A. Davey & A. Wells (Eds.). *Worry and its psychological disorders: Theory, assessment, and treatment* (pp. 101-119). Hoboken, NJ: Wiley & Sons.

Streeter, C. C., Gerbarg, P. L., Saper, R. B., Ciraulo, D. A., & Brown, R. P. (2012). Effects of yoga on the autonomic nervous system, gamma-aminobutyric-acid, and allostasis in epilepsy, depression, and post-traumatic stress disorder. *Medical Hypotheses, 78*(5), 571–579.

Sztajzel, J. (2004). Heart rate variability: A noninvasive electrocardiographic method to measure the autonomic nervous system. *Swiss Medicine Weekly, 134*, 514–522.

Taylor, C. B., & Chang, V. Y. (2008). Issues in the dissemination of cognitive-behavior therapy. *Nordic Journal of Psychiatry, 62*(Suppl 47), 37–44.

Thayer, J. F., Friedman, B. H., & Borkovec, T. D. (1996). Autonomic characteristics of generalized anxiety disorder and worry. *Biological Psychiatry, 39*, 255–266.

van der Kolk, B. A. (2006). Clinical implications of neuroscience research in PTSD. In Yehuda (Ed.), *Psychobiology of posttraumatic stress disorders: A decade of progress* (Vol. 1071, pp. 277–293). Oxford: Blackwell Publishing.

Vancampfort, D., De Hert, M., Knapen, J., Wampers, M., Demunter, H., Deckx, S., Maurissen, K., & Probst, M. (2011). State anxiety, psychological stress and positive well-being responses to yoga and aerobic exercise in people with schizophrenia: A pilot study. *Disability and Rehabilitation, 33*, 584–689.

Vrana, S. R., Cuthbert, B. N., & Lang, P. J. (1989). Processing fearful and neutral sentences: Memory and heart rate change. *Cognition and Emotion, 3*(3), 179–195.

World Health Organization (WHO). (2001). *The World Health Report: 2001—Mental health: New understanding, new hope*. Geneva, Switzerland: World Health Organization.