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Effect of Yoga-Based Interventions for Anxiety Symptoms: A Meta-Analysis of Randomized Controlled Trials

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Anxiety is a common and debilitating condition, which tends to follow a chronic course if left untreated. While studies have provided evidence that yoga is an effective mind-body intervention for a variety of psychological symptoms, more meta-analytic evidence supporting yoga's efficacy specifically for anxiety symptoms is needed. The aim of this study was to investigate the effect of yoga on anxiety symptoms using meta-analytic methods. A systematic search was conducted for randomized controlled trials (RCTs) on yoga and anxiety on electronic databases over key terms. Risk of bias was assessed using the Cochrane tool. Outcome data were extracted from eligible studies, and moderators were coded across studies to indicate differences in study sample, delivery method, and type of dependent variable. Effect size aggregation and omnibus analyses, as well as moderator tests, were performed. A total of 38 RCTs (N = 2,295 adults) met inclusion criteria. Yoga practice had a large and statistically significant effect on anxiety symptoms compared with control conditions (d = 0.80). In subomnibus analyses, statistically significant effects of the yoga intervention were detected on biological measures (d = 0.45), nonanxiety mental health outcomes (d = 0.55), physical health measures (d = 0.45), and mental and physical health outcomes combined (d = 0.65). Significant moderation was found by study location, with the largest effects appearing in Indian samples. Results suggest that yoga significantly decreases anxiety symptoms, while it appears to have an ameliorative effect on psychological symptoms more globally.

Keywords: anxiety, meta-analysis, review, yoga, RCTs

Anxiety is a common and debilitating mental health condition. Anxiety disorders (ADs) represent the most common mental disorders (Shiban, Schelhorn, Pauli, & Mühlberger, 2015), with over a third of the population meeting diagnostic criteria for an AD at some point across the life span (Kessler, Petukhova, Sampson, Zaslavsky, & Wittchen, 2012; Kessler,

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Ruscio, Shear, & Wittchen, 2010). These estimates are even higher when considering those individuals who suffer from subclinical levels of anxiety (Rucci et al., 2003).

In addition to being highly prevalent, ADs are significantly distressing and impairing for the individual. In fact, ADs constitute the sixth leading cause of disability, in terms of years of life lived with disability (YLDs) worldwide (Baxter, Vos, Scott, Ferrari, & Whiteford, 2014). It is well-established that ADs result in poor health and decreased quality of life (Creed et al., 2002; de Beurs et al., 1999), poorer relationships (Heerey & Kring, 2007), and increased economic and health care costs (Gregg & Tarrier, 2007). If left untreated, anxiety disorders typically follow a chronic course (Kessler et al., 2009).

Given the disabling nature of ADs, it is essential to develop effective treatments to help individuals suffering from these disorders and address this public health priority (Nelson, 2013). Both pharmacotherapy (e.g., SSRIs) and psychotherapy (e.g., cognitive–behavioral therapy) are efficacious in the treatment of ADs. Despite notable progress in the treatment of anxiety over the last decades, there remains significant room to increase the effectiveness of these treatments. Strikingly, less than one third of patients with anxiety symptoms and disorders receive appropriate care (Young, Klap, Sherbourne, & Wells, 2001), and, among those who do, many drop out of treatment prematurely (Bados, Balaguer, & Saldaña, 2007; Issakidis & Andrews, 2004). The increased cost, intolerance of medication, lack of available clinicians, and potentially aversive nature of some intervention techniques (i.e., exposure) may limit the acceptability and implementation of existing treatments (Bystritsky, Khalsa, Cameron, & Schiffman, 2013; Cuijpers et al., 2013; Weissman et al., 2006). In addition, a significant percentage of anxiety patients experiences treatment-resistant anxiety that follows a chronic and debilitating course (Bystritsky, 2006; Pollack et al., 2008).

There has been a growing interest in mind-body approaches (i.e., practices that address the mind and body as nondualistic (Barrows & Jacobs, 2002)) for the alleviation of anxiety symptoms and disorders (Kessler et al., 2001). Yoga is within the family of mind-body therapies and is comprised of a group of physical and meditative practices that originated in ancient India. Yoga-based interventions have been adopted both as a standalone anxiety treatment or an adjunct to medication or psychological treatments (da Silva, Ravindran, & Ravindran, 2009). While research supports the salutatory effects of yoga on both physiological and psychological symptoms of anxiety (Skowronek, Mounsey, & Handler, 2014), the community would benefit from more meta-analytic evidence of its efficacy for anxiety symptoms. The present study aims to address this gap in the anxiety treatment literature.

Yoga as a Mind-Body Intervention

Yoga is a philosophy and way of living with origins in Hindu spiritual traditions from India. The Sanskrit word "yoga" means "union" (Taneja, 2014). Typical yoga asana practice involves engaging in slow, rhythmic physical poses while maintaining awareness on the breath and body, essentially cultivating a mindful attitude during practice characterized by awareness and openness to experience. In this way, yoga is intended to facilitate union, or the uniting of the mind and body (Wanning, 1993).

The spiritual components related to yoga practice include the concepts of impermanence and egolessness. These concepts are important because they may relate to possible mechanisms of action of yoga on anxiety (see further discussion in the Theories of Change for Yoga-Based Interventions for Anxiety section). Impermanence refers to the reality that change is inevitable and a key condition of life. Change is always happening, whether it is in ourselves, the environment around us, and other people. Suffering arises when we deny or ignore this reality and try to keep things the same. Our tendency to fight the truth of impermanence is illustrated in the classic Hindu text *The Mahabarata* (Narayan, 1978), where a character comments that the greatest wonder of the world is that "Day after day and hour after hour, people die and corpses are carried along, yet the onlookers never realize that they are also to die one day, but think they will live forever" (p. 92). In order to accept the reality of impermanence and therefore decrease suffering, the gurus recommend meditating on how change is a fundamental part of life.

Another central teaching is lack of self, or egolessness. Yoga teaches that a person is not their individual body, thoughts, feelings, sensations, or history, but rather they are part of all creation, the energy of being or true self. This is exemplified by the Sanskrit mantra "So hum" meaning "I am that," where "that" means "all creation." Sri Nisargadattta Maharaj, noted Indian yoga teacher, wrote eloquently about these ideas in his seminal book, *I am That* (Maharaj, 2012). He encourages individuals to stop identifying with their body and mind, or with anything observable: "Give up all questions except one, 'Who am I?' After all the only fact you are sure of is that you 'are.' The 'I am' is certain, the 'I am this' is not. Struggle to find out what you are in reality." He advocates a process of discovery through yoga and meditation to understand experientially that we are not individual selves but rather all part of a universal connected self or being.

Indian traditional teachings integrate the physical acts of yoga with spiritual understanding. In the key text on yoga *The Yoga Sutras of Patanjali,* yoga is defined as "yogacittavrttinirodhah" or "Yoga is the restriction of the fluctuations of consciousness" (Feuerstein, 1989). Therefore, yoga is conceptualized as a series of practices in service of quieting the mind. The mind is quieted in order to understand the true nature of reality and of the self, specifically the truths of impermanence and lack of self. To have a successful practice, the yoga sutras state "Practice becomes firmly grounded when well attended to for a long time, without break and in all earnestness" (Satchidananda, 1990). Therefore, in order to be successful in the practice of yoga, one must practice over a long period of time, without a significant interruption, and with a true desire to increase understanding.

Traditional yoga involves eight components or limbs outlined in the *Yoga Sutras of Patanjali*: yamas (commandments; e.g., not harming anyone or anything); niyamas (personal disciplines; e.g., cleanliness, self-discipline); asanas (practicing physical postures); pranayama (breathing practices); pratyahara (developing a nonattached attitude toward the activities of the world); dharna (concentration); dhyana (meditation); and samadhi (bliss, becoming one with the Divine; Satchidananda, 1990). Hatha yoga, as taught in most contemporary classes in the West, most often involves practicing physical postures (asanas), breathing practices (pranayama), and meditation (dhyana; Iyengar, 1966).

Effectiveness of Yoga

There have been several qualitative reviews that have examined the effectiveness of yoga and anxiety (Chugh-Gupta, Baldassarre, & Vrkljan, 2013; da Silva et al., 2009; Field, 2011; Kirkwood, Rampes, Tuffrey, Richardson, & Pilkington, 2005; Li & Goldsmith, 2012). These reviews have found preliminary support for yoga's effectiveness. Likewise, there have been meta-analyses conducted on specific populations (e.g., patients with cancer) that have examined the effect of yoga on a variety of outcomes, including anxiety; these reviews suggest a significant effect of yoga on anxiety at least in the subpopulations studied ($d = -0.98$ to -0.76; Lin, Hu, Chang, Lin, & Tsauo, 2011; Pan, Yang, Wang, Zhang, & Liang, 2015).

A meta-analysis was conducted by Cramer et al. (2018) and included six studies (319 participants), assessing the effectiveness of yoga on anxiety. All the studies were randomized controlled trials (RCTs), but they were not required to have yoga asana as the primary component of the intervention. Two of the six studies did not have yoga asana as the primary component of the intervention. Cramer et al. (2018) found small short-term effects of yoga on anxiety compared to no treatment ($d = -0.43$) and large effects compared with active treatment comparators ($d = -0.86$). Another meta-analysis was conducted by Hofmann, Andreoli, Carpenter, and Curtiss (2016) focusing specifically on Hatha yoga and anxiety. Seventeen studies and 501 participants were included. Six of the 17 studies were dissertations. A prepost within-group effect size of $d = 0.44$ and a controlled effect sizes of $d = 0.61$ was found. Though there is some meta-analytic support on yoga for anxiety, it is based on relatively limited studies/participants, the inclusion of studies that were not primarily focused on yoga asana, and the inclusion of studies that were not published in peer reviewed publications. Therefore, this has left a need for more meta-analytic evidence supporting the physical practice of yoga on anxiety symptoms.

Meta-analyses conducted on yoga for related mental and physical health conditions have also

shown significant effects. Evidence suggests yoga may be effective in the treatment or prevention of depression (d = .59 to .69; Cramer, Lauche, Langhorst, & Dobos, 2013; Gong, Ni, Shen, Wu, & Jiang, 2015), cardiovascular disease (e.g., total cholesterol mean difference = −13.09 mg/dl to −18.48 mg/dl; Chu, Gotink, Yeh, Goldie, & Hunink, 2014; Cramer, Lauche, Haller et al., 2014), hypertension (e.g., systolic blood pressure mean difference = −4.17 mmHg to −9.65 mmHg; Cramer, Lauche, Haller et al., 2014; Hagins, States, Selfe, & Innes, 2013), pain disability (e.g., d = −0.79 to −0.59; Büssing, Michalsen, Khalsa, Telles, & Sherman, 2012; Cramer et al., 2013; Ward, Stebbings, Cherkin, & Baxter, 2013), and fatigue (d = −0.52 to 0.27; Boehm, Ostermann, Milazzo, & Büssing, 2012; Cramer, Lauche, Azizi, Dobos, & Langhorst, 2014). In addition, yoga has been shown to improve overall physical function (d = −0.64; Ward et al., 2013), lung function in patients with COPD or asthma (Cramer, Lauche, Haller et al., 2014; Liu et al., 2014), and increase quality of life for patients with cancer (d = 0.27; Zhang, Yang, Tian, & Wang, 2012).

Theories of Change for Yoga-Based Interventions for Anxiety

There are both psychological and physiological reasons why yoga may be a particularly well-suited intervention for the treatment of anxiety. On a physiological level, anxiety can be viewed as an overactivation of the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic nervous system (SNS; Faravelli et al., 2012; Hoehn-Saric & McLeod, 1988). The activation of these systems results in the release of cortisol and the catecholamine neurotransmitters (specifically dopamine, epinephrine, and norepinephrine; Takahashi et al., 2005). This in turn activates the "fight or flight" response (i.e., increased heart rate and blood pressure, and faster, shallower breathing), preparing the body to deal with a perceived threat (Reimold et al., 2011).

Yoga may help to shift from the activated HPA axis and SNS to the parasympathetic nervous system (PNS), and it may help to decrease the possibility of becoming activated in the first place (Kiecolt-Glaser et al., 2010). Yoga has been shown to decrease cortisol levels (Vadiraja et al., 2009; West, Otte, Geher, Johnson, & Mohr, 2004) and to decrease many outcomes of HPA and SNS activation, such as heart rate (Satyapriya, Nagendra, Nagarathna, & Padmalatha, 2009) and blood pressure (Innes, Bourguignon, & Taylor, 2005). This relaxation response may be activated through yoga's use of slow movements and steady deep breathing (Benson, Beary, & Carol, 1974).

Indeed, it has also been argued that aerobic exercise works on a physiological level to decrease anxiety through supporting regulation of the SNS and HPA. Meta-analyses of exercise for anxiety have shown significant, albeit small effect sizes (d = 0.16 to 0.36; Ensari, Greenlee, Motl, & Petruzzello, 2015; Long & Stavel, 1995).

Psychological pathways include constructs drawn from mindfulness-based therapies (i.e., mindfulness) and cognitive–behavioral therapy (CBT). Mindfulness may be a particularly likely candidate psychological pathway. Yoga has been conceptualized as "embodied mindfulness" or "mindfulness in motion" as it cultivates a similar cognitive-emotional frame as mindfulness training (Salmon, Lush, Jablonski, & Sephton, 2009). Mindfulness-based treatment approaches, including mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1990), mindfulness-based cognitive therapy (MBCT; Segal, Williams, & Teasdale, 2002), and acceptance and commitment therapy (ACT; S. C. Hayes, Strosahl, & Wilson, 1999) encourage bringing attention to present moment experience (i.e., thoughts, feelings, body sensations) in a nonjudgmental way. Indeed, the spiritual concepts of impermanence and egolessness embedded in the yoga practice (discussed in detail above), may encourage this decentered mindful stance. Higher levels of dispositional mindfulness have been associated with decreased psychological symptoms and increased well-being (Baer et al., 2008). Further, mindfulness has been shown to exert a powerful influence on cognitive processes commonly operant in psychiatric conditions like anxiety and depression. Most notably, mindfulness training has been shown to decrease repetitive negative thinking (e.g., worry) which in turn has been shown to decrease psychological symptoms (for a review see Gu, Strauss, Bond, & Cavanagh, 2015). Mindfulness-based interventions such as MBSR have shown moderate sized effects on anxiety (d =

.53; deVibe, Bjørndal, Tipton, Hammerstrøm, & Kowalski, 2012), and have been shown to be superior to psychological placebos in effects on anxiety (Goyal et al., 2014). It is also worth noting here that MBSR, the most commonly studied mindfulness-based intervention, does include a mindful yoga component within the standard curriculum (Kabat-Zinn, 1990).

A classic psychological construct emphasized in CBT that may facilitate yoga's effects on anxiety is exposure (Wolpe, 1973). Early meta-analyses proposed exposure as a mechanism of change in mindfulness-based interventions (Baer, 2003). Baer (2003) noted prolonged exposure to unpleasant physical sensations and psychological states (e.g., chronic pain, Kabat-Zinn, 1982; symptoms of anxiety, Kabat-Zinn et al., 1992). Baer (2003) likens the exposure obtained through mindfulness meditation with interoceptive exposure drawn from behavioral therapies (Barlow & Craske, 2007). This kind of exposure can also be seen as decoupling feared or avoided situations and their presumed catastrophic result (Resick, Nishith, Weaver, Astin, & Feuer, 2002). By practicing mindfulness, a person who is experiencing anxiety exposes themselves to the components of the anxiety experience, such as body tension, racing heart rate, and catastrophic thoughts, without reacting (Baer, 2003). Rather the individual is encouraged to stay with these body sensations and thoughts and noticing how they shift and change (Kabat-Zinn, 1990). In this way, the person eventually becomes less identified with these body sensations and thoughts, meaning she or he recognizes that they are not a statement of truth or a stable part of one's personality, but rather a transitory experience (S. A. Hayes, Orsillo, & Roemer, 2010).

It is theoretically plausible that exposure may operate similarly in yoga interventions for anxiety. Through engaging in embodied mindfulness (Salmon et al., 2009), individuals practicing yoga are likewise gaining exposure to unpleasant physical sensations and psychological states, perhaps even to a greater degree given the at times challenging physical postures employed in yoga practice (Iyengar, 1966).

Purpose of the Study

The purpose of this study was to estimate the effect of yoga on anxiety symptoms as measured in randomized clinical trials using meta-analytic methods. Specifically, we aimed to assess the magnitude of any treatment effects on anxiety symptoms and related outcomes and whether study-level characteristics moderated the size of these effects. These results could then inform the treatment of both clinical and subclinical anxiety as well as enrich our understanding of the effect of yoga-based interventions on anxiety and its symptomatology.

Method

Inclusion and Exclusion Criteria of Primary Studies

For inclusion in this meta-analysis, studies had to be: (a) a RCT that (b) used yoga as an intervention, (c) with a comparison to a control condition, and (d) measured anxiety symptoms as an outcome. Participants had to be adults aged 18 years or older. In addition, the study had to be published in a peer-reviewed journal in English. Conference articles and unpublished dissertations were excluded. The yoga intervention needed to include active yoga asana as a primary component; therefore, studies that included only breathing, meditation, restorative yoga, or in which the asana component was not the primary component of the intervention (e.g., MBSR), were excluded. Yoga interventions needed to be primarily yoga asana to ensure sufficient homogeneity across interventions being compared and also because it reflects a very common form of yoga practice today. The study needed to use a questionnaire that specifically measured anxiety symptoms, such as State–Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970) or the Beck Anxiety Inventory (Beck, Steer, & Brown, 1996). Interventions that involved multiple components and for which only one part was yoga, were eliminated (e.g., intervention group received combined CBT and yoga), unless the nonyoga component was received by all groups (i.e., both intervention and control received CBT).

While anxiety symptomatology was the primary variable of interest, all dependent variables reported in each study were coded, and analyses were conducted across all dependent variables and with various subgroups of dependent variables of interest. Biological measures whose directional meaning was ambiguous (i.e.,

whether higher is more desirable or lower is more desirable) were eliminated (e.g., root-mean-square of the successive normal sinus cycle length variability [RR] of interval difference [RMSSD]; Cheema et al., 2013); ratio of cycle length variability [RR] interval corresponding to the 30th and 15th heartbeat upon standing from supine position ([30:15 ratio]; Kanojia, Gandhi, Kukreja, Sharma, & Kapoor, 2013).

Search Strategies

A systematic search for published articles on yoga and anxiety was conducted in June and July 2014 across eight electronic databases (PsycINFO, MEDLINE, Scopus, Social Work Abstracts, SocINDEX with Full Text, General Science Full Text, CINAHL, Physical Education Index) over key terms (yoga, anxiety, stress), search string: ["yoga" ab AND "anxiety OR stress" ab]. Reference lists of quantitative studies, literature review articles, and meta-analyses were inspected for additional articles.

Moderator Analyses

Moderators were coded across studies in order to characterize differences in study samples and delivery method. These moderators included sample mean age, percentage female, total treatment time, control group type (i.e., active vs. nonactive), and treatment type (e.g., general Hatha yoga, Iyengar yoga, or other). Another moderator was study location, which was coded as "India versus outside of India" because yoga originated in India and therefore may be particularly resonant and culturally compatible in India (Benish, Quintana, & Wampold, 2011; Frank & Frank, 1993). In addition, we coded sample origin as clinical or subclinical versus nonclinical, depending on whether elevated levels of clinical symptoms were required for study inclusion. Finally, we coded baseline anxiety score as clinical or subclinical versus nonclinical, depending on whether individuals met *DSM–IV–TR* criteria for an anxiety disorder at baseline (American Psychiatric Association, 2000).

Coding Procedures

Moderator and effect size coding was completed by two graduate students, with any disagreements discussed and a consensus reached. In those studies that did not report data necessary to compute exact effect sizes, study authors were contacted directly requesting pre- and posttest means and standard deviations.

Quality Assessment

Risk of bias of included studies was assessed with the Cochrane Collaboration's tool (Higgins & Altman, 2008). This tool assesses seven possible sources of bias: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. Two independent reviewers (SZ and EV) assessed each study, and for each individual domain studies were classified into low, unclear, and high risk of bias. The criterion of blinding of treatment assignment was excluded from analysis, given that it is not possible to achieve in studies where people receive psychosocial interventions.

Data Analysis

Effect sizes were computed in the same metric as Cohen's *d*, although they technically are equivalent to Becker's *del* (Becker, 1988). This method has the advantage of using all available study data (i.e., not just posttreatment outcomes). Specifically, prepost mean differences (*d*) and the variance of these differences were computed for treatment and control groups separately within each study. In order to correct for bias, these within-group effects sizes (and variances) were converted to Hedge's *g* using standard formulas (Cooper, Hedges, & Valentine, 2009). To produce an effect size reflecting the difference in change between groups (the actual effect size of interest), the control group *g* was subtracted from the treatment group *g*. The variance of this final effect size was computed by summing the variance of *g* for the two groups (Becker, 1988). As readers are most familiar with Cohen's *d*, and because *del* is in the same metric as *d*, the effect size is referred to as *d*. For studies lacking pre- and posttest means and standard deviations, alternative study data were used when available (e.g., *t*- and *F*-statistics from ANOVA models, *p* values from paired *t* tests).

Effect size aggregation. Across all the measures from all studies there were a total of $k = 302$ effect sizes. To address dependency among effect sizes (e.g., aggregating within

studies prior to omnibus analyses) we followed procedures recommended by Gleser and Olkin (2009) using the "Mad" package (Del Re & Hoyt, 2010) in the R statistics program (R Development Core Team, 2010). A correlation of $r = .50$ was assumed between outcome measures within a given study (see Wampold et al., 1997 for a rationale).

Omnibus and moderator analyses. Omnibus analyses were conducted using the "Mad" and "metaphor" packages (Del Re & Hoyt, 2010; Viechtbauer, 2010) based on recommended procedures (Cooper et al., 2009; Hedges & Olkin, 1985). Restricted maximum likelihood estimation was used, in which each study contributes a single effect size (d) that is weighted based on the inverse of its variance. In omnibus analyses, studies were treated as random effects based on the assumption that there was significant theoretical heterogeneity between the studies (different populations, different treatment types, different lengths of treatment). Q-statistics were computed using random effects models, serving as the statistical test of whether study effect sizes exhibited greater heterogeneity than expected by chance alone. For each analysis, an I^2 value was computed reflecting the magnitude of heterogeneity. A higher I^2 value indicates greater between-study heterogeneity (J. P. Higgins, Thompson, Deeks, & Altman, 2003). Values were interpreted based on Higgins, Thompson, Deeks, and Altman's (2003) guidelines.

Primary omnibus analyses were conducted for anxiety outcomes. Further, several additional sub-omnibus analyses were conducted for aggregated subgroupings of outcomes of interest. These groups included biological measures (e.g., blood pressure, cortisol), nonanxiety mental health measures (e.g., Beck Depression Inventory [BDI]; Beck et al., 1996), physical health measures (e.g., weight, body mass index [BMI], muscle strength), stress (e.g., Lipp Stress Symptom Inventory [LSSI]; Lipp, 2000), and physical and mental health outcomes combined.

Moderator tests were conducted using two distinct methods. For categorical moderators, a weighted least squares approach was used (Borenstein, Hedges, Higgins, & Rothstein, 2009; Hedges & Olkin, 1985) employing the "Mad" package (Del Re & Hoyt, 2010). For continuous moderators, metaregression was conducted using restricted maximum likelihood (REML) estimation found in the "metaphor" package (Viechtbauer, 2010).

Publication bias. In order to assess potential publication bias, a funnel plot was constructed using the "metaphor" package (Viechtbauer, 2010).

Results

Literature Search Results

A total of 1,703 articles were identified across the eight databases. Once duplicates were eliminated 939 articles remained. Following examination of the articles' title and abstract, 858 articles were eliminated due to the following reasons: not empirical (e.g., theoretical, book review), not peer-reviewed journal article, not a treatment study (e.g., correlational, systematic review), not yoga treatment or yoga treatment not primarily yoga asana, no anxiety outcome measured, lack of control group, lack of random assignment, not in English, included participants under 18-years-old, or case study. The full texts of the remaining 81 articles, plus two additional articles obtained through inspecting reference lists, were assessed for eligibility. Of these 83 articles, 45 were eliminated due to the following reasons: no anxiety outcome measured, yoga treatment not primarily yoga asana, lack of control group, lack of random assignment, commentary article, not in English, not sufficient data, nonequivalent intervention, same data as already included study, included participants under 18-years-old, or unable to access full text of article. As shown in Figure 1, a total of 38 articles remained for inclusion in the meta-analysis.

Overview of the Literature

Characteristics of the studies included are displayed on Table 1. Of the 38 studies, 11 included participants who had clinical or subclinical psychological symptoms. Specifically, two studies included participants who met criteria for an anxiety disorder, three studies had participants who met criteria for a depression diagnosis, and six studies included participants with elevated, though subclinical, symptoms (four with elevated worry or stress symptoms, one with elevated posttraumatic stress disorder [PTSD] symptoms, one with elevated depres-

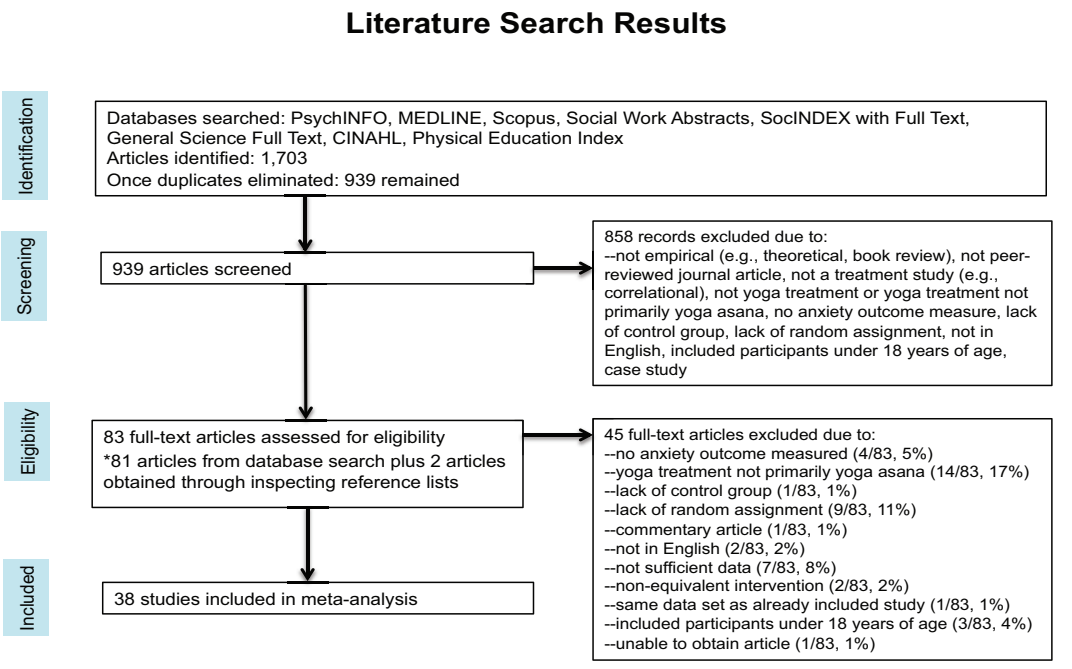

Figure 1. Literature search flowchart. See the online article for the color version of this figure.

sion symptoms). Fourteen of the studies involved participants identified due to a physical condition (e.g., cancer, multiple sclerosis). Therefore, of the 38 studies, 25 involved clinical or subclinical populations due either to a mental or physical condition. Seventeen of the studies included only females and two studies included only males. In terms of location, 13 studies were conducted in the United States, 11 were conducted in India, and 14 were conducted outside of the United States and India. Most of the studies ($N = 29$) used an otherwise unspecified form of hatha yoga, seven studies used Iyengar yoga, and two studies used another form of yoga (i.e., Kripalu, medical yoga).

Risk of Bias of Included Studies

Overall, most studies ($n = 23$) had low risk of bias regarding the method of random sequence. Two studies were at high risk for selection bias due to inadequate generation of a randomized sequence, while 13 studies did not report sufficient data to assess for selection bias. Over half of the studies did not provide sufficient information to determine risk for selective reporting, equally distributed between studies conducted in India and elsewhere. Furthermore, for the majority of the studies (26 of 38), the method of allocation concealment was unclear. In approximately half of the included studies (18 of 38), there was evidence of possible detection bias due to knowledge of the allocated interventions by outcome assessors. Most studies (27 out of 38) reported on procedures to address attrition bias (see Table 2).

Analyses of Overall Effects

Table 3 reports results from both omnibus analyses and all subomnibus analyses examining outcomes in specific domains. Across the 38 studies, a large and statistically significant effect was noted on measures of anxiety in the yoga conditions relative to the control groups ($d = 0.80$, 95% CI [0.49, 1.10], $p < .001$; see Figure 2). A high and statistically significant amount of between-study heterogeneity was noted (Q [37] = 346.17, $p < .001$, $I^2 = 90.88\%$). In subomnibus analyses, statistically significant effects of the yoga intervention were also detected on biological measures ($d = 0.45$, 95% CI [0.02, 0.89], $I^2 = 87.99\%$), nonanxiety mental health outcomes ($d = 0.55$, 95% CI

Table 1
Overview of Included Studies

ID	Author	Year	Control type	*n*	Location	Yoga type	Sample origin	Measures
1	Afonso et al.	2012	No intervention, active	44	Brazil	Hatha	Medical—insomnia	BAI, BDI, KMI, ISI, MSQOL, ISSL
2	Ahmadi et al.	2013	Waitlist, active	31	Iran	Hatha	Medical—MS	BAI, BDI, FFS, balance, walk time, walk distance
3	Bock et al.	2010	Active	55	United States	Hatha	Medical—smokers	STAI, CESD, SF-36, SST
4	Bowden et al.	2012	Active	33	England	Iyengar	Healthy	DASS, Cortisol, SVS, MAAS, PSQI, ISQ, 2-Back, TAS
5	Call et al.	2013	Waitlist, active	91	United States	Hatha	Psych—worry	DASS, PHLMS
6	Chan et al.	2012	Active	14	Australia	Hatha	Medical—stroke	STAI, GDS
7	Chandwani et al.	2010	Waitlist	58	United States	Hatha	Medical—breast cancer	STAI, CESD, BFI, PSQI, IES, BFS, SF36
8	Cheema et al.	2013	No intervention	37	Australia	Hatha	Healthy	STAI, JIG, SF-36, HR, physical fitness
9	Danucalov et al.	2013	Waitlist	46	Brazil	Hatha	Caregivers	BAI, BDI, cortisol
10	Dhananjai et al.	2013	Active	272	India	Hatha	Medical— obese	Hamilton Anxiety, Hamilton Depression, weight, BMI, waist, hip
11	Donesky-Cuenco et al.	2009	No intervention	29	United States	Iyengar	Medical—COPD	STAI, CESD, 6-min walk
12	Ebnezar et al.	2012	Active	235	India	Hatha	Medical—osteoarthritis	STAI, NRS, stiffness, BP
13	Field et al.	2012	No intervention, active	84	United States	Hatha	Psych—prenatal dep	STAI, CESD, STAXI, relationships, pain
14	Field et al.	2013	Active	79	United States	Hatha	Psych—prenatal dep	STAI, CESD, EPDS, POMS, STAXI, relationships, pain
15	Gupta and Mamidi	2013	Active	12	India	Hatha	Psych—GAD	HADS anxiety
16	Immink et al.	2014	Waitlist	22	Australia	Hatha	Medical—Hemiparesis	STAI, GDS, MAS, BBS, 2MWD, CGS, SIS
17	Innes and Selfe	2011	Active	18	United States	Iyengar	Medical—RLS	STAI, POMS, PSQI, sleep, PSS, DSSI, HR, BP, waist, weight, BMI
18	Javnbakht et al.	2009	Waitlist	65	Iran	Iyengar	Healthy—female	STAI
19	John et al.	2007	Active	65	India	Hatha	Medical—Migraine	HADS, migraine frequency and intensity, SF-MPQ
20	Sarita Kanojia et al.	2013	No intervention	50	India	Hatha	Healthy—female	DIPAS anxiety, DIPAS dep, DIPAS well-being, weight, HR, BP
21	Kinser et al.	2013	Active	18	United States	Hatha	Psych—depression	STAI, PHQ, PSS, RRS, Brief Symptom Inventory
22	120	2013	No intervention	37	Sweden	Medical	Psych—stress	HADS anxiety, HADS depression, PSS, SMBQ, ISI, EQ_VAS, HR, BP
23	Malathi and Damodaran	1999	No intervention	50	India	Hatha	Healthy—students	STAI
24	Michalsen et al.	2012	Waitlist	62	Germany	Iyengar	Psych-stress	STAI, CESD, CPSS, BSI, Bf-S Zerssen, POMS, SF36, pain, FBL
25	Mitchell et al.	2014	No Intervention	38	United States	Kripalu	Psych—PTSD	STAI, CESD, PCL
26	Newham et al.	2014	No intervention	45	United Kingdom	Hatha	Healthy—pregnant	STAI, EPDS, WDEQ
27	Oken et al.	2004	Waitlist, active	57	United States	Iyengar	Medical—MS	STAI, CESD, POMS, SF36, MFI, cognitive functioning, SSS, fitness
28	Ranjbar et al.	2013	No intervention	40	Iran	Hatha	Psych—OCD	BAI, Y-BOCS

Table 1 (*continued*)

ID	Author	Year	Control type	*n*	Location	Yoga type	Sample origin	Measures
29	Rocha et al.	2012	Active	36	Brazil	Hatha	Healthy—Army	BAI, BDI, LSSI, Memory, Cortisol
30	Satyapriya et al.	2013	Active	96	India	Hatha	Healthy—pregnant	STAI, HADS anxiety, HADS depression, PEQ, BP
31	Shankarapillai et al.	2012	Active	100	India	Hatha	Healthy—students	STAI, VAS Anxiety
32	Smith et al.	2007	Active	122	Australia	Hatha	Psych—stress	STAI, GHQ, SF-36
33	Stoller et al.	2012	No intervention	70	United States	Hatha	Healthy—military	STAI, AASP
34	Telles et al.	2010	Waitlist	22	India	Hatha	Flood survivors	VAS, heart rate, breath rate
35	Toise et al.	2014	No intervention	46	United States	Hatha	Medical—ICD	FSAS, CESD, FPAS, PHE, STPI, SEC, SCS, IPS
36	Vadiraja et al.	2009	Active	75	India	Hatha	Medical—breast cancer	HADS Anxiety, HADS Depression PSS, Cortisol
37	Varambally et al.	2013	Waitlist	18	India	Hatha	Caregivers	HADS Anxiety, HADS Depression, WHOQOL, BAS
38	Woolery et al.	2004	Waitlist	23	United States	Iyengar	Psych—depression	STAI, BDI, Cortisol

Note. BAI = Beck Anxiety Inventory; BDI = Beck Depression Inventory; KMI = Kupperman Menopausal Index; ISI = Insomnia Severity Index; MSQOL = Menopause Specific Quality of Life; ISSL = Inventory of Stress Symptoms for Adults; FFS = Fatigue Scale Score; STAI = State-Trait Anxiety Inventory; CESD = Center for Epidemiologic Studies Depression Scale; SF-36 = Short Form Health Survey; SST = Temptations to Smoke; DASS = Depression Anxiety Stress Scales; SVS = Subjective Vitality Scale; MAAS = Mindful Attention Awareness Scale; PSQI = Pittsburgh Sleep Quality Index; ISQ = Illness Symptom Questionnaire; 2-Back = The Dual-Back Task; TAS = Tellegen Absorption Scale; PHLMS = Philadelphia Mindfulness Scale; GDS = Geriatric Depression Scale; BFI = Brief Fatigue Inventory; IES = Impact of Events Scale; BFS = Benefit Finding Scale; JIG = job satisfaction; HR = heart rate; HAM-A = Hamilton Anxiety Rating Scale; HAM-D = Hamilton Depression Rating Scale; BMI = body mass index; NRS = Numerical Pain Scale; BP = blood pressure; STAXI = State-Trait Anger Expression Inventory; EPDS = Edinburgh Postnatal Depression Score; POMS = profile of mood states; HADS Anxiety = Hospital Anxiety and Depression Score; MAS = Motor Assessment Scale; BBS = Berg Balance Test; 2MWD = 2-minute walk distance; CGS = comfortable gait speed; SIS = Stroke Impact Inventory; PSS = Perceived Stress Scale; DSSI = Duke Social Support Index; MPQ = McGill Pain Questionnaire; DIPAS = Defense Institute of Physiology and Allied Sciences; PHQ = Patient Health Questionnaire; RRS = Ruminative Response Scale; SMBQ = Shirom-Melamed Burnout Questionnaire; EQ VAS = Euro Quality of Life Visual Analogue Scale; CPSS = Cohen Perceived Stress Scale; BSI = Brief Symptom Inventory; FBL = Freiberg Somatic Complaints; PCL = PTSD Checklist; WDEQ = Wijma Delivery Expectancy Questionnaire; MFI = Multidimensional Fatigue Inventory; SSS = Stanford Sleepiness Scale; Y-BOCS = Yale-Brown Obsessive Compulsive Scale; LSSI = Lipp Stress Symptom Inventory; PEQ = Pregnancy Experiences Questionnaire; VAS = Visual Analog Scale; GHQ = General Health Questionnaire; AASP = Adolescent/Adult Sensory Profile; FSAS = Florida Shock Anxiety Scale; FPAS = Florida Patient Acceptance Survey; PHE = Positive Health Expectation Scale; STPI = State-Trait Personality Inventory; SEC = Symptom/Emotion Checklist; SCS = Self-Compassion Scale; IPS = Interpersonal Support Evaluation; WHOQOL = World Health Organization Quality of Life; BAS = Burden Assessment Scale.

Table 2
Risk of Bias of Included Studies

First author	Publication date	1. Random sequence generation	2. Allocation concealment	3. Selective reporting	4. Other sources of bias	5. Blinding (outcome assessment)	6. Incomplete outcome data
Afonso	2012	Unclear	Unclear	Unclear	Low	Low	Low
Ahmadi	2013	Unclear	Unclear	Unclear	Low	High	Low
Bock	2010	Low	Unclear	Unclear	Low	Low	Unclear
Bowden	2012	Low	Unclear	Low	Low	Unclear	High
Call	2013	Unclear	Unclear	Unclear	Low	Low	High
Chan	2012	Low	Low	Low	Low	Low	Low
Chandwani	2010	Low	Unclear	Unclear	Low	High	Low
Cheema	2013	Low	Low	Low	Low	Low	High
Danucalov	2013	Unclear	Unclear	Low	Low	High	Low
Dhananjai	2013	Unclear	Unclear	Unclear	Low	High	Low
Donesky-Cuenco	2009	Unclear	Unclear	Unclear	Low	High	Low
Ebnezer	2012	Low	Low	Unclear	Low	Low	Low
Field	2012	Unclear	Unclear	Unclear	Low	High	Low
Field	2012	Low	Unclear	Low	Low	Low	Unclear
Gupta	2013	High	Unclear	Unclear	Low	High	Low
Immink	2014	Low	Low	Low	Low	Low	Low
Innes	2011	Low	Low	Low	Low	Low	Low
Javnbakht	2009	Unclear	Unclear	Unclear	Low	High	Low
John	2007	Low	Unclear	Low	Low	High	Low
Kanojia	2013	Unclear	Unclear	Unclear	Low	High	Low
Kinser	2013	Low	Unclear	Low	Low	High	Low
Kohn	2013	Low	Low	Low	Low	High	Unclear
Malathi	1999	Unclear	Unclear	Unclear	Low	High	Low
Michalsen	2012	Low	Low	Unclear	Low	High	Low
Mitchell	2014	Low	Unclear	Low	Low	High	Low
Newham	2014	Low	Low	Low	Low	Low	Low
Oken	2004	Low	Unclear	Low	Low	Low	Low
Ranjbar	2013	Unclear	Unclear	Unclear	Low	Low	Low
Rocha	2012	Unclear	Unclear	Low	Low	Low	Low
Satyapriya	2013	Low	Unclear	Unclear	Low	Low	Unclear
Shankarapillai	2012	High	Unclear	Unclear	Low	Low	Low
Smith	2007	Low	Low	Unclear	Low	Low	Low
Stoller	2012	Low	Low	Low	Low	Low	Unclear
Telles	2010	Low	Unclear	Unclear	Low	Unclear	Low
Toise	2014	Low	Unclear	Low	Low	Low	Unclear
Vadiraja	2009	Low	Low	Low	Low	High	Unclear
Varambally	2013	Low	Low	Low	Low	High	High
Woolery	2004	Unclear	Unclear	Unclear	Low	High	Low

[0.28, 0.81], $I^2 = 83.90\%$), physical health measures ($d = 0.45$, 95% CI [0.15, 0.75], $I^2 = 87.27\%$), and mental and physical health outcomes combined ($d = 0.65$, 95% CI [0.44, 0.86], $I^2 = 86.70\%$).

Moderator Tests

Having detected evidence for an overall effect of yoga relative to control conditions on anxiety and other outcomes, alongside significant variability across studies in overall effect, moderator tests were conducted to assess whether study-level characteristics predicted between-study variation in outcomes. Moderator tests were conducted predicting anxiety outcomes. Three moderators were tested including sample mean age, percentage female, and total treatment time, as predictors of variation in intervention effects on anxiety. None of these study-level characteristics were found to moderate treatment effects on anxiety (see Table 4). In addition, five categorical moderators were tested including control group type (i.e., waitlist, active, and waitlist and active), study loca-

Table 3
Omnibus and Subomnibus Analyses for Effects of Yoga Interventions

Outcome type	*k*	*d* [95% CI]	*SE*	*z*	*p*	*Q*	*Qp*	I^2
Anxiety	38	.80 [.49, 1.1]	.15	5.17	<.001	346.17	<.001	90.88
Biological measures	12	.45 [.02, .89]	.22	2.03	.042	56.18	<.001	87.99
Other mental health	29	.55 [.28, .81]	.14	4.06	<.001	143.65	<.001	83.9
Physical health	18	.45 [.15, .75]	.15	2.96	.003	109.72	<.001	87.27
Clinical outcomes combined	38	.65 [.44, .86]	.11	6.00	<.001	243.72	<.001	86.7

Note. *k* = number of studies within given outcome type category; *d* = effect size (equivalent to Becker's *del*); CI = confidence interval; *SE* = standard error; *z* = *z*-statistic; *p* = *p*-value for *z*-statistic; *Q* = *Q*-statistic (tests heterogeneity); *Qp* = *p*-value for test of heterogeneity; I^2 = proportion of variation in effect sizes.

tion (India vs. outside India), sample origin (i.e., clinical or subclinical vs. nonclinical; American Psychiatric Association, 2000), baseline anxiety (clinical or subclinical vs. nonclinical), and treatment type (unspecified Hatha yoga vs. Iyengar yoga vs. other [e.g., Kirpalu yoga]).

Only location was found to significantly moderate effects, with the largest intervention effects found in studies taking place in India versus outside of India (d = 1.26 vs. d = 0.62; Q-between [1] = 4.05 p = .044; see Table 5). No evidence for moderation was found when clinical/subclinical anxiety samples (i.e., obsessive–compulsive disorder, posttraumatic stress disorder; k = 7) as per *DSM–IV–TR* (American Psychiatric Association, 2000) were compared with nonclinical anxiety samples (Q [1] = 1.54, p = .214). Similarly, control group type, sample origin, and treatment type did not moderate treatment effects on anxiety outcomes.

Assessment for Publication Bias

A funnel plot with standard error on the vertical axis and effect size on the horizontal axis was constructed based on data used in the primary omnibus analyses (anxiety outcome only) and inspected for asymmetry suggestive of pub-

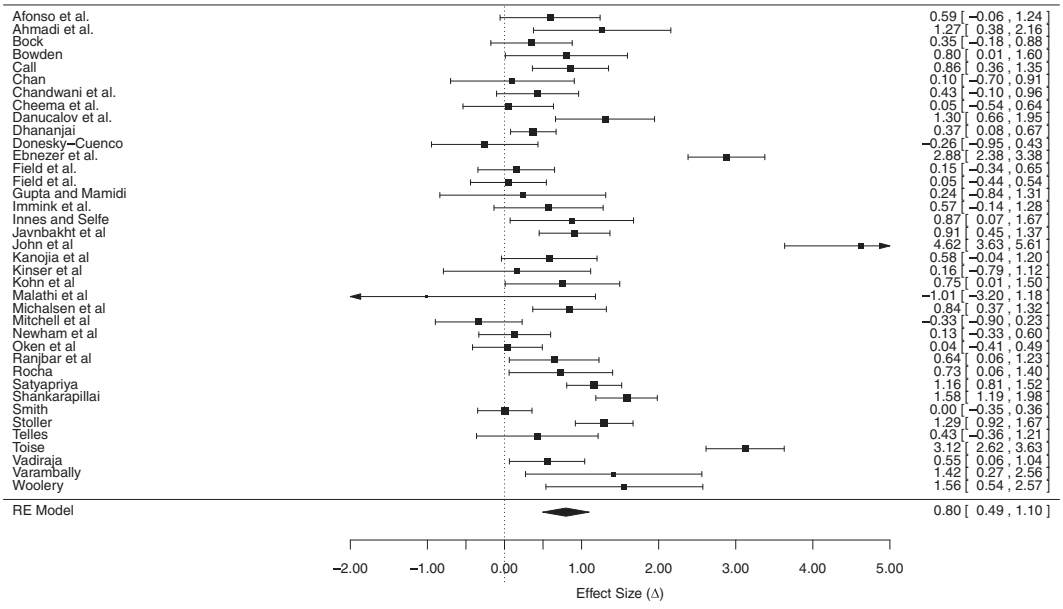

Figure 2. Forest plot displaying mean d effect sizes with 95% confidence intervals for individual studies and omnibus effect on anxiety outcomes. The size of boxes is proportional to each study's weight in the omnibus analysis.

Table 4
Continuous Moderators for Anxiety Outcomes Alone and All Outcomes Combined

Outcome	Moderator variable	k	B_0	B_1	95% CI (B_1)	z (B_1)	p
Anxiety only	Age	36	.61	.0043	[−.018, .027]	.37	.709
Anxiety only	% Female	37	1.33	−.0066	[−.016, .0032]	−1.33	.185
Anxiety only	Total treatment time	36	.81	.0005	[−.014, .015]	.066	.94
All outcomes	Age	36	.94	−.0084	[−.023, .0065]	−1.11	.269
All outcomes	% Female	37	.89	−.0039	[−.011, .0029]	−1.11	.266
All outcomes	Total treatment time	36	.46	.0064	[−.0033, .016]	1.29	.196

Note. k = number of studies; B_0 = intercept; B_1 = slope coefficient; CI = confidence interval for slope coefficient; z = z-statistic for slope coefficient; p = p-value for slope coefficient; REM = % racial or ethnic minority (only coded for United States based studies).

lication bias (see Figure 3). Effects were largely symmetrically distributed around the mean effect indicating that publication bias alone does not appear to account for observed effects.

In addition, a trim-and-fill analysis was conducted. For anxiety outcomes, a large and significant effect size was found in the yoga conditions relative to the control groups (d = 0.80, 95% CI [0.49, 1.10], $p < .001$). The lack of significant change in effect size from the omnibus suggests that there was little or no impact from these outlier studies.

Discussion

Summary of Findings

This meta-analysis of RCTs that utilized a yoga intervention and measured anxiety symptomatology as an outcome found an overall large effect size on anxiety measures/scores for the yoga conditions relative to the control groups (d = 0.80), albeit with substantial between-study heterogeneity (I^2 = 90.88%).

The benefits of yoga appear to extend beyond effects on anxiety symptomatology. Yoga significantly improved symptoms across a variety of outcome types relative to the control (i.e., nonanxiety mental health outcome, physical health measures, stress, mental and physical health outcomes combined, life satisfaction, and depression), including on outcomes that did not rely on self-report (i.e., biological measures).

Agreement With Prior Research

The large effect of yoga on anxiety symptoms is comparable with effect sizes found in other meta-analyses on anxiety and yoga (Cramer et al., 2018; Hofmann et al., 2016), and for similar mind-body practices, such as mindfulness-based interventions (Goldberg et al., 2018; Khoury et al., 2013), Chigong (Yin & Dishman, 2014), and relaxation (Bandelow et al., 2015). In addition, the significant findings of yoga for anxiety are in agreement with meta-analyses on exercise for anxiety (Ensari et al., 2015; Long & Stavel, 1995).

The significant treatment effects on other dependent variable types (e.g., nonanxiety mental health, stress, physical health) was (not unexpectedly) similar to that found in previous meta-analyses and randomized trials on yoga. Our meta-analysis corroborates effects reported for physical health (Cramer, Lauche, Haller et al., 2014; Hagins et al., 2013) and depression (Cramer et al., 2013; Gong et al., 2015).

Moderation

While showing moderate to large overall effects, the high degree of between-study heterogeneity suggests that systematic differences may exist that impact the effectiveness of yoga-based interventions. Despite significant between-study heterogeneity in effects, four out of the five moderators tested did not explain these differences, suggesting that additional moderators could be explored in future meta-analyses. The one significant moderator was study location, with studies conducted in India showing the largest effects, roughly twice the magnitude of that found in studies conducted outside of India (d = 1.26 vs. d = 0.62). This finding does not appear to reflect site differences in the quality of study methodology. Risk of bias analysis revealed that studies conducted in India were generally similar or at lower risk

Table 5
Categorical Moderators for Anxiety Outcomes Alone and All Outcomes Combined

Outcome	Moderator variable	*k*	*d*	95% CI	*Q*	*df*	*p*
Anxiety only	Control type				.85	2	.655
	Waitlist	18	.74	[.32, 1.16]	138.36	17	<.001
	Waitlist and active	5	.56	[−.22, 1.34]	10.57	4	.032
	Active	15	.95	[.49, 1.40]	189.40	14	<.001
Anxiety only	Location				4.05	1	.044
	India	11	1.26	[.73, 1.78]	143.67	10	<.001
	Outside India	27	.62	[.30, .95]	175.30	26	<.001
Anxiety only	Sample origin				2.87	1	.09
	Nonclinical	27	.95	[.62, 1.27]	285.14	26	<.001
	Clinical/subclinical	11	.43	[−.073, .93]	27.22	10	.002
Anxiety only	Baseline anxiety				1.54	1	.210
	Nonclinical	31	.88	[.57, 1.19]	308.78	26	<.001
	Clinical/subclinical	7	.43	[−.21, 1.07]	19.57	10	.003
Anxiety only	Treatment type				1.35	2	.51
	Hatha	29	.87	[.55, 1.20]	308.40	28	<.001
	Iyengar	7	.66	[−.001, 1.31]	18.65	6	.005
	Other	2	.19	[−1.034, 1.41]	5.22	1	.022
All outcomes	Control type				3.33	2	.189
	Waitlist	18	.51	[.22, .79]	53.34	17	<.001
	Waitlist and active	5	.28	[−.23, .79]	2.99	4	.56
	Active	15	.79	[.48, 1.088]	164.04	1	<.001
All outcomes	Location				13.16	1	<.001
	India	11	1.07	[.76, 1.37]	77.94	10	<.001
	Outside India	27	.40	[.21, .59]	78.67	26	<.001
	Outside India	27	.40	[.21, .59]	78.67	26	<.001
All outcomes	Sample origin				3.47	1	.062
	Nonclinical	27	.70	[.48, .91]	183.62	26	<.01
	Clinical/subclinical	11	.31	[−.028, .65]	21.16	10	.02
All outcomes	Baseline anxiety				2.54	1	.111
	Nonclinical	31	.66	[.45, .87]	207.31	30	<.01
	Clinical/subclinical	7	.26	[−.18, .70]	12.98	6	.043
All outcomes	Treatment type				2.63	2	.269
	Hatha	29	.66	[.43, .88]	208.53	28	<.001
	Iyengar	7	.47	[.024, .92]	16.60	6	.011
	Other	2	−.020	[−.86, .82]	3.02	1	.082

Note. k = number of studies; d = effect size (equivalent to Becker's *del*) within a given category level, Q for categories represents Q-between and tests whether moderator accounts for significant variability between studies; Q for levels of categorical moderators tests whether significant variability exists between studies included in a given level; p = probability value for given Q-statistic (i.e., whether moderator explains significant variability between studies or whether significant variability remains within level of category.

for bias relative to studies conducted elsewhere in most domains compared with studies carried out outside of India, with the exception of allocation bias.

This finding suggests yoga delivered in India may be particularly beneficial for improving anxiety symptoms. There are a number of possible explanations for this phenomenon. In India yoga is part of the fabric of the country's tradition and identity. Intertwined with India's largely Hindu culture, yoga is something that Indians are immersed in throughout their lives, including at home, school, and religious or other community gatherings.

Because yoga originated in India, there is not only a universal familiarity and intimacy with yoga, but also cultural pride surrounding its practice. Cultural pride has been linked to a healthy sense of self (e.g., Spencer, Fegley, & Harpalani, 2003), and in India yoga functions to create a "shared history" and "unifying identity" (Strauss, 2002). As an illustration, Indians recently celebrated their pride in yoga during International Yoga Day on June 21, 2015, in

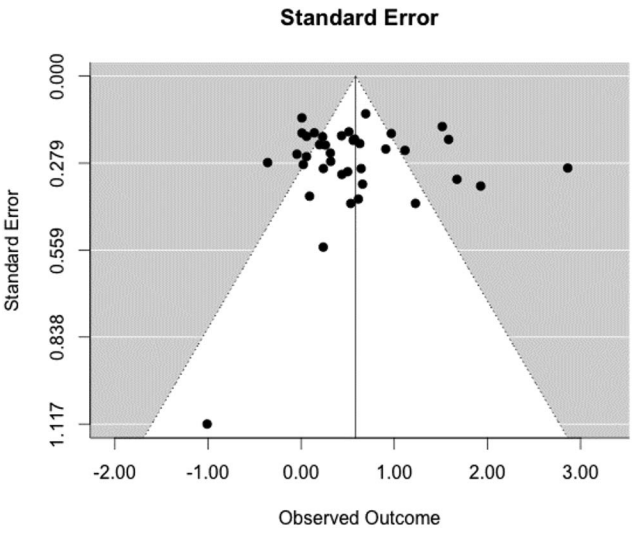

Figure 3. Funnel plot for all outcomes.

which Prime Minister Narendra Modi led 35,000 Indians in a yoga class (India Yoga, 2015). Moreover, Indians share a cultural belief in the effectiveness of yoga as part of the Ayurvedic tradition; indeed, belief in a healing practice has been shown to increase its effectiveness (Frank & Frank, 1993). Previous research on psychological interventions generally has also noted the importance of a culturally consistent rationale and ritual for treatment (Benish et al., 2011; Frank & Frank, 1993).

Not only is yoga in India more integrated into the rest of India's culture, yoga is more often part of a spiritual practice in India than outside of India. In India yoga is more likely to be performed holistically and in a manner that more closely resembles its original form and intention (Budhos, 2002). Specific ways in which this might contribute to yoga's effectiveness are described below.

First, there are usually differences in the curriculum—that is, class components, sequencing, and goals—of a yoga class in India versus outside of India. Classes in India tend to include a variety of different practices that complement the physical postures. Specifically, classes in India usually include chanting, breathing exercises, and meditation. The intention is to cultivate an inward focus, connect with breath and body, and to move through the poses easefully and mindfully (Dhananjai, Sadashiv, Tiwari, Dutt, & Kumar, 2013; Gupta & Mamidi, 2013). In contrast, outside of India, classes are more often explicitly focused on physical fitness (Askegaard & Eckhardt, 2012). The intention is often on achieving the "best" version of the pose and the hardest physical postures. Even if this is not the intention stated by the instructor, this often ends up being the intention of the participants as they are coming into class with this predisposition (Jain, 2014). The variety and sequence of practices in Indian yoga classes, with the intentional focus on breath and body and on subjective experience throughout the practice, may encourage regulation of the nervous system.

Second, there are differences in the environments of the practice. Yoga classes in India are often practiced at a yoga center that is also a spiritual center set up to help participants transition out of their daily way of being. This space encourages participants to slow down, calm their mind and body, connect with their inner experience, and focus on a higher power or energy outside the self. To that end, lighting is often dim, sounds are calming, and the space is relatively clear and contains only objects necessary to support the yoga practice. References to money or capitalistic culture (e.g., company logos) are kept to a minimum (Strauss, 2005). Participants may be surrounded by religious leaders dressed in traditional garb. In contrast,

outside of India, yoga classes are likely to be performed at a fitness center with a more traditionally western environment and no explicit connection to spirituality. At these fitness centers, there are often bright lights and mirrors, and teacher and participants are often dressed in workout gear. Classes are often given in exercise studios adjacent to other fitness offerings with only a glass wall separating the two spaces. Participants in the yoga class may be surrounded by treadmills and top 40 popular music. This gym environment would not seem to provide the same support to calm the mind and nervous system. It would not seem to facilitate students' focusing on their inner experience and transitioning out of daily ways of being (Isaacs, 2017). While the settings of the yoga classes included in this study were not always reflective of this distinction between classes in India being conducted in a yoga center and classes outside of India being conducted at a gym, classes in India are more likely to be informed by the traditional settings of the yoga practice.

Third, there are differences in the extent to which a spiritual or religious lineage, including its traditional spiritual teachings, are included in the class. In India, yoga centers are often established by a particular Swami, or yogic leader, who is part of a specific yoga lineage through his teacher. There are often multiple references to the Swami and the lineage in the yoga center (e.g., pictures, books). In addition, there are often references to higher powers or cosmic forces, specifically to the Hindu deities, through the presence of altars or chanting (Strauss, 2005). The teacher often emphasizes the key philosophical teachings of yoga, which are often spiritually based, such as impermanence and egolessness. They also often emphasize that the purpose of the practice is to quiet the mind and that to be effective, the practitioner must practice regularly over the long period of time, with a desire to increase understanding. While there are yoga centers outside of India that incorporate spirituality, it is less universally the case than in India.

Fourth, there are differences in terms of community. In India, there are aspects of the class experience that make practitioners feel more connected with each other Yoga classes given at a dedicated yoga center are more likely to be part of the expression of a yogic lifestyle. Participants are more likely to feel among a community of like-minded individuals who share similar values. At a yoga center in India the shared knowledge and appreciation for the Swami and his yoga lineage may cause participants to feel personally grounded in a healing tradition and also connected to other members who also value this lineage. Yoga centers more often offer communal activities outside of classes to gain exposure to the yogic lifestyle (e.g., preparing and serving meals together). These activities can serve to strengthen connection to others at the center. In contrast, to participate in a yoga class at a gym in a Western environment, a person requires hardly any more commitment than their regular gym membership. They may take yoga 1 day of the week and other fitness classes on other days. The gym community as a whole is unlikely to possess an interest in the yogic lifestyle. There are less indications that there are shared spiritual values among the participants, and there are less likely to be supports to foster a sense of community.

Fifth, there are differences in the teachers of yoga classes. Teachers of yoga classes in India are more likely to have wholly devoted themselves to the yogic lifestyle, whether they are swamis (senior religious teachers) or individuals who live at the yoga center. These teachers serve as an embodied example of the power and benefits of yoga. While some yoga teachers outside of India are devoted to a yogic lifestyle, this commitment is not necessary to teach yoga in western gym environments.

Strengths and Limitations

Strengths of this meta-analysis were the inclusion of a large number of RCTs ($k = 38$) with a diverse origin (e.g., medical diagnosis, psychological criteria, pregnant women, community sample, and study location). This strength is also a limitation, as we included studies that varied in numerous ways. Although a significant moderator was detected, excess variance remained even after controlling for study location. It is likely that systematic variation in effects does exist in these studies, and that we were unable to model these differences. Another strength is that we only included studies that used an active yoga asana as a primary intervention component (vs. also including studies that included only breathing, meditation, or restorative yoga).

One limitation is that few included studies used a population that met criteria for an anxiety disorder. However, given that this meta-analysis is focused on populations that expressed anxiety symptoms rather than populations with anxiety disorders, we do not consider this a major limitation. As discussed above, there is an empirical reason to suggest that the current effect size estimates would nonetheless generalize to a population with clinical levels of anxiety (i.e., lack of moderation by sample origin). However, it is possible that yoga may not be effective for individuals experiencing a more debilitating level of anxiety: Despite a nonsignificant test of moderator, effect sizes were numerically larger for the nonclinical anxiety samples ($d = .88$) than the clinical/subclinical anxiety samples ($d = .43$). Indeed, these treatments could potentially prove countertherapeutic for some individuals (e.g., through flooding).

Second, the quality of studies included in the review varied. Many studies had insufficient reporting to determine risk of bias regarding random sequence generation, allocation concealment, or selective reporting. Risk of bias due to insufficient blinding of assessors was high in about half of the studies. It is vital that future studies in this area employ blind outcome assessment, when possible.

A third limitation was the lack of placebo control conditions. In some ways in contrast to the mindfulness literature that has been criticized for a lack of active control conditions (Baer, 2003; Goldberg et al., 2017), the included studies had a substantial number of active comparison conditions. This allows a more rigorous test of the effects of yoga, in theory demonstrating the efficacy above and beyond what might be obtained from another active treatment (i.e., what has been termed "relative efficacy" in the psychotherapy literature; Wampold & Imel, 2015). Psychological placebos were not, however, well represented in the included studies. Such comparisons are designed to control for nonspecific effects of treatment (e.g., therapist attention, group support, expectancy; Wampold & Imel, 2015; Wampold, Minami, Tierney, Baskin, & Bhati, 2005). Designing psychological placebos is not straightforward, given many so-called nonspecific factors are dependent upon a cogent treatment rationale (see Wampold et al., 2005). Based on the current pattern of findings, we would expect yoga to outperform placebo controls (given they outperformed active therapies); this possibility could be tested in future clinical trials.

To address the aforementioned limitations, findings of this meta-analysis point toward four primary recommendations for future research. First, future trials should target clinical populations meeting diagnostic criteria for an anxiety disorder and investigate whether yoga-based interventions are efficacious in reducing stress and anxiety symptoms either as monotherapy or adjunctive treatment. Although results suggest yoga will prove beneficial in samples with an anxiety diagnosis, future RCTs will be needed to confirm this possibility. Second, it is recommended that more research be conducted on the differential effect of yoga on anxiety based on study location, perhaps conducting further moderator testing to better understand which factors are contributing to the differential effectiveness (e.g., instructor training). Further qualitative (e.g., interviews, focus groups) and quantitative research can potentially deepen our understanding of the apparent effect of study location. Third, studies of yoga on anxiety would do well to measure potential mediators of treatment effects and to test these candidate mechanisms. Research on mindfulness-based interventions can serve as a model for this. Some of the same psychological and physiological mechanisms at play in mindfulness therapies may be useful to examine, including mindfulness (Gu et al., 2015) and cortisol (Goldberg, Manley et al., 2014; Matousek, Dobkin, & Pruessner, 2010), along with aspects unique to these treatments (e.g., practice time and practice quality; Goldberg, Del Re, Hoyt, & Davis, 2014) and common across psychological interventions (e.g., therapeutic alliance; Goldberg, Davis, & Hoyt, 2013; Wampold & Imel, 2015). Fourth, future research designs should try to address the placebo effect by including a placebo treatment as active control that is comprised of the nonspecific aspects and the ritual of treatment.

Clinical Practice and Research Implications

This meta-analysis provides some quantitative evidence from RCTs to support yoga as an effective intervention for anxiety symptoms. Although only seven of the included trials were drawn from populations with clinical ($k = 2$) or subclinical ($k = 5$) levels of anxiety symptoms,

effects on anxiety did not differ significantly between clinical or subclinical samples relative to nonclinical, even though outcomes were numerically larger for the nonclinical anxiety samples. Therefore, yoga appears to be a valuable tool for patients presenting with nonclinical anxiety symptoms, though more research is needed to ascertain whether it is a safe and effective intervention—either as monotherapy or adjunct intervention—in the treatment of anxiety disorders.

Conclusion

This meta-analysis of RCTs employing yoga intervention to target anxiety symptoms revealed an overall large effect size of yoga conditions relative to control groups on anxiety measures, and a moderate effect size relative to control groups on a variety of outcome types (i.e., biological measures; nonanxiety mental health outcomes [e.g., depression]; physical health measures; stress, mental, and physical health outcomes combined; life satisfaction; and depression), albeit with high heterogeneity in effects across studies. The effect size for studies conducted in India was in the large range and twice the magnitude of that found in studies conducted outside of India, suggesting that yoga may be particularly beneficial when conducted in India. The findings of this meta-analysis suggest that future research should consider focusing on yoga interventions with both clinical anxiety and nonclinical populations, examining yoga as both a treatment for psychopathology and as a health and wellness intervention.

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