Yoga and Anxiety:

A Meta-Analysis of Randomized Controlled Trials

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ABSTRACT

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The aim of this study was to investigate the effect of yoga on anxiety using meta-analytic methods, examining overall effect size, the effect size of sub-categories of dependent variables, and moderation.

A systematic search was conducted for published randomized controlled trials on yoga and anxiety on electronic databases over key terms. Reference lists of quantitative studies and literature review articles were inspected for additional articles. Once included studies were determined, outcome data were extracted and moderators were coded across studies in order to characterize differences in study sample, delivery method, and type of dependent variable. Effect size aggregation and omnibus analyses were performed, and moderator tests were conducted.

Results support the hypothesis that yoga significantly decreases anxiety symptoms, in addition to symptoms more globally (i.e., anxiety and other mental health outcomes, physical health outcomes, etc taken in aggregate). Results from sub-omnibus analysis show significant effects of the yoga intervention on biological measures, non-anxiety mental health outcomes, physical health measures, stress, mental and physical health outcomes combined, and life satisfaction. In addition, significant moderation was found by location, with highest effects appearing in Indian samples.

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DEDICATION

To my mother, for her unconditional love. She was my biggest fan and most fervent supporter. I know she is beaming down with love and pride.

To my father and brother for their love and support.

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Introduction

Prevalence, Impact, and Treatment of Anxiety

Anxiety is a common and debilitating mental health condition. Globally, the 3-month prevalence of any anxiety disorder is 7.3% and within Euro/Anglo countries (Western Europe, North America, Australasia) the 3-month prevalence is 10.4% (Baxter, Scott, Vos, & Whiteford, 2013). In the United States, anxiety disorders impact over a third of the population across the lifespan, with a lifetime prevalence of 33.7%; rates are higher for females than males (40.4% vs. 26.4%; Kessler, 2012).

In addition to the high numbers of people who meet criteria for an anxiety disorder, many suffer from subclinical levels of anxiety (Rucci, 2003). Clinical and subclinical levels of anxiety have a negative impact across a variety of domains, including poorer relationships (Heerey, 2007), decreased quality of life (De Beurs, 1999; Creed, 2002), and increased economic and health care costs (Marciniak, 2004).

Taken as a whole, anxiety is characterized by disproportionate apprehension or worry, driven by an inaccurate assessment of danger, and leading to subsequent avoidance behavior. Therefore, anxiety treatments seek to shift these maladaptive thoughts and behaviors, including increasing a person's exposure to previously avoided situations. While the psychological treatments for anxiety vary by specific disorder, overall the treatments with the strongest support are Cognitive therapy, Behavioral therapy, and Exposure therapy (Bandelow, 2014; Barlow, 2000; Franklin, 2000; Otto, 2004; Power, 1990).

In the treatment of Generalized anxiety disorder (GAD), Cognitive behavioral therapy has been shown to have medium to large effect sizes (Butler, 2006; Mitte, 2005). For Obsessive compulsive disorder, Exposure and response prevention therapy and Cognitive therapy have

been shown to significantly reduce symptoms (Franklin, 2000; Van Oppen, 1995). For Panic disorder, Cognitive behavioral therapy has been shown to be most effective with medium to large effect sizes (Barlow, 2000; Gould, 1995; Mitte, 2005). There remains, however, significant room to increase the effectiveness of anxiety treatments, especially for those individuals who do not meet clinical criteria for an anxiety disorder, but are experiencing decreased functioning and distress due to their anxiety symptoms.

Yoga as a Mind Body Intervention

Yoga is within the family of mind body therapies that include Chigong and mindfulness meditation (Barrows, 2002). Yoga is a philosophy and way of living that originated in India; the word "yoga" means "union." Yoga involves engaging in slow, rhythmic physical poses while maintaining awareness on the breath and body, essentially cultivating a mindful attitude (i.e., awareness and openness to experience) during practice. In this way, yoga facilitates union, or the uniting of the mind and body (Wanning, 1993).

Core tenets of yoga include the concepts of impermanence and egolessness. 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*, where a character comments that the greatest wonder of the world is that "[p]eople see death all around them, but do not believe they're going to die themselves." 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*. 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.

In the key text on yoga *The Yoga Sutras of Patanjali,* yoga is defined as "Yoga Chitta Vritti Nirodhah," or "The restraint of the modifications of the mind is Yoga" (Satchidananada, 2012). 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, 2012). 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, known as "Hatha 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 non-attached attitude

towards the activities of the world); dharna (concentration); dhyana (meditation); and samadhi (bliss, becoming one with the Divine). Hatha yoga, as taught in most contemporary classes, most often involves practicing physical postures (asanas), breathing practices (pranayama), and meditation (dhyana) (Iyengar, 1966).

One of the most popular types of yoga today in the Hatha yoga tradition is Iyengar yoga, which was developed by B.K.S. Iyengar and focuses on postures and breathing. Iyengar yoga emphasizes alignment and utilizes props to aid in achieving the desired physical actions of the poses regardless of each individual's physical limitations (Iyengar, 1966). Kripalu is another form of commonly practiced hatha yoga. Developed by Amrit Desai, Kripalu yoga also utilizes postures and breathing and emphasizes gentleness and compassion, including working at your own level of practice (Faulds, 2005).

Effectiveness of Yoga

While there has yet to be a meta-analysis conducted specifically on yoga and anxiety, there are several qualitative reviews that have examined the effectiveness of yoga and anxiety (Chugh Gupta, 2013; Kirkwood, 2005; Li, 2012, Field, 2011, da Silva, 2009). These reviews have found preliminary support for yoga's effectiveness. However, the reviews noted methodological limitations of studies (e.g., lack of randomization and/or control group), heterogeneity of included study populations, and variation in control group type (e.g., waiting list control, active control). Therefore, review authors cautioned against drawing definitive conclusions.

There have been meta-analyses conducted on specific focused populations that have examined the effect of yoga on anxiety a variety of outcomes, including anxiety. Lin (2011) and Pan (2015) each conducted a meta-analysis of patients with cancer and found significantly

greater improvements in the yoga group on anxiety as compared to controls, with medium effects (SMD = -0.76; 95% CI -1.34 to -0.19) and large effects (SMD: -0.98, 95% CI: -1.38, -0.57) respectively.

Meta-analyses have also been conducted on yoga for related mental and physical health conditions. Crammer (2013) conducted a meta-analysis of yoga for depression across twelve RCTs and found a medium effect size on yoga for severity of depression, specifically compared to usual care (SMD = -0.69; 95% CI -0.99 to -0.39), relaxation (SMD = -0.62; 95% CI -1.03 to -0.22), and aerobic exercise (SMD = -0.59; 95% CI -0.99 to -0.18). Gong (2015) also found medium effect sizes for yoga on prenatal depression across six RCTs, with level of depression significantly reduced in the yoga group as compared to the control group (SMD = -0.59; 95% CI -0.94 to -0.25).

In terms of physical health, meta-analyses have shown yoga's effectiveness in decreasing risk factors for cardiovascular disease (Crammer, 2014; Chu, 2014); as an adjunctive treatment for hypertension (Cramer, 2014; Hagins, 2013); for decreasing pain (Bussing, 2012; Cramer, 2012; Ward, 2013) and fatigue (Boehm, 2012; Cramer, 2014); for improving physical function (Ward, 2013); improving lung function in patients with COPD or asthma (Liu, 2014; Cramer, 2014); and for increasing quality of life for patients with cancer (Pan, 2015; Zhang, 2012).

Across other mind body modalities, such as mindfulness, Chigong, and relaxation, meta-analyses have demonstrated their effectiveness on anxiety. For mindfulness, meta-analyses have found a range of effect sizes from small to large. Khoury et al (2013) conducted a comprehensive meta-analysis of mindfulness-based therapies (MBT) across a variety of outcomes and study designs. Examining pre-post studies, a large effect size of MBT on anxiety

was found (Hedges's g = .89; 95% CI 71-1.08). Analyzing waitlist-controlled trials, a large effect size was also found for MBT on anxiety (Hedges's g = .96; 95% CI .67-1.24).

Hofmann et al. (2010) conducted a meta-analysis of MBT for anxiety and depression. For anxiety, a medium effect size (Hedges's g = 0.63; 95% CI 0.53-0.73) was found. A large effect size (Hedges's g = 0.97; 95% CI 0.73-1.22) was found including only those studies with populations meeting criteria for an anxiety disorder. Zhang et al (2015) conducted a meta-analysis of MBT for anxiety and depression in patients with cancer. For anxiety, a medium effect size was found (SMD = -0.75;, 95% CI -1.28 to -.0.22).

Piet et al. (2012) conducted a meta-analysis of MBT for adult cancer patients and survivors examining anxiety and depression. A medium effect size was found for non-randomized studies (Hedges's g = 0.60; 95% CI 0.39-0.80) and a small effect size was found for randomized controlled trials (Hedges's g = 0.37; 95% CI 0.24-0.50). Bohlmeijer et al. (2010) conducted a meta-analysis of randomized controlled trials (RCTs) using Mindfulness Based Stress Reduction (MBSR) on the mental health of adults with chronic medical diseases. They found a small effect size on anxiety (Hedges's g = 0.47; 95% CI 0.11-0.83), which was moderated by quality of study, with the effect size decreasing once lower quality studies were excluded (Hedges's g = 0.24; 95% CI 0.10-0.38).

For Chigong and Tai Chi, medium and small effect sizes on anxiety have been found. Yin and Dishman (2014) conducted a meta-analysis on Tai Chi and Qigong for depression and anxiety. They found a medium effect size of Qigong on anxiety (Hedges's d = 0.72; 95% CI 0.4 – 1.03) and a small effect size of Tai Chi on anxiety (Hedges's d = 0.34; 95% CI 0.02-0.66), with a larger reduction in symptoms found for Asian participants. Wang et al. (2014) conducted a meta-analysis on Tai Chi for depression, anxiety, and psychological well-being. Given

substantial differences in study design, a meta-analysis was not performed on the anxiety outcomes. A meta-analysis was conducted on depression outcomes, which revealed a large effect size (ES = -5.97; 95% CI -7.06 to -4.87).

In terms of relaxation, Manzoni et al (2008) conducted a meta-analysis of relaxation training for anxiety. They found a medium effect size for the within-group analysis (Cohen's d = 0.57; 95% CI .52-.68) and the between-group analysis (Cohen's d = .51; 95% CI 0.46-0.634). Bandelow et al. (2015) conducted a meta-analysis of RCTs for participants who met criteria for an anxiety disorder, and found a large effect size for relaxation (Cohen's d = 1.36; 95% CI 1.08 – 1.64).

Since yoga practice involves a movement component, it is interesting to note that meta-analyses on exercise and anxiety have shown significant effect sizes (Ensai, 2015; Petruzzello, 1991). In addition, studies have also demonstrated that mood can be improved through mindful exercise without an aerobic component (Berger, 1992).

Theories of Change – Yoga and Anxiety

On a physiological level, anxiety can be viewed as an over-activation of the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic nervous system (SNS). The activation of these systems results in the release of cortisol and the catecholamine neurotransmitters (specifically dopamine, epinephrine, and norepinephrine). 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 the perceived threat (Reimold, 2011).

Yoga may help to shift from the 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-Galser, 2010). Yoga has been shown to decrease cortisol levels (West, 2004; Vadiraja,

2009) and to decrease many outcomes of HPA and SNS activation, such as heart rate (Satyapriya, 2009) and blood pressure (Innes, 2005). This relaxation response may be activated through yoga's use of slow movements and steady deep breathing (Benson, 1975; Jareth, 2015). Yoga has been shown to increase GABA levels (Streeter, 2010); anxiety is also associated with decreased levels of the neurotransmitters GABA and serotonin.

Another way to understand how yoga acts on anxiety is through examining how the mindfulness component of yoga works. Mindfulness-based treatment approaches, including Mindfulness-Based Stress Reduction (MBSR), Mindfulness-Based Cognitive Therapy (MBCT), and Acceptance and Commitment Therapy (ACT), encourage bringing attention to present moment experience (i.e., thoughts, feelings, body sensations) in a non-judgmental way. Through this way of attending to present moment experience, mindfulness seeks to shift a person's relationship to their experience. By noticing the transience of one's experience (e.g., thoughts), a person becomes less identified with their experience. In this way, mindfulness practice can be thought of as a form of exposure, encouraging individuals to sit with their discomfort rather than to avoid or attempt to remove it (Baer, 2003; Hayes, 2006). In ACT, this sitting with experience is called "acceptance." Therefore, a person who is experiencing anxiety and practicing mindfulness exposes themselves to the components of the anxiety experience (e.g., body tension, racing heart rate, catastrophic thoughts) without reacting, rather staying with these body sensations and thoughts, and noticing how they shift and change. In this way, the person eventually becomes less identified with these body sensations and thoughts, and recognizes that they are not a statement of truth or a stable part of one's personality, but rather a transitory experience (Hayes, 2010).

Yoga practice involves mindfulness while moving through physical poses. As with sitting mindfulness practice, a person stays open to all aspects of their experience (i.e., body sensations, thoughts, feelings), whether they are labeled by the mind as "pleasant," "unpleasant," or "neutral." However, in yoga this mindfulness is taking place as the person moves through physical poses. Therefore, yoga can be thought of as an "embodied mindfulness" or "mindfulness in motion" (Salmon, 2009).

The mechanisms through which yoga acts can also be understood in the context of cognitive behavioral therapy (CBT). CBT also involves an exposure component, though this exposure component is different from the acceptance component in mindfulness-based approaches. Whereas in mindfulness one stays with an experience to learn that thoughts and feelings are impermanent and not a stable aspect of the self, CBT uses exposure (i.e., systematic behavioral exposure) to feared or avoided situations in order to unlearn the link between the stimulus and the feared result (Beck, 2011). One could argue that exposing oneself to the physical sensations of anxiety in the body (e.g., muscle tension, racing heart) while practicing yoga is a kind of systematic exposure.

Another component of change is the issue of cultural fit or acceptability. Research has shown the importance of cultural fit for the effectiveness of psychotherapy, with more robust outcomes occurring when the explanation of the causes of illness is in alignment with the patient's beliefs (Benish, 2011). There is widespread acceptability of yoga as a healing modality in India, and it continues to be incorporated into the fabric of the culture (Najar, 2015). Therefore, not surprisingly, much recent research on yoga has been performed in India.

Purpose of the Study

The purpose of this study was to quantitatively assess: 1) What is the overall effect size of yoga on anxiety? Among studies in which anxiety was measured as an outcome, what is the overall effect size of yoga across all outcomes? 2) What is the effectiveness of yoga across sub categories of outcome types (e.g., non-anxiety mental health, physical health, biological measures)? 3) Which moderators increase yoga's effectiveness? Specifically in what form and for whom (e.g., treatment length, population) is yoga most helpful? These results can inform the treatment of both clinical and subclinical anxiety as well as enrich our understanding of yoga-based interventions and anxiety.

Method

Inclusion and Exclusion Criteria

For inclusion in this study, an article must have been published in a peer-reviewed journal in English. Conference papers and unpublished dissertations were excluded. All participants in the study needed to be 18 years of age or older. The study needed to be a randomized controlled trial that used yoga as an intervention and measured anxiety as an outcome. The yoga intervention needed to include an active yoga asana component as the primary component of the intervention. 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. The asana component needed to be equal to or longer than the other components of the yoga class. This included adding the asana and loosening components together, since loosening exercises are preparatory exercises for asana practice. The study needed to use a questionnaire that specifically measured anxiety (e.g., State-Trait Anxiety Inventory, Beck Anxiety Inventory) rather than a combined concept (e.g., Profile of Mood States "Tension/Anxiety" Scale, General Health Questionnaire "Anxiety and Insomnia" Domain).

Interventions that involved multiple components and for which only one part was yoga, were eliminated (e.g., intervention group received combined cognitive behavioral therapy and yoga), unless the other component was received by all groups (i.e., both intervention and control).

While anxiety 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 sub-groups of dependent variables of interest. Biological measures whose directional meaning was ambiguous out of context (i.e., whether higher is more desirable or lower is more desirable) were eliminated (e.g., Log SDNN, Log RMSSD, pNN50, EI Ratio, 3015 Ratio).

Search Strategies

A systematic search for published articles on yoga and anxiety was conducted in June and July 2014 across eight electronic databases (PsychINFO, 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, and to test for potential moderations. These moderators included sample mean age, percentage female, total treatment time, study year, number of participants, percentage racial or ethnic minority (for United States based studies only), percent drop out, control group type (i.e., active vs. non-active), study location (India, US, or elsewhere), sample origin (i.e., clinical or subclinical vs. non-clinical), sample origin (healthy vs. not healthy – having a medical or psychological, clinical or subclinical, issue), administrator (recording vs.

experienced vs. trained for study or not specified), and type of treatment (Unspecified Hatha yoga vs. Iyengar yoga vs. other). As the primary interest was on the effect of yoga on anxiety, changes in anxiety as a moderator of changes in other outcomes (as has been done examining mindfulness-based interventions, e.g., Khoury et al., 2013) was also examined.

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 post-test means and standard deviations.

Data Analysis

Effect sizes were computed in the same metric as Cohen's (1988) *d*, although they technically match Becker's (1988) *del* most closely. Specifically, pre-post 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*, yielding an effect size equivalent to Becker's *del*. The variance of this final effect size was computed by summing the variance of *g* for the two groups. As readers are most familiar with Cohen's *d*, and since *del* is in the same units as *d*, the effect size is referred to as *d*. For studies lacking pre- and post-test 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 (1994) 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 metafor packages (Del Re & Hoyt, 2010; Viechtbauer, 2010) based on recommended procedures (Hedges & Olkin, 1985; Cooper et al., 2009) using restricted maximum likelihood estimation, 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.

Primary omnibus analyses were conducted for anxiety outcomes alone as well as for all outcomes combined. Further, several additional sub-omnibus analyses were conducted for aggregated sub-groupings of outcomes of interest. These groups included biological measures, non-anxiety mental health measures, physical health measures, stress, physical and mental health outcomes combined, measures of regulation (e.g., fatigue, sleep, attention), social functioning (e.g., social support, relationship quality), life satisfaction, mindfulness and related constructs (e.g., self-compassion). An additional sub-omnibus included outcomes that did not fit any of these categories (e.g., burnout, pregnancy-specific outcomes).

Moderator tests were conducted using two distinct methods. For categorical moderators, a weighted least squares approach was used (Hedges & Olkin, 1985; Borenstein, Hedges,

Higgins, & Rothstein, 2009) employing the MAd package (Del Re & Hoyt, 2010). For continuous moderators, meta-regression was conducted using restricted maximum likelihood (REML) estimation found in the metafor package (Viechtbauer, 2010).

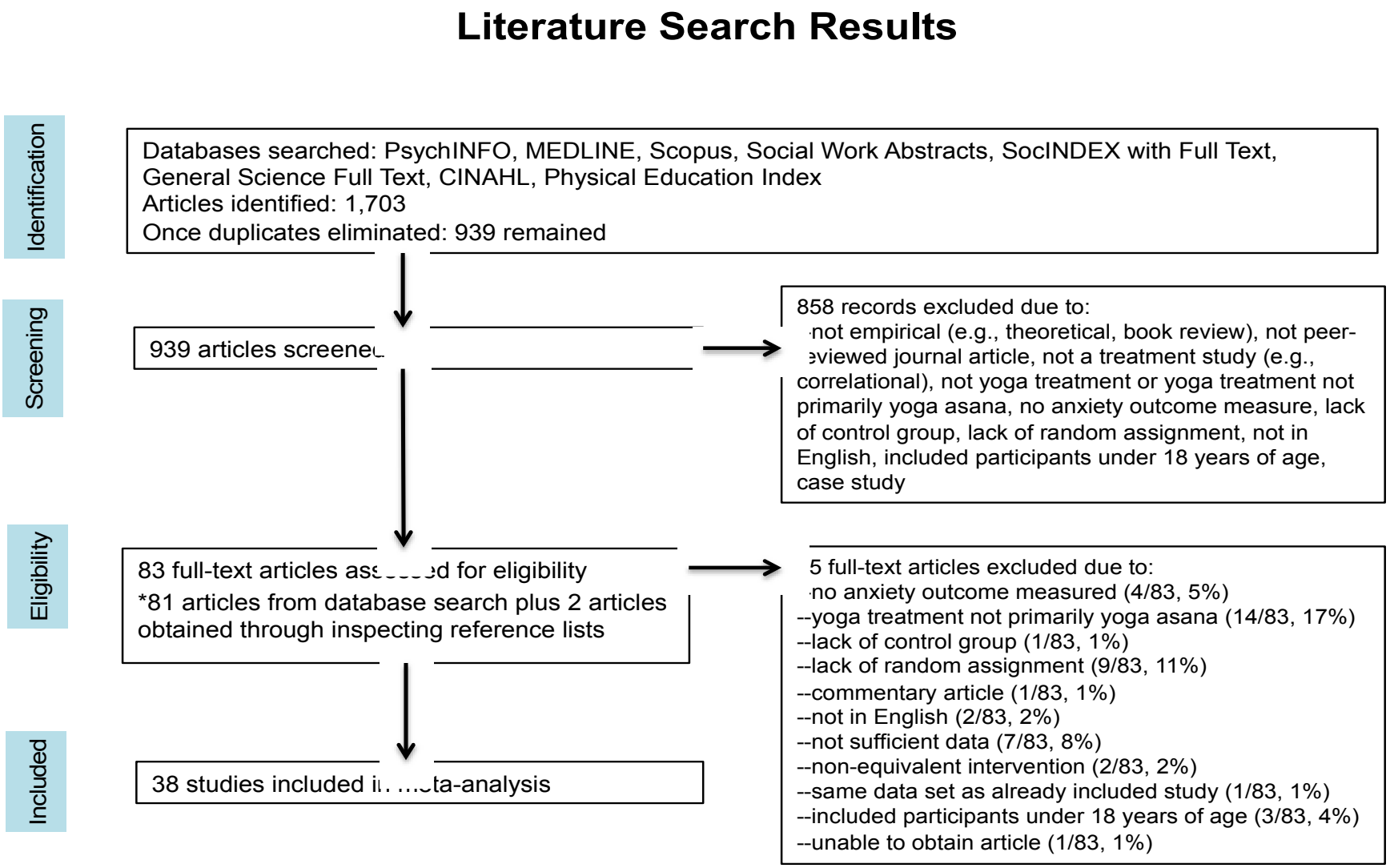
Publication bias. In order to assess potential publication bias, a funnel plot was constructed using the metafor package (Viechtbauer 2010).

Results

Literature Search Results

1,703 articles were identified across the eight databases. Once duplicates were eliminated 939 articles remained. 858 articles were eliminated through examining their title and abstract. These 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, non-equivalent intervention, same data as already included study, included participants under 18 years old, or unable to access full text of article. 38 articles remained for inclusion in the meta-analysis (Figure 1).

Fig. 1 Literature Search Results



Overview of the Literature

Of the 38 studies, 11 included participants who had clinical or subclinical psychological symptoms. Specifically, 2 studies included participants who met criteria for an anxiety disorder, 3 studies had participants who met criteria for a depression diagnosis, and 6 studies included participants with elevated, though sub-clinical, symptoms. 14 of the studies involved participants identified due to a physical condition (e.g., cancer, insomnia). Therefore, of the 38 studies, 25 involved "not healthy" participants due either to a mental or physical condition. 17 of the studies included only females and 2 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 (29) used a otherwise unspecified form of hatha yoga, 7 studies used Iyengar yoga, and 2 studies used another form of yoga (i.e., Kirpalu, Medical Yoga) (Table 1).

Table 1. Overview of Included Studies

id	Author	Year	Control Type	n	Location	Yoga Type	Sample Origin	Measures
1	Afonso	2012	No intervention, active	44	Brazil	Hatha	Medical-insomnia	BAI, BDI, KMI, ISI, MSQOL, ISSL
2	Ahmadi	2013	Waitlist, active	31	Iran	Hatha	Medical-MS	BAI, BDI, FFS, Balance, Walk Time, Walk Distance
3	Bock	2010	Active	55	United States	Hatha	Medical-smokers	STAI, CESD, SF-36, SST
4	Bowden	2012	Active	33	England	Iyengar	Healthy	DASS, Cortisol, SVS, MAAS, PSQI, ISQ, 2-Back, TAS
5	Call	2013	Waitlist, active	91	United States	Hatha	Psych -- worry	DASS, PHLMS
6	Chan	2012	Active	14	Australia	Hatha	Medical-stroke	STAI, GDS
7	Chandwani	2010	Waitlist	58	United States	Hatha	Medical-breast cancer	STAI, CESD, BFI, PSQI, IES, BFS, SF36
8	Cheema	2013	No intervention	37	Australia	Hatha	Healthy	STAI, JIG, SF-36, HR, Physical Fitness
9	Danucalov	2013	Waitlist	46	Brazil	Hatha	Caregivers	BAI, BDI, Cortisol
10	Dhananjai	2013	Active	272	India	Hatha	Medical- obese	Hamilton Anxiety, Hamilton Depression, Weight, BMI, Waist, Hip
11	Donesky-Cuenco	2009	No intervention	29	United States	Iyengar	Medical-COPD	STAI, CESD, 6 minute walk
12	Ebnezer	2012	Active	235	India	Hatha	Medical-Osteoarthritis	STAI, NRS, Stiffness, BP
13	Field	2012	No intervention, active	84	United States	Hatha	Psych-prenatal dep	STAI, CESD, STAXI, Relationships, Pain
14	Field	2012	Active	79	United	Hatha	Psych-prenatal	STAI, CESD, EPDS, POMS, STAXI,

id	Author	Year	Control Type	n	Location	Yoga Type	Sample Origin	Measures
					States		dep	Relationships, Pain
15	Gupta	2013	Active	12	India	Hatha	Psych-GAD	HADS Anxiety
16	Immink	2014	Waitlist	22	Australia	Hatha	Medical-Hemiparesis	STAI, GDS, MAS, BBS, 2MWD, CGS, SIS
17	Innes	2011	Active	18	United States	Iyengar	Medical-RLS	STAI, POMS, PSQI, Sleep, PSS, DSSI, HR, BP, Waist, Weight, BMI
18	Javnbakht	2009	Waitlist	65	Iran	Iyengar	Healthy-female	STAI
19	John	2007	Active	65	India	Hatha	Medical-Migraine	HADS, Migraine Freq and Intensity, SF-MPQ
20	Kanojia	2013	No intervention	50	India	Hatha	Healthy-female	DIPAS anxiety, DIPAS dep, DIPAS well-being, weight, HR, BP
21	Kinser	2013	Active	18	United States	Hatha	Psych-depression	STAI, PHQ, PSS, RRS, Brief Symptom Inventory
22	Kohn	2013	No intervention	37	Sweden	Medical	Psych-Stress	HADS anxiety, HADS depression, PSS, SMBQ, ISI, EQ_VAS, HR, BP
23	Malathi	1999	No intervention	50	India	Hatha	Healthy-Students	STAI
24	Michalsen	2012	Waitlist	62	Germany	Iyengar	Psych-Stress	STAI, CESD, CPSS, BSI, Bf-S Zerssen, POMS, SF36, Pain, FBL
25	Mitchell	2014	No Intervention	38	United States	Kripalu	Psych-PTSD	STAI, CESD, PCL
26	Newham	2014	No intervention	45	United Kingdom	Hatha	Healthy-Pregnant	STAI, EPDS, WDEQ
27	Oken	2004	Waitlist, active	57	United States	Iyengar	Medical-MS	STAI, CESD, POMS, SF36, MFI, Cognitive Functioning, SSS, Fitness
28	Ranjbar	2013	No intervention	40	Iran	Hatha	Psych-OCD	BAI, Y-BOCS
29	Rocha	2012	Active	36	Brazil	Hatha	Healthy-Army	BAI, BDI, LSSI, Memory, Cortisol

id	Author	Year	Control Type	n	Location	Yoga Type	Sample Origin	Measures
30	Satyapriya	2013	Active	96	India	Hatha	Healthy - pregnant	STAI, HADS anxiety, HADS depression, PEQ, BP
31	Shankarapillai	2012	Active	100	India	Hatha	Healthy-students	STAI, VAS Anxiety
32	Smith	2007	Active	122	Australia	Hatha	Psych-stress	STAI, GHQ, SF-36
33	Stoller	2012	No intervention	70	United States	Hatha	Healthy-military	STAI, AASP
34	Telles	2010	Waitlist	22	India	Hatha	Flood survivors	VAS, Heart Rate, Breath Rate
35	Toise	2014	No intervention	46	United States	Hatha	Medical-ICD	FSAS, CESD, FPAS, PHE, STPI, SEC, SCS, IPS
36	Vadiraja	2009	Active	75	India	Hatha	Medical-Breast Cancer	HADS Anxiety, HADS Depression PSS, Cortisol
37	Varambally	2013	Waitlist	18	India	Hatha	Caregivers	HADS Anxiety, HADS Depression, WHOQOL, BAS
38	Woolery	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; 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.

Analyses of Overall Effects

Table 2 reports results from both omnibus analyses and all sub-omnibus 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], $p < .001$) (Figure 2). Significant heterogeneity was likewise noted between these studies (Q [37] = 346.17, $p < .001$, I^2 = 90.88%). Across all outcome measures combined, a moderate effect was noted in the yoga group relative to the control (d = 0.59, 95% CI [0.38, 0.79], $p < .001$) again with significant between-study variability in outcomes (Q [37] = 240.96, $p < .001$, I^2 = 86.42%). In sub-omnibus analyses, statistically significant effects of the yoga intervention were also detected on biological measures (d = 0.45, *CI* [0.02, 0.89]), non-anxiety mental health outcomes (d = 0.55, *CI* [0.28, 0.81]), physical health measures (d = 0.45, *CI* [0.15, 0.75]), stress (d = 1.00, *CI* [0.28, 1.72]), mental and physical health outcomes combined (d = 0.65, *CI* [0.44, 0.86]), and life satisfaction (d = 0.29, *CI* [0.07, 0.52]). Effects on regulation, social functioning, mindfulness and related constructs, and outcomes that could not be categorized did not differ significantly from zero.

Table 2. Omnibus and sub-omnibus analyses for effects of yoga interventions

Outcome Type	*k*	*d* [95% *CI*]	*SE*	*z*	*p*	*Q*	*Qp*	I^2
All outcomes combined	38	0.59 [0.38,0.79]	0.10	5.6	<.001	240.96	< .001	86.42
Anxiety	38	0.80 [0.49,1.1]	0.15	5.17	<.001	346.17	< .001	90.88
Biological Measures	12	0.45 [0.02,0.89]	0.22	2.03	.042	56.18	< .001	87.99
Other Mental Health	29	0.55 [0.28,0.81]	0.14	4.06	<.001	143.65	< .001	83.9
Physical Health	18	0.45 [0.15,0.75]	0.15	2.96	.003	109.72	< .001	87.27
Stress	13	1.00 [0.28,1.72]	0.37	2.73	.006	89.64	< .001	93.69
Clinical outcomes combined	38	0.65 [0.44,0.86]	0.11	6.00	<.001	243.72	< .001	86.7
Regulation	10	0.16 [-0.01,0.34]	0.09	1.87	.062	7.97	.537	0.00
Social Functioning	5	0.11 [-0.14,0.35]	0.13	0.84	.403	2.14	.710	0.00
Life Satisfaction	14	0.29 [0.07,0.52]	0.12	2.52	.012	32.28	.002	62.74
Other	6	0.29 [-0.12,0.70]	0.21	1.37	.170	15.82	.007	66.9
Mindfulness, Self-Compassion	4	0.22 [-0.24,0.67]	0.23	0.94	.349	8.18	.042	66.04

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

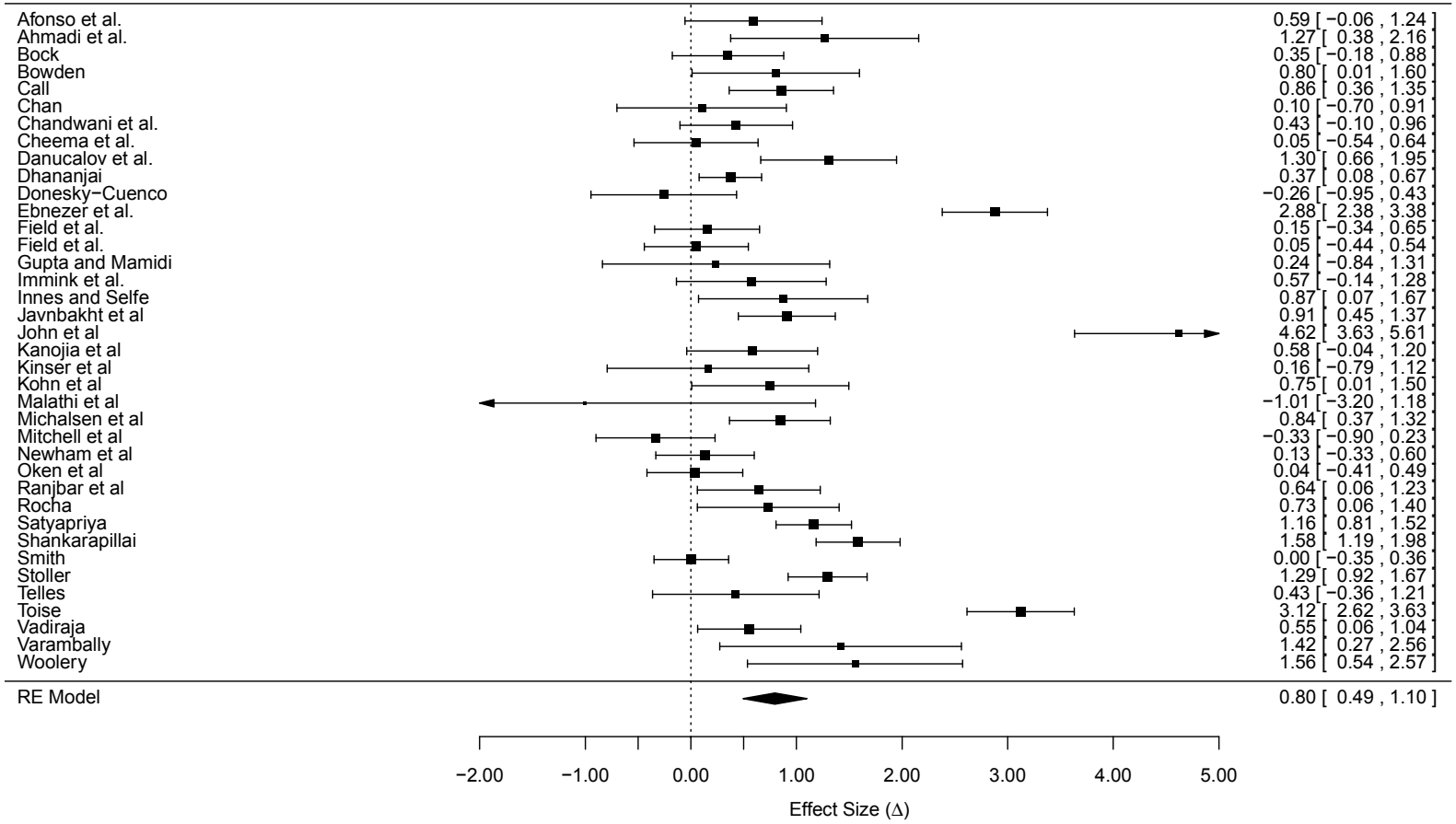


Figure 2. Forest plot displaying mean *d* effect sizes with 95% confidence intervals for individual studies and omnibus effect on anxiety outcomes. The size of boxes are proportional to each study's weight in the omnibus analysis.

Due to the high level of heterogeneity, outliers were identified for the omnibus and sub-omnibus analyses and excluded, and then the analyses were rerun. With outlier studies excluded, yoga's effect on anxiety continued to be significant and in the moderate range (d = 0.57, 95% CI [0.39, 0.74], p < .0001). Across all outcome measures combined, yoga's effect continued to be significant and in the moderate range (d = 0.53, 95% CI [0.35, 0.70], p < .0001). In addition, non-anxiety mental health (d = 0.45, 95% CI [0.25, 0.65], p < .0001), physical health (d = 0.34, 95% CI [0.13, 0.54], p = .0012), stress (d = 0.71, 95% CI [0.20, 1.23], p = .0068), and clinical outcomes combined (d = 0.59, 95% CI [0.41, 0.77], p < .0001) were still significant. Biological measures were no longer significant (p = .0596), and depression became significant (d = 0.48, 95% CI [0.25, 0.71], p <.0001). There were no outliers for regulation, social functioning, life satisfaction, mindfulness, and other dependent variable categories (Table 3).

Table 3. Omnibus and sub-omnibus analyses for effects of yoga interventions with outliers excluded

Outcome Type	*k*	*d* [95% *CI*]	*SE*	*z*	*p*	*Q*	*Qp*	I^2
Anxiety	35	0.57 [0.39, 0.74]	0.09	6.38	<.0001	120.07	< .0001	69.24
All outcomes combined	37	0.53 [0.35, 0.70]	0.09	6.02	<.0001	179.12	< .0001	79.90
Biological Measures	11	0.30 [-0.01, 0.61]	0.16	1.88	.06	36.15	< .0001	75.13
Other Mental Health	28	0.45 [0.25, 0.65]	0.10	4.45	<.0001	94.54	< .0001	70.34
Physical Health	17	0.34 [0.13, 0.54]	0.10	3.24	.0012	56.14	< .0001	70.69
Stress	12	0.71 [0.20, 1.23]	0.26	2.70	.0068	64.12	< .0001	87.75
Clinical outcomes combined	37	0.59 [0.41, 0.77]	0.09	6.41	<.0001	185.91	< .0001	81.00
Depression	25	0.48 [0.25, 0.71]	0.12	4.13	<.0001	86.60	<.0001	70.58

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

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, first predicting anxiety outcomes alone and then predicting overall effect (i.e., all outcomes combined).

Seven continuous moderators were tested including sample mean age, percentage female, total treatment time, study year, number of participants, percentage racial or ethnic minority (for United States based studies only), and percent drop out as predictors of variation in intervention effects on anxiety. None of these study-level characteristics were found to impact effect on anxiety (Table 4). In addition, nine categorical moderators were tested including control group type (i.e., waitlist, active, and waitlist and active), control group type (waitlist vs. active), study location (India vs. outside India), study location (India, US, or elsewhere), sample origin (i.e., clinical or subclinical vs. non-clinical), sample origin (healthy vs. not healthy – having a medical or psychological, clinical or subclinical, issue), administrator (tape vs. experienced vs. trained for study or not specified), treatment type (unspecified Hatha yoga vs. Iyengar yoga vs. other), treatment type (unspecified Hatha yoga vs. Iyengar yoga). Only location was found to significantly moderate effects, with the largest intervention effects found in studies taking place in India vs. outside of India (d = 1.26 vs. d = 0.62) (Q-between [1] = 4.046, p = .044) (Table 5).

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	0.61	0.0043	[-0.018, 0.027]	0.37	.709
Anxiety Only	% Female	37	1.33	-0.0066	[-0.016, 0.0032]	-1.33	.185
Anxiety Only	Total treatment time	36	0.81	0.0005	[-0.014, 0.015]	0.066	.948
Anxiety Only	Study year	38	0.58	0.018	[-0.091, 0.13]	0.32	.746
Anxiety Only	N	38	0.58	0.0034	[-0.0021, 0.0090]	1.20	.228
Anxiety Only	REM	10	1.17	-0.016	[-0.037, 0.0052]	-1.48	.139
Anxiety Only	Drop out	29	1.18	0.027	[-0.071, 0.017]	-1.21	.227
All Outcomes	Age	36	0.94	-0.0084	[-0.023, 0.0065]	-1.11	.269
All Outcomes	% Female	37	0.89	-0.0039	[-0.011, 0.0029]	-1.11	.266
All Outcome	Total treatment time	36	0.46	0.0064	[-0.0033, 0.016]	1.29	.196
All Outcomes	Study year	38	0.66	-0.0058	[-0.083, 0.071]	-0.15	.882
All Outcomes	N	38	0.43	0.0025	[-0.0012, 0.0061]	1.32	.186
All Outcomes	REM	10	0.42	-0.0044	[-0.0088, -0.0000]	-1.96	.0495
All Outcomes	Drop out	29	0.64	-0.010	[-0.038, 0.017]	-0.75	.451

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)

Table 5. Categorical moderators for anxiety outcomes alone

Outcome	Moderator variable	*k*	*d*	95% *CI*	*Q*	*df*	*p*
Anxiety only	Control type				0.85	2	.655
	Waitlist	18	0.74	[0.32, 1.16]	138.36	17	<.001
	Waitlist and Active	5	0.56	[-0.22, 1.34]	10.57	4	.032
	Active	15	0.95	[0.49, 1.40]	189.40	14	< .001
Anxiety only	Control Type				0.40	1	.526
	Waitlist	18	0.74	[0.30, 1.18]	138.36	17	< .001
	Active	15	0.95	[0.47, 1.42]	189.40	14	< .001
Anxiety only	Location				4.046	1	.044
	India	11	1.26	[0.73, 1.78]	143.67	10	< .001
	Outside India	27	0.62	[0.30, 0.95]	175.30	26	< .001
Anxiety only	Location				3.93	2	.140
	US	13	0.64	[0.17, 1.11]	144.36	12	< .001
	India	11	1.26	[0.72, 1.79]	143.67	10	< .001
	Other	14	0.61	[0.16, 1.07]	28.84	13	.007
Anxiety only	Sample origin				2.869	1	.09
	Non-clinical	27	0.95	[0.62, 1.27]	285.14	26	< .001
	Clinical or subclinical	11	0.43	[-0.073, 0.93]	27.219	10	.002
Anxiety only	Sample origin				0.001	1	.97
	Healthy	13	0.80	[0.32, 1.29]	43.73	12	< .001
	Not Healthy	25	0.79	[0.45, 1.14]	293.69	24	< .001
Anxiety only	Administrator				0.25	2	.884
	Tape	1	0.86	[-0.86, 2.57]	0.00	0	1
	Experienced	28	0.74	[0.41, 1.08]	218.23	27	< .001
	Trained or NS	8	0.92	[0.28, 1.57]	114.064	7	< .001
Anxiety only	Treatment Type				0.34	1	.56
	Hatha	29	0.87	[0.55, 1.20]	308.40	28	< .001
	Iyengar	7	0.65	[-0.003, 1.31]	18.65	6	< .001

Anxiety only	Treatment Type				1.35	2	.51
	Hatha	29	0.87	[0.55, 1.20]	308.40	28	<.001
	Iyengar	7	0.66	[-0.001, 1.31]	18.65	6	.005
	Other	2	0.19	[-1.034, 1.41]	5.22	1	.022

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).

These same seven continuous moderators and nine categorical moderators were tested as predictors of overall intervention effect (i.e., across all outcomes combined). Again, only location was found to significantly moderate effects with the largest intervention effects noted in studies originating from India, both comparing India vs. outside India (d = 1.07 vs. d = 0.40) (Q-between [1] = 13.16, p = .000), (d = 1.07) and comparing India vs. US vs. elsewhere (d = 1.07 vs. 0.3 vs. 0.5) (Q-between [2] = 13.84, p = .001), (d = 1.07). The remaining moderators did not explain significant between-study variation in effects (Tables 4 and 6).

Table 6. Categorical moderators for all outcomes combined

Outcome	Moderator variable	*k*	*d*	95% *CI*	*Q*	*df*	*p*
All outcomes	Control type				3.33	2	.189
	Waitlist	18	0.51	[0.22, 0.79]	53.34	17	<.001
	Waitlist and Active	5	0.28	[-0.23, 0.79]	2.99	4	0.56
	Active	15	0.79	[0.48, 1.088]	164.043	1	< .001
All outcomes	Control Type				1.54	1	.214
	Waitlist	18	0.51	[0.20, 0.81]	53.34	17	< .001
	Active	15	0.79	[0.46, 1.11]	164.043	14	< .001
All outcomes	Location				13.163	1	< .001
	India	11	1.07	[0.76, 1.37]	77.94	10	< .001
	Outside India	27	0.40	[0.21, 0.59]	78.67	26	< .001
All outcomes	Location				13.84	2	.001
	US	13	0.3	[0.03, 0.57]	22.2	12	.035
	India	11	1.07	[0.76, 1.38]	77.94	10	< .001
	Other	14	0.5	[0.23, 0.77]	54.56	13	< .001
All outcomes	Sample origin				3.47	1	.062
	Non-clinical	27	0.70	[0.48, 0.91]	183.62	26	< .01
	Clinical or subclinical	11	0.31	[-0.028, 0.65]	21.16	10	.02
All outcomes	Sample Origin				2.088	1	0.149
	Healthy	13	0.79	[0.45, 1.12]	66.31	12	< .001
	Not Healthy	25	0.49	[0.26, 0.72]	158.87	24	< .001
All outcomes	Administrator				0.78	2	.68
	Tape	1	0.43	[-0.70, 1.57]	0.00	0	1
	Experienced	28	0.51	[0.29, 0.74]	166.68	27	< .001
	Trained or NS	8	0.73	[0.28, 1.18]	57.83	7	< .001
All outcomes	Treatment Type				0.51	1	.48
	Hatha	29	0.66	[0.43, 0.88]	208.53	28	< .001
	Iyengar	7	0.47	[0.022, 0.92]	16.61	6	.011
All outcomes	Treatment Type				2.63	2	.269
	Hatha	29	0.66	[0.43, 0.88]	208.53	28	< .001
	Iyengar	7	0.47	[0.024, 0.92]	16.60	6	.011
	Other	2	-0.020	[-0.86, 0.82]	3.02	1	.082

Note: "all outcomes" includes all outcome measures in all studies, this includes measures of: anxiety, biology (e.g., heart rate), other mental health (e.g., depression), physical health, stress, regulation, social functioning, life satisfaction, mindfulness, self-compassion, pregnancy specific outcomes, *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).

To further examine the moderation by location finding, moderation was tested for each dependent variable type (e.g., physical health, life satisfaction). Significant moderation by location (India vs. Everywhere else) was found for mental health (not anxiety) (Q-between [1] = 11.91, p = .001) (d = 1.154 vs. d = 0.332), physical health (Q-between [1] = 12.12, p = .000) (d = 1.003 vs. d = 0.153), life satisfaction (Q-between [1] = 12.58, p = .000) (d = 1.00 vs. d = .13), clinical outcomes (Q-between [1] = 7.35, p = .007) (d = 1.052 vs. d = .50). Non-significant moderation by location was found for biological measures, stress, and regulation. Moderation by location could not be run for social functioning, mindfulness, and other outcomes categories because no studies from India measured this outcome type (Table 7).

Table 7. Moderation by Location Across Dependent Variable Categories

Outcome	Moderator variable	*k*	*d*	95% *CI*	*Q*	*df*	*p*
All Outcomes	Location				13.163	1	<.001
	India	11	1.068	[0.761, 1.374]	77.936	10	<.001
	Not India	27	0.402	[0.214, 0.590]	78.671	26	<.001
Anxiety	Location				4.046	1	.044
	India	11	1.257	[0.730, 1.784]	143.671	10	<.001
	Not India	27	0.623	[0.301, 0.946]	175.297	26	<.001
Biological Measures	Location				0.961	1	0.327
	India	5	0.610	[0.111, 1.108]	15.351	4	.004
	Not India	7	0.268	[-0.199, 0.735]	31.579	6	<.001
Mental Health	Location				11.91	1	<.001
	India	7	1.154	[0.748, 1.559]	54.002	6	<.001
	Not India	22	0.332	[0.101, 0.563]	39.624	2	.008
Physical Health	Location				12.117	1	<.001
	India	6	1.003	[0.617, 1.388]	60.834	5	<.001
	Not India	12	0.153	[-0.131, 0.436]	8.179	11	.697
Stress	Location				0.065	1	.798
	India	2	0.769	[-0.490, 2.028]	0.843	1	.359
	Not India	11	0.950	[0.368, 1.532]	85.782	10	<.001
Regulation	Location				0.178	1	0.673
	India	1	0.332	[-0.464, 1.128]	0.000	0	1.000
	Not India	9	0.157	[-0.021, 0.334]	7.791	8	0.454
Life Satisfaction	Location				12.584	1	<.001
	India	3	0.992	[0.550, 1.434]	8.027	2	0.018
	Not India	11	0.133	[-0.041, 0.307]	8.467	10	0.583
Clinical	Location				7.347	1	0.007
	India	11	1.052	[0.711, 1.393]	79.044	10	<.001
	Not India	27	0.498	[0.287, 0.708]	106.698	26	<.001

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).

In addition, the percentage of effect sizes measured for each dependent variable type was compared for studies conducted in India versus outside India in order to determine if there were significant differences in type of outcomes measured (Table 8). Differences in types of outcomes measures were observed for physical health measures (42.62% vs. 22.04%), regulation (1.64% vs. 8.57%), and life satisfaction (6.56% vs. 17.14%) for India vs. outside India respectively.

Table 8. Indian Studies: Number of Effect Sizes for Each Outcome Type

Number	Study	Total ES	Anxiety	Other Mental	Physical	Stress	Regulation	Social	Life Satisfaction	Mindfulness	Other
1	Dhanajai	7	1	1	5						
2	Ebnezar	7	2		5						
3	Gupta	1	1								
4	John	9	1	1	7						
5	Kanojia	14	1	2	6	4			1		
6	Malathi	1	1								
7	Satyapriya	7	3	1	2				1		
8	Shankarpillai	2	2								
9	Telles	5	1	2	1		1				
10	Vadiraja	4	1	1		2					
11	Varambally	4	1	1					2		
	Total # of ES:	61	15	9	26	6	1	0	4	0	0
	% of Total Effect Size:		24.59	14.75	42.62	9.84	1.64	0	6.56	0	0

Table 8 cont. Outside India: Number of Effect Sizes for Each Outcome Type

Number	Study	Total ES	Anxiety	Other Mental	Physical	Stress	Regulation	Social	Life Satisfaction	Mindfulness	Other
1	Afonso	8	1	1	1	3	1		1		
2	Ahmadi	6	1	1	3		1				
3	Bock	4	1	1					2		
4	Bowden	10	1	1	2	2	1			2	1
5	Call	4	1			1				2	
6	Chan	3	2	1							
7	Chandwani	9	1	3			2		2	1	
8	Cheema	9	2		5				2		
9	Danucalov	3	1	1		1					
10	Donesky-Cuenco	23	1	1	16				7		
11	Field_BMT	8	1	2	4			1			
12	Field_YPT	11	1	4	2	1	2	1			
13	Immink	13	2	1	4				6		
14	Innes	14	2	1	6	1	2	2			
15	Javnbakht	2	2								
16	Kinser	6	1	2		1		2			
17	Kohn	9	1	1	3	1	1		1		1
18	Michalsen	13	2	6	1	1			3		
19	Mitchell	4	3	1							
20	Newham	4	2	1							1
21	Oken	46	2	7	7		7		9		14
22	Ranjbar	2	2								
23	Rocha	7	1	1		1					4
24	Smith	10	1	1					8		
25	Stoller	6	2				4				
26	Toise	8	1	3				1	1	1	1
27	Woolery	3	1	1		1					
	Total # of ES:	245	39	42	54	14	21	7	42	6	22
	% of Total Effect Size:		15.92	17.14	22.04	5.71	8.57	2.86	17.14	2.45	8.96

To further examine the moderation by location finding, a meta-regression was conducted with India as the dummy variable and the other predictors added to the model. For anxiety outcomes, the first model had three predictors: (1) sample origin -- non-clinical vs. clinical or subclinical (2) control type (3) location -- India vs. outside India. This model did not explain a significant amount of variability (QM (df = 4) = 4.54, k = 38, p = .34, I^2 = 90.31%), and the amount of variance unaccounted for was more than would be expected by chance (QE (df = 33) = 296.81, p < .0001). This indicates that there is likely another unaccounted for moderator. For anxiety outcomes, the second model had six predictors: (1) sample origin, (2) control type, (3) mean age, (4) percentage female, (5) treatment length, (6) location. This model accounted for less variability than the previous model with three predictors (QM (df = 7) = 5.11, k = 33, p = .65, I^2 = 91.65%; QE (df = 25) = 217.20, p < .0001). This appears to be due to the fact that fewer studies were included (k = 33 vs. k = 38), which then decreased the power of the analysis.

For all outcomes, the first model with three predictors (sample origin, control type, location) explained a significant amount of variability (QM (df = 4) = 11.06, k = 38, p = .03, I^2 = 81.95%). Location appeared to be the factor driving the results (b = -0.51, SE = 0.24, p = .03). However, the amount of variance unaccounted for was more than would be expected by chance (QE (df = 33) = 150.60, p < .0001), which indicates that there is likely another unaccounted for moderator. For all outcomes, the second model with six predictors (sample origin, control type, mean age, % female, treatment length, location) accounted for less variability than the previous model with three predictors (QM (df = 7) = 12.82, k = 33, p = .08, I^2 = 84.09%; QE (df = 25) = 128.45, p < .0001). This appears to be due to the fact that fewer studies were included (k = 33 vs. k = 38), which then decreased the power of the analysis.

Due to the focus of this study on the impact of yoga on anxiety, a final moderator test was conducted examining whether changes in anxiety predicted changes in other outcomes (i.e., overall intervention effects with anxiety measures excluded). Changes in anxiety were shown to significantly moderate overall effects (B_1 = 0.37 [0.21, 0.53], p < .001, Figure 3), indicating that studies showing larger effects on anxiety also showed larger effects on other outcomes.

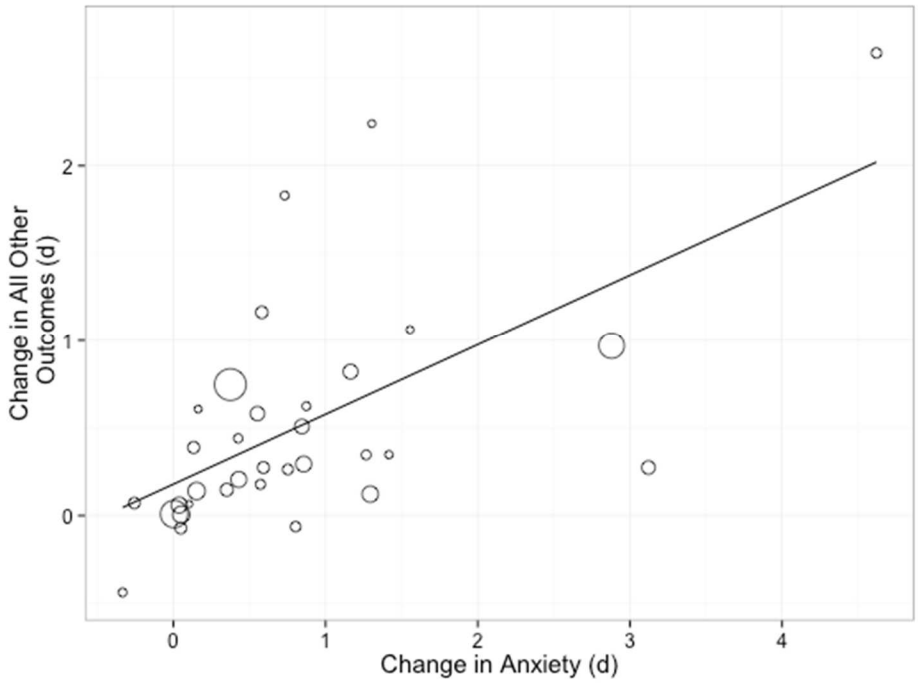


Figure 3. Changes in anxiety moderate changes in other outcomes combined. Each circle represents a given study with each diameter proportional to the weight of that particular study in analyses. *d* = effect size (equivalent to Becker's *del*).

Assessment for Publication Bias

A funnel plot was constructed and inspected for outliers indicative of publication bias (Figures 4 and 5). Asymmetry was detected, and therefore three outlier studies were taken out and the analysis was re-run. Without the outlier studies, for anxiety outcomes a medium and significant effect size was found in the yoga conditions relative to the control groups (d = 0.57, 95% CI [0.40, 0.74], p <.0001). For all outcomes, a small and significant effect size was found in the yoga conditions relative to the control groups (d = 0.47, 95% CI [0.31, 0.62], p < .0001).

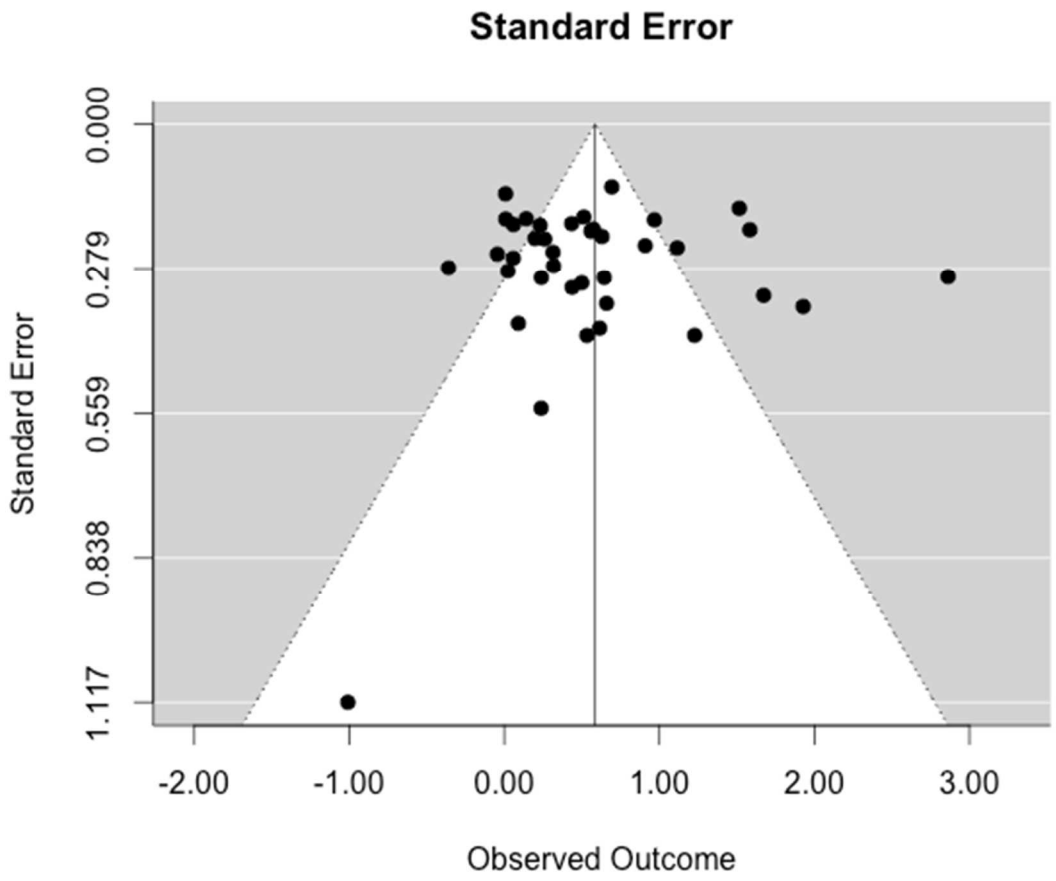


Figure 4. Funnel plot for all outcomes

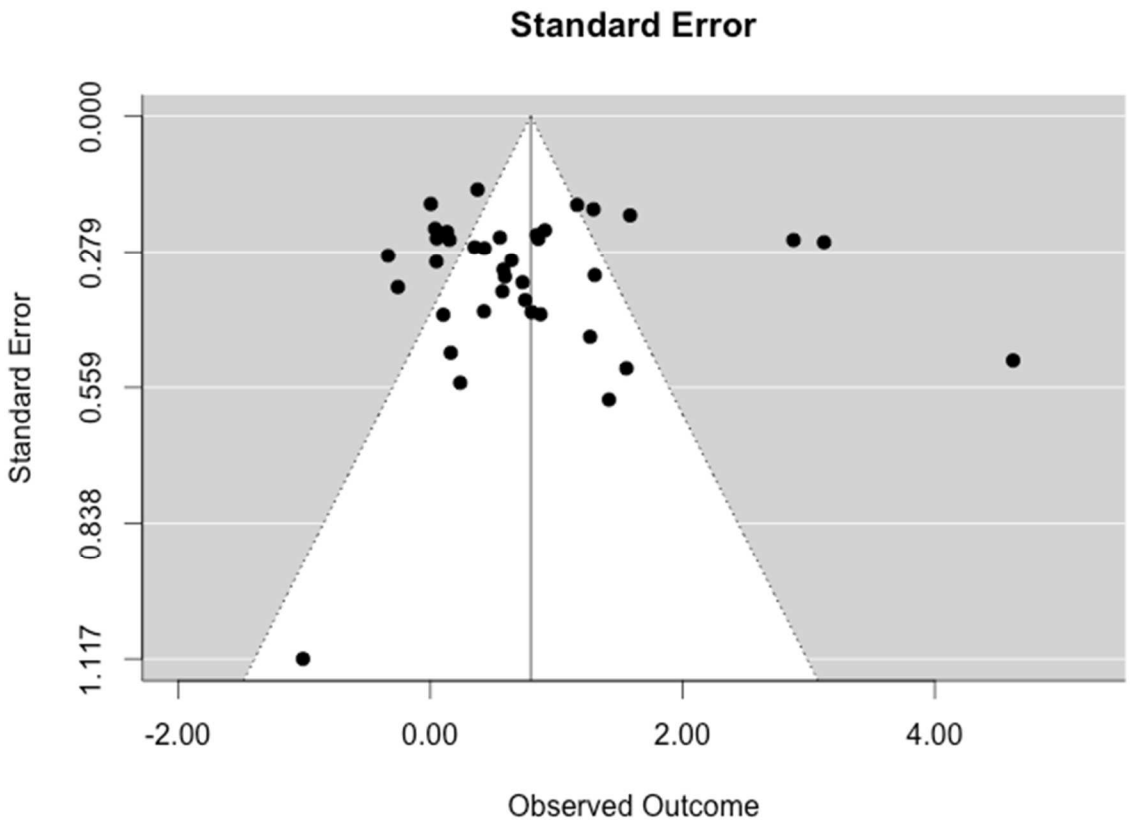


Figure 5. Funnel plot for anxiety outcomes

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], $p < .0001$). For all outcomes, a medium and significant effect size was found in the yoga conditions relative to the control groups (d = 0.59, 95% CI [0.38, 0.80], $p < .0001$). The lack of significant change in effect size from the omnibus indicates that were was little or no impact from these outlier studies.

Discussion

This meta-analysis on RCTs that utilized a yoga intervention and measured anxiety as an outcome found an overall large effect size on anxiety for the yoga conditions relative to the control groups (d = 0.80). Across all outcome measures, a moderate effect size was found for the yoga conditions relative to the controls (d = 0.59). The yoga condition also significantly improved symptoms across a variety of outcome types relative to the control (i.e., biological measures, non-anxiety mental health outcomes e.g., depression, physical health measures, stress, mental and physical health outcomes combined, life satisfaction, and depression). 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.

Omnibus Analysis

Large Effect Size of Yoga on Anxiety

This meta-analysis found an overall large effect (d = 0.80) on measures of anxiety in the yoga conditions relative to the control groups. With outlier studies excluded, yoga's effect on anxiety continued to be significant and in the moderate range (d = 0.57). Among these yoga studies in which anxiety was measured as an outcome, across all outcome measures combined, a

moderate effect (d = 0.59) was found in the yoga group relative to the control. With outlier studies excluded, yoga's effect on anxiety continued to be significant and in the moderate range (d = 0.53).

While the effect of yoga on anxiety has been shown in individual studies (e.g., see reviews of Chugh Gupta, 2013; Kirkwood, 2005) and as a subsection of a larger meta-analysis (Lin, 2011; Pan, 2015), this is the first time to our knowledge that yoga's effect on anxiety has been demonstrated in a stand alone and comprehensive meta-analysis. Yoga's large effect size on anxiety is comparable to the effect sizes found for similar mind-body practices, such as mindfulness (Khoury et al., 2013), Chigong (Yin and Dishman, 2014), and relaxation (Bandelow et al, 2015).

Sub-Omnibus Analyses

Significant Effect Sizes on Other Dependent Variable Types

In the sub-omnibus analysis, statistically significant effects of the yoga intervention were detected on biological measures, non-anxiety mental health outcomes (e.g., depression), physical health measures, stress, mental and physical health outcomes combined, life satisfaction and depression (with outliers excluded). This indicates that for these yoga studies that measured anxiety as an outcome, the yoga conditions significantly improved symptoms across a variety of outcome measures relative to the control groups.

While these sub-omnibus analyses were completed on a subset of studies (i.e., yoga studies that measured anxiety as an outcome), the effect sizes found for these constructs is similar to the effect sizes found in studies focusing on each specific outcome. For depression, the medium effect sizes found for the sub-analysis of depression (excluding outliers) and for "non-anxiety mental health outcomes" (predominantly depression measures) is comparable to the

effect sizes that have been found in other meta-analyses and individual studies examining yoga and depression (Crammer, 2013; Gong, 2015).

For stress, similar large effect sizes have been found for yoga in other studies (Pascoe, 2015; Chang, 2011). Of note, the largest effect size across all dependent variables types was found on stress outcomes (d = 1.00). Perhaps this large effect was due to yoga's ability to re-regulate the nervous system (Arora, 2008). This hypothesis is supported by the fact that the biological measures (e.g., cortisol, blood pressure) sub-analysis was also significant. It is possible that the regulation of the HPA axis and SNS serves to mediate yoga's effect on anxiety.

In terms of physical health, the significant sub-analysis agrees with previous findings of yoga's effectiveness on physical health parameters. While previous studies have demonstrated yoga's effectiveness for specific physical ailments, such as cardiovascular disease (Crammer, 2014) or hypertension (Hagins, 2013), this sub meta-analysis demonstrates yoga's effectiveness across a variety of physical health parameters.

Moderation

Significant Moderation by Location

The effect size for yoga on anxiety for studies conducted in India was in the large range (d = 1.3) and twice the magnitude of that found in studies conducted outside of India (d = 0.62). This suggests that anxiety may be particularly beneficial when conducted in India. Across all outcomes, studies conducted in India had three times the effect size compared to those conducted in the United States, and twice the effect size relative to those studies conducted in neither India nor the United States (d = 1.07 vs. d = 0.3 vs. d = 0.5).

Breaking down the moderation by location (India vs. outside India) finding by dependent variable type further illustrates the breadth and magnitude of this moderation. Yoga was shown

to be seven times as helpful in India vs. outside India on life satisfaction, six times more helpful on physical health, three times more helpful on mental health not anxiety (predominantly depression), and twice as helpful on clinical outcomes combined (anxiety, mental health excluding anxiety, physical health, and stress). Moderation by location could not be run for social functioning, mindfulness, and other outcomes categories because no studies from India measured these outcome types.

It is interesting to note which constructs are more or less likely to be studied in India. Studies in India did not have a direct measure of mindfulness, which may speak to the fact that mindfulness is already part of the culture. Having a discrete category of "mindfulness" may not speak to the Indian sensibility. Also studies in India did not measure social functioning, which may be because yoga is regarded as an individual practice for personal development and therefore there is little interest in yoga's impact on the interpersonal sphere. Additionally, physical health measures were proportionally more likely to be reported in India and measures of life satisfaction and regulation where more likely to be reported outside of India. This may speak to a prioritization in India of measuring more concrete concepts (i.e., physical health) over more amorphous constructs (i.e., life satisfaction, regulation).

Possible Mechanisms

There are a number of possible reasons for the greater effect of yoga on anxiety in India versus outside India. One major reason why yoga may be more effective in India is that it is part of the fabric of the culture. Originating in India, yoga is something that Indians are immersed in throughout their lives, whether it is at home seeing their parents practice, through school classes, visiting yoga centers or temples, or seeing holy men practicing yoga.

Not only is there this familiarity, but there is also cultural pride. Yoga functions in India to create a "shared history" and "unifying identity" (Strauss, 2002). Indeed, Indians recently celebrated their accomplishment of yoga during International Yoga Day on June 21, 2015, in which Prime Minister Narendra Modi led 35,000 Indians in a yoga class ("India Yoga: PM Narendra Modi Leads Thousands in Celebration," 2015). Cultural pride has been linked to healthy sense of self (e.g., Spencer, 2003). Relatedly, there is a cultural belief in yoga's healing potential; belief in a healing practice has been shown to increase its effectiveness (Frank,1993).

Related to yoga having its origin in and being part of the culture of India, yoga is, overall, practiced in a more holistic and spiritual way in India than outside of India. Yoga is practiced in a way that is closer to the original intent of the practice (Budhos, 2002). This more holistic way of practicing may contribute to yoga's greater effectiveness. The specific differences in how yoga is practiced in India vs. outside of India that may contribute to the differential in healing potential are described below.

First, there are differences in class intention, components, and sequencing. Classes in India tend to include a variety of different practices other than the physical postures. Specifically, classes most often follow a sequence of chanting, breathing exercises, warm up movements, physical postures, savasana or final relaxation, and then end with meditation and chanting. Perfect alignment in physical postures is often the primary emphasis; rather, the intention is to cultivate an inward focus, connect with breath and body, and to move through the poses easefully and mindfully (e.g., Dhanajai, 2013, Gupta, 2013). In contrast, outside of India, classes are often focused on health and fitness (Askegaard, 2012). In addition, the intention is often on completing the "best" version of the pose and the hardest physical postures. Even if this is not the stated intention 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 through the practice, may encourage regulation of the nervous system.

Second, there are differences in the location of the practice. Yoga classes in India are often practiced at a yoga center that is set up to help participants transition out of their daily way of being. The 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 clean 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). In contrast, outside of India, yoga classes are often given at a gym where there are bright lights and mirrors, with participants wearing expensive yoga gear. Classes are often given in an exercise studio right off the main gym floor, with only a glass wall separating the two spaces. Participants in the yoga class can see people on treadmills and hear the top 40 popular music. This gym environment does not provide the same support to calm the mind and nervous system, focus on one's inner experience, and transition out of daily ways of being (Isaacs, 2003). 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, the classes may still be informed by the traditional settings of the yoga practice.

Third, there are differences in how much a yoga lineage, spirituality, and yoga teachings are included in the class. In India, yoga classes are often taught as part of a lineage, they have a spiritual component, and they emphasize key tenants of yoga. Yoga centers are often established by a particular Swami, or yoga master, 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 teachings of yoga, 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. Outside of India, it is less likely that a lineage and higher power is included in the class.

Fourth, there are differences in terms of community. In India, there are aspects of the class experience that make practitioners feel more connected and in community both to each other and also to the yoga lifestyle. First, more effort and commitment are needed to take a yoga class at a yoga center than at a gym. To take a class at a yoga center a person needs to locate the center and decide to take a class, make a specific trip, and pay extra money. To take class at a gym a person may already happen to be at the gym when the yoga class is given, and they do not need to pay extra money, as it is most often included in their membership. The added effort and commitment in taking a class at a yoga center may encourage a feeling of community among participants; they may feel among a community of like-minded individuals, who share similar values. Second, at a yoga center 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. Third, yoga centers often offer communal activities outside of classes to gain exposure to the yoga lifestyle (e.g., preparing and serving meals). These activities can serve to strengthen connection to others at the center. In

contrast, at a gym there are less indications that there are shared values among the participants and less supports to foster a sense of community.

Fifth, there are differences in the teachers of yoga classes. Teachers of yoga classes in India often bring a long-term commitment to the yoga lifestyle, whether they are swamis (senior religious teacher) or individuals who live at the yoga center. Therefore, they serve as an embodied example of the power and benefits of yoga. In contrast, teachers of yoga in the United States often have to make less of a commitment to the yoga lifestyle in order to teach classes.

Moderation Trends

While no moderators other than location reached clinical significance, there were some trends that bear examining. Sample origin (non-clinical vs. clinical or sub-clinical) was approaching significance for anxiety outcomes ($p = .09$) and for all outcomes ($p = .062$). Yoga was shown to be twice as effective on anxiety for non-clinical vs. clinical or sub-clinical samples across both anxiety outcomes and all outcomes combined ($d = 0.95$ vs. $d = 0.43$ and $d = 0.70$ vs. $d = 0.31$). This suggests that yoga may be particularly effective with healthy individuals versus those who meet criteria for a clinical condition.

Clinical Practice and Research Implications

This meta-analysis provides quantitative evidence to support yoga as an effective adjunctive treatment for anxiety symptoms. Given that greater effect sizes were shown in studies originating in India, it may be beneficial to modify how yoga is practiced outside of India to increase its effectiveness. Overall, this may include making the yoga class more holistic and spiritual. To that end, possible modifications are: 1) To have the yoga teacher articulate that one intention of the class is to connect the breath with movement and to move easefully and mindfully, and to bring the participants' awareness back to taking full and deep breaths

throughout class; 2) to have the yoga teacher emphasize the key tenants of yoga, specifically impermanence and egolessness, and that the purpose of yoga is to quiet the mind, and that the practice must be regular and sustained over a long period of time to be effective; 3) to include practices other than the physical poses, such as breathing exercises (e.g., alternate nostril breathing) in order to further encourage re-regulations of the sympathetic nervous system; 4) to create a space for practice that encourages slowing down and connecting with inner experience through gentle lighting and an absence of distractions (e.g., no posters of people "working out"); 5) To connect the practice to a lineage and to bring in spiritual components. Some potential ways to do this include the teacher referencing her teacher, chanting, or ringing a bell; 6) to facilitate a sense of community in the yoga journey through such interventions as inviting participants to share what motivated them to take class.

In terms of further research, there are five primary recommendations. First, studies should be conducted on populations that met criteria for an anxiety disorder using yoga as an adjunctive treatment. Given the limited number of studies on clinical anxiety populations, this meta-analysis was not able to include only clinical anxiety samples. However, the significant effect size found in this meta-analysis supports conducting studies with clinical anxiety populations. Second, it is recommended that more research be conducted on the differential effect of yoga on anxiety based on location, perhaps conducting further moderator testing to better understand which factors are contributing to the differential effectiveness and to conduct qualitative research using such means as focus groups or participant observation. Third, it would be beneficial to develop a codified yoga treatment, comparable to how Mindfulness Based Stress Reduction (MBSR) is utilized in many studies of mindfulness. This standardization of intervention would decrease the heterogeneity of yoga interventions and therefore allow for more

conclusions to be drawn from the studies and allow for component studies. Currently, the heterogeneity of yoga interventions limits the generalizability of findings. Fourth, further RCTs should be conducted with yoga on anxiety to increase the availability of studies utilizing solid study design, which can then allow for more refined meta-analyses. These RCTs can be conducted with both clinical and non-clinical populations and would allow for further examination of the previously mentioned trend of yoga's greater effectiveness on non-clinical populations. Fifth, mediation analysis should be conducted to examine how and why yoga affects anxiety. Possible mediators supported by the literature to test include mindfulness (Baer, 2013) and stress (Kiecolt-Gelser, 2010).

Strengths and Limitations

This meta-analysis included a number of strengths. First, there were a fair number of studies (38) with a diverse origin (i.e., medical diagnosis, psychological criteria, sub-population e.g., pregnant women, community sample) from a variety of countries. Second, only RCTs were included, which increases the strength of the conclusions that can be drawn from the findings. Limitations of this study include that few studies included in the meta-analysis used a population that met criteria for an anxiety disorder.

Future Directions

The findings of this meta-analysis suggest that future research might focus on yoga interventions with both clinical anxiety and non-clinical populations, examining yoga as both an adjunctive treatment for psychopathology and as a health and wellness intervention. Further research may also focus on quantitatively and qualitatively determining what are the differential factors contributing to yoga's increased effectiveness on anxiety symptoms in India versus outside India.

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