

Yoga as an intervention for anxiety in children and adolescents: A meta-analysis

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Abstract

There is growing interest in yoga as a complementary therapy for anxiety reduction in children. However, the available evidence has primarily relied on uncontrolled studies, which may overestimate treatment effects. The aims of this study are to systematically appraise the rigour of current research investigating yoga as an intervention for children and adolescents (aged 3-21 years) and to complete a meta-analysis of the data to determine the effectiveness and optimal dosage of yoga for anxiety. Ten independent controlled trials, involving a pooled sample of 3879 children and adolescents, were identified from the Embase, PubMed and PsycINFO databases. Study reporting quality was assessed using the QualSyst tool. Standardised mean group differences (Hedges' g) in addition to 95% confidence intervals, p values and heterogeneity statistics (Q , I^2 , Tau) were calculated using a random effects model. Although five studies identified immediate improvements in anxiety symptoms with yoga, the overall pooled effect was not significant ($g = 1.06$, [CI: -.16, 2.27], $p = 0.08$). The findings were, however, characterised by a single outlier study - the removal of which changed the overall significance ($g = .59$, [CI: .16, 1.13], $p = .01$). Subgroup analyses identified a 'dose-response' effect, with very large and significant effects being associated with yoga interventions that extended beyond 9 weeks ($g = 1.81$ [CI: .32 to 3.29] $p = 0.02$). These studies provide preliminary data to suggest that yoga may have some mental health benefits for children. Further controlled research incorporating follow-up assessment is warranted given the findings in this review.

Keywords: yoga, anxiety, children, adolescent, meta-analysis

Declaration

To my knowledge, this thesis does not contain any material which has been accepted for the award of any other degree or diploma in any University, and, to the best of my knowledge contains no material previously published except where due reference is made. I give permission for the digital version of this thesis to be made available on the web, via the University of Adelaide's digital thesis repository, the Library Search and through web search engines, unless permission has been granted by the School to restrict access for a period of time.

Date 29th September 2020

Contribution

In writing this thesis, my supervisors (A.T. & D.D.) and I collaborated to generate the research question of interest and to design the appropriate methodology. I conducted the literature search and undertook the screening process, while my supervisors assisted in screening full-texts and assessing texts for eligibility. I extracted data and completed the data analyses under the supervision of my supervisor (D.D.). Finally, I was responsible for writing the full thesis.

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Finally, thank you to my incredible friends and family. Your encouragement, understanding, support, sacrifices and optimism throughout this year has been greatly appreciated. I am so thankful for the support I received from you all.

Chapter 1

Introduction

Overview

According to the World Health Organisation (2020) between 10 and 20% of children will experience some form of mental illness in their lifetime. In 2015, a survey of Australian children between the age of 5-14 found that 3 out of the top 5 health disorders contributed to the burden of disease were mental health related (Australian Institute of Health and Welfare, 2020). Anxiety is one of the most common mental health disorders among school-aged children, yet treatments are readily available (Beyond Blue, 2020). Left untreated, anxiety can increase the risk of developing other mental illnesses such as depression or even substance abuse (Lepine, 2002).

While traditional interventions, such as psychotropic medication and Cognitive Behavioural Therapy (CBT), have demonstrated treatment efficacy in the management of anxiety disorders in youths, there is an increasing demand for other low cost, convenient and effective interventions (Kaczurkin & Foa, 2015). Yoga is an alternative intervention that has shown particular promise. Yoga can help to support the development of an adaptive connection between the mind and body and, in turn, assist with building emotional regulation skills along with resilience to cope with daily stressors (Noggle, Steiner, Minami & Khalsa, 2012). Importantly, the techniques used in yoga can be readily adapted to children.

However, whilst the evidence-base for yoga is growing, current data on its application and effectiveness in reducing anxiety in children is of mixed quality (Breedvelt et al., 2019; (Noggle, Steiner, Minami & Khalsa, 2012). This chapter reviews the evidence-base,

commencing with a discussion of mental health issues in children, focusing on the prevalence of anxiety. This will be followed by a brief discussion of yoga as a potential intervention.

The evidence surrounding yoga will be evaluated and the need for a meta-analysis of controlled trials will be reviewed.

Mental Health in Children

Recent research has found that children and adolescents are the most “stressed-out” generation of our time due to their fast-paced lifestyles, influence of globalisation, societal and parental expectations, constant stimulation of technology and social media (Hagen & Nayar, 2014). The 2013-14 Australian Child and Adolescent Survey of Mental Health and Wellbeing found that 13.9% of children aged between 4-17 years had experienced a mental illness in the previous 12 months (Australian Institute of Health and Welfare, 2020). Anxiety is the second most common disorder in children after Attention Deficit Hyperactivity Disorder (ADHD), anxiety having a prevalence rate of 6.9%, equating to approximately 293,000 children in Australia (Australian Institute of Health and Welfare, 2020).

Anxiety is characterised by excessive worry and fear, resulting in somatic and behavioural disturbances (American Psychiatric Association, 2013). Anxiety can be difficult to diagnose in children as it can manifest as fears and worries that are typically seen during development. Normative fears are characterised by a range of symptoms including panic attacks, hot and cold flushes, racing heart, tightening of the chest, fast breathing, restlessness, fatigue, difficulty concentrating, muscle tension, irritability, and sleep disturbances, all of which can be frightening for children and a cause for concern for their parents (American Psychiatric Association, 2013; Bystritsky, Khalsa, Cameron, & Schiffman, 2013). The concomitant effect is that the social and behavioural demands placed on children during their

transition to adulthood contribute to poorer mental health outcomes (Telles et al., 2019). In puberty, anxiety can intensify as natural growing psychological challenges present as part of biological changes in addition to the social pressures of developing one's own identity (Hagen & Nayar, 2014).

Anxiety may be experienced so frequently and with such a severity that it becomes pathological. Typical anxiety disorders seen in childhood and adolescence include Separation Anxiety Disorder (SAD), Generalised Anxiety Disorder (GAD), Panic Disorder, and Social Phobia (American Psychiatric Association, 2013; Bystritsky, Khalsa, Cameron, & Schiffman, 2013). These disorders can result in, avoidance behaviour and impairment in everyday functioning - including early school dropout rates and missed social experiences (Van Ameringen, Mancini & Farvolden, 2003). An association of poor future life outcomes have been identified – with the suggestion that anxiety in childhood may prevent the development of key skills that are critical to adult self-esteem - namely resilience, relationships with peers, problem solving and adaptive social skills (Nguyen, Wright, Dedding, Pham & Bunders, 2019).

In their national comorbidity study of 10,123 adolescents aged 13–18 years, Merikangas et al (2010) noted that one in four adolescents who did not receive treatment for mental health disorders, such as anxiety, experienced severe impairment across their lifetime. A further study in New Zealand found that more than a third of people who suffered from anxiety in their 30's had experienced symptoms before the age of 15 years (Gregory & Eley, 2007). The social and economic costs associated with an anxiety disorder are substantial and include the direct costs related to accessing formal mental health supports, but also indirect costs associated with parent's reducing their attendance at work (Bystritsky, Khalsa,

Cameron, & Schiffman, 2013). Notably, many children who live with daily, debilitating anxiety may not have been clinically diagnosed – many do not want to worry their parents and so will hide their emotional distress (Hagen & Nayar, 2014). Disconcertingly, it is estimated that up to 80% of children who have required mental health treatment did not receive it due to feelings of shame, stigma, cost or cultural barriers (Reardon et al., 2017).

The high prevalence of excessive childhood anxiety, along with its significant impact on functioning, highlights a need for early and targeted interventions to promote child mental health and prevent the burden of illness later in adulthood (Gregory & Eley, 2007). Anti-anxiety medications (anxiolytics and antidepressants) such as sertraline, fluoxetine, fluvoxamine and paroxetine, may be of clinical benefit however they are cautiously prescribed – and usually as a last resort when there has been no response to psychological treatment (Kodish, Rockhill & Varley, 2011). Safety concerns and severe side effects, particularly increased suicidal thoughts, nausea, headaches, and sleep disturbances present a significant barrier to pharmacological treatments (Kodish, Rockhill & Varley, 2011).

In comparison, the ‘gold standard’ treatment for anxiety, Cognitive Behavioural Therapy (CBT), has established benefits using strategies such as psychoeducation for both the child and their family, techniques for managing somatic symptoms, and recognition of cognitive thought patterns that provoke anxiety (Wehry, Beesdo-Baum, Hennelly, Connolly & Strawn, 2015; Hofmann, Andreoli, Carpenter & Curtiss, 2016). However, CBT requires a commitment on the part of the child and their parents that extend beyond the typical one hour per week session, including the additional time needed to complete homework tasks between sessions. The accessibility and affordability of mental health services can be major barriers for many families (Tristina, Yusuf, Fitriyasaru, Wahyuni & Nihayati, 2017). A combination

of these evident community demands has seen the rise of yoga as an alternative, accessible, low cost intervention to alleviate mental health symptoms such as anxiety.

Yoga as a Mental Health Intervention

The word Yoga is taken from the Sanskrit term *Yuj*, meaning to *join* or *unite* (Sengupta, 2012). An important aim is to achieve harmony and balance between the mind and body. A person that can achieve this state is known to be in *Yoga* (Basavaraddi, 2015). In contemporary cultures, yoga is understood as a combination of mindful focus on one's physical state and attention to breath and energy (Woodyard, 2011). The most common form of Yoga practice is *Hatha*. Hatha yoga uses breathing techniques and physical postures that incorporate meditation as part of its routine (Stephens, 2017; Woodyard, 2011). Modern day yoga instruction commonly uses different aspects of Hatha yoga, including styles known as Iyengar, Vinyasa and Viniyoga, all of which use various breathing techniques (pranayama) and physical posturing movements (asanas) (Basavaraddi, 2015; Uebelacker et al., 2017).

Whilst a variety of yoga styles are widely documented, the specific exercises taught depends on the philosophy of the instructor (Tran, Holly, Hashbrook & Amsterdam, 2007). The traditional aim of yoga, as an Eastern philosophy of the mind and body is spiritual connection and promoting holistic health. Ancient civilizations such as the Vedic, Upanishadic, Buddhist, Darshanas, Ramayana, and Tantric used yoga as a daily way of life, using specific postures, breathing and meditation techniques to benefit the overall spiritual and physical health and wellbeing (Sengupta, 2012).

The interest and the benefits of yoga has been researched for many years in India. In the early 1920's, the physical health benefits of yoga were first documented in an Indian journal called *Yoga Mimamsa* (Jeter, Slutsky, Singh & Khalsa, 2015). The journal reported

on a type of yoga that involved two body movements, *navli* and *agnisara*. The postural movements involve contracting the abdominal muscles and the effects were analysed using physical examinations, such as x-rays and barometric measurements of the viscera (Braud, 2008). Additional studies examined the potential power of yoga - referred to as *Siddhi* (Raghavendra et al., 2013). This is likened to a mind-over-body phenomenon using mental mastery and breath to regulate heart rate and blood pressure, enhance physical health, strengthen immunity, improve cognitive abilities and increase resilience (Jones, 2019; Raghavendra et al., 2013).

It was not until the 1970s that research interest in yoga from the western scientific community emerged. This is evidenced by the first known Randomised Controlled Trials (RCTs) which were conducted by cardiologist Dr. Chandra Patel, who demonstrated the effectiveness of simpler forms of yoga on patients with hypertension (Patel & North, 1975). Numerous other physical health benefits of yoga have since been described, including reduced musculoskeletal pain, as well as reported benefits to the management of chronic conditions and illnesses such as coronary heart disease, hypertension, diabetes, respiratory diseases, obesity, gastrointestinal disorder or even cancer (Taneja, 2014; Bussing et al., 2012; Bridges & Sharma, 2017).

Whilst yoga has shown promise as an intervention to promote overall physical health, its applicability to mental health care has also been noted, with emphasis on its treatment focus on the self-regulation of thoughts and behaviour (Mocanu, Mohr, Pouyan, Thuillard, & Dan-Glauser, 2018). Indeed, some of the main goals of yoga are to achieve a sense of peace and tranquillity, connecting body and mind, enabling the person to relax, improve concentration, and to increase focus. A study by Gard, Noggle, Park, Vago and Wilson

(2014) found that a decline in fluid intelligence often seen in old age could be counteracted by those who regularly practiced yoga. There is evidence that yoga can also help adults better manage their anger, ability to cope, and their emotional stability in general (Taylor et al., 2011; Hazaleus & Deffenbacher, 1986). These benefits have been confirmed by neurobiological studies, with yoga reportedly promoting serotonin production - a neurotransmitter which plays a major role in mood regulation, as well as reducing cortisol levels in stress-related anxiety (Krishnakumar, Hamblin & Lakshmanan, 2015).

Recent meta-analytic data supports the effectiveness of Hatha yoga on anxiety in adults (Hoffman, Andreoli, Carpenter & Curtiss, 2016). Based on 17 studies and 501 participants, Hofmann, Andreoli, Carpenter and Curtiss (2016) remarked that yoga was effective, particularly for those with high levels of anxiety at baseline with this subgroup reported receiving the most benefit. However, the authors suggest that the benefits may be enhanced when yoga was combined with other evidenced based interventions, such as CBT. In their systematic reviews, Kirkwood, Rampes, Tuffrey, Richardson & Pilkington, (2005) and Becker (2000) found yoga to be a promising and attractive low-cost option for the treatment of anxiety across the lifespan. However, the poor level of quality of this research was emphasised. Their review inferred that uncontrolled trials might overestimate noted treatment effects.

Yoga for Children with Anxiety

As previously mentioned, yoga offers the ability to develop skills that are valuable in adulthood such as resilience, mindfulness and anger management (Nanthakumar, 2017). As such, yoga has become increasingly popular in recent decades as an alternative intervention for children. Indeed, school-based programs that have been adapted from adult models have

been a recent addition to many curriculums (Greenberg & Harris, 2011).

As demonstrated with adults, the practice of yoga has benefits for stress and anxiety by improving a child's self-awareness, consciousness, emotional regulation, concentration, confidence, and academic performance (Hagen & Nayar, 2014; Nanthakumar, 2017; Ferreira-Vorkapic et al., 2015). Regular yoga practice can assist with the development of proactive coping strategies that help to promote mental health (Hagen & Nayar, 2014; Bussing et al., 2012). Anxiety, stress, insomnia, and depression commonly respond to yoga with the main aim of the yoga practice being to achieve peace of the mind (Nanthakumar, 2017, Woodyard, 2011). Yoga can also help anxious individuals achieve a state of relaxation by shifting the body's stress position of the fight or flight state to a more relaxed response (Woodyard, 2011).

Importantly, no significant adverse effects of yoga for children have been documented. A small number of studies have reported minor musculoskeletal strains, with recommendation that physical postures need to be tailored to a child's ability and should always be supervised and taught by a qualified instructor (Kaley-Isley, Peterson, Fishcher & Peterson, 2010; Sengupta, 2012). There is strong evidence to support yoga as a therapeutic intervention and its role in reducing heart rate, tension, and physical symptoms of anxiety (Stueck & Gloeckner, 2005; Telles, Narendran, & Raghuraj, 1997; Telles & Srinivas, 1998).

Despite the promise of yoga as a treatment intervention, research into its application for children with anxiety has been limited (Alvarez, Sutton, Barton & Vaidya, 2020). This is in part because data from individual studies published in non-English journals have been challenging to obtain (Bussing et al., 2012). The methodological quality of included studies is an additional concern. A mixed methods study from 2012 found 48% of studies involved a

single group or an uncontrolled study design (Bussing et al., 2012). Weaver and Darragh (2015) conducted a systematic review of 16 studies including 6 randomized controlled trials but also pre-post designs with or without a control group. In their study, they highlighted the need for a greater understanding of the physiological and psychological mechanisms that underpin anxiety in children. Importantly, the authors reported that individual yoga elements were particularly beneficial including postures, meditation, and controlled breathing techniques. Additionally, they found that the effectiveness of yoga could be enhanced when applied within a variety of settings, such as home or school (Weaver & Darragh, 2015). Data from individual studies were not readily obtained or available, thereby preventing the calculation of standardised mean group differences in anxiety levels pre to post-yoga and, in turn, preventing a quantitative comparison of treatment effects across studies. Future studies can improve these findings by including a control group, potentially using a no-treatment control group or standard care group (e.g. physical exercise). Notably, additional controlled RCTs have been published since the systematic review by Weaver and Darragh (2015) although a meta-analysis of this data has not yet been provided.

A further systematic review by James-Palmer, Anderson, Zucker, Kofman and Daneault (2020) reported similar findings to Weaver and Darragh (2015), highlighting the potential benefits of yoga across 16 studies. In their qualitative synthesis, the authors proposed that there might be a dose-response effect, whereby yoga interventions delivered for a longer duration typically produced greater reductions in self-reported anxiety. More specifically, James-Palmer et al (2020) recommended that to be minimally effective for anxiety, a yoga intervention needed to involve at least 30-minute sessions, at a rate of 2-3 times a week for 6-12 weeks. Notably, only three individual studies in this review were rated as having 'moderate' methodological quality.

Current Study

There remains a need for studies of high methodological quality for yoga to be recognised as a credible therapeutic intervention for children with anxiety. Previous reviews provide promising, albeit preliminary findings, although did not include a meta-analysis (James-Palmer et al., 2020; Weaver & Darragh, 2015). As such, there remains debate about the effectiveness of yoga as an intervention on anxiety, largely due to the low methodological quality of included studies. It is important to empirically measure treatment effectiveness, so that evidence-based decisions can be made regarding the implementation of yoga for the improved mental health of children. Studies with methodological rigour, ideally RCTs, are needed to assess what type of yoga is beneficial and to understand how it might impact the developing child (Alvarez, Sutton, Barton & Vaidya, 2020).

The current study builds on previous reviews by focusing exclusively on treatment effects reported by yoga studies conducted with children and adolescents in comparison to a control (or comparison) group. The study also incorporates meta-analytic techniques to synthesise the statistical data across multiple studies and form a pooled estimate, as well as a measure of the strength of the evidence presented in these studies (Ahn & Kang, 2018). If the effect varies from one study to the next, a meta-analysis can be used to highlight potential reasons for the variation (Ahn & Kang, 2018).

A meta-analysis adds new information, assists in planning new studies, and helps to explore treatment questions that still need to be answered. Additionally, it can provide important information on specific populations and outcomes that are likely to yield significant results, and which variants of interventions are likely to be most powerful (Ahn &

Kang, 2018). In this study meta-analysis will help to identify whether yoga is effective in managing anxiety symptoms in children and adolescents in comparison to no treatment or another active treatment. The specific aims of this meta-analysis are to:

1. To systematically appraise the rigour of the current research investigating yoga as an intervention for children.
2. To evaluate whether yoga is effective as a psychological intervention for reducing anxiety in children in comparison to other control conditions or comparative treatments.
3. To examine the potential moderating role of yoga intensity (defined as intervention duration) on anxiety symptoms.

Chapter 2

Methods

Literature Search

Potentially eligible studies that examined the effectiveness of yoga interventions for anxiety in children were identified through a search of three electronic databases: Embase, PsycINFO and PubMed. The search was dated from database inception until May 30th, 2020 with automatic alerts created within each database until June 30th, 2020. Search terms were tailored to the vocabulary of each database and developed with the assistance of an expert research librarian to ensure accuracy. This included terms related to the *population* (i.e., “Child” [Mesh] OR child OR children OR paediatric or pediatric), *intervention* (e.g., “Yoga” [Mesh] OR yoga) and *outcome* (i.e., anxiety) of interest. Terms were combined using Boolean operators and the ‘advanced search’ option (see Appendix A for complete logic grids). In addition, the reference lists of included studies and relevant systematic reviews (James-Palmer et al., 2020; Weaver and Darragh, 2015) were hand-searched to identify articles that may have been missed, although no new studies were identified through this process.

Inclusion and Exclusion Criteria

In addition to being published in the English language, or with English translation, eligible studies had to meet key PICO-D (Population, Intervention, Comparison, Outcome, Design) criteria (O’Connor, Green, Higgins, 2019). First, the population needed to be drawn from a sample of children or adolescents (aged ≤ 21 years; the highest common entry age specified for adolescent inpatient or outpatient services). Second, the intervention had to include ‘yoga’ in its description. This included yoga practice with physical posture

techniques (asana) or yoga breathing (pranayama) (Stephens, 2017; Woodyard, 2011). Third, studies had to include a waitlist or standard care control condition, ideally with random assignment as this design provides strong evidence of treatment efficacy (Shadish et al., 2002). Fourth, studies needed to assess anxiety symptom severity in children, using a validated self-report or clinician-administered measure. This included measures specifically designed to assess state anxiety (e.g. State Trait Anxiety Inventory Scale; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) as well as measures of affect or mood that incorporated an anxiety subscale (e.g., Profile of Mood States; McNair, Lorr, & Droppleman, 1971). Finally, studies had to provide quantitative data and follow a repeated measures design, whereby anxiety was assessed on study enrolment (i.e. baseline or pre-intervention) and post-intervention. As the focus of this review was on primary studies that had been peer reviewed, book chapters, editorials and grey literature (e.g., dissertations, conference proceedings) were excluded.

Study Screening

Potentially eligible articles identified from the electronic database searches were imported into Covidence software; a data extraction tool for intervention reviews (Veritas Health Innovation, n.d.). Study screening was undertaken by the student reviewer (A.C) in consultation with a project supervisor (A.T). The first author (A.C) completed the initial steps of excluding references, based on titles and abstracts that did not fit the inclusion criteria. A second reviewer (project supervisor, A.T) then screened 98 records to ensure accuracy with the full-text screening. Inter-rater reliability was high, with reviewers agreeing in 86% of cases ($k = 0.86$). The few discrepant papers were discussed and compared, with full agreement then reached.

Data Extraction

As per the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009), key data were extracted for each individual study using a purposely designed Microsoft Excel sheet. These data included: study characteristics (e.g., country of origin, sample size, study design, anxiety measurement), sample characteristics (e.g., age, gender), intervention characteristics (e.g., type or style of yoga, discipline of yoga instructor, assessment interval) and effect size data to calculate standardised group mean differences, or Hedges' g (i.e., pre- and post-intervention means and standard deviations). Two studies (Khalsa, Hickey-Schulz, Cohen, Steiner & Cope, 2012; Moody et al., 2017) provided either raw mean difference scores or pooled within-groups SDs. These data were converted to Hedges' g (Higgins & Green, 2011; Morris & DeShon, 2002). The data extraction process was performed by the first author (A.C) and checked by the project supervisors (A.T and D.D).

Risk of Bias Assessment

It is important to assess a study's risk of methodological bias when conducting a meta-analysis, as risk of bias can lead to large or inflated effect estimates (Viswanathan, 2012). The *QualSyst Tool* was therefore utilised for this purpose (Kmet, Lee, Research & Cook, 2004). The *QualSyst* includes 14 items which assess a study's research questions and objectives, design, group selection, characteristics and allocation, outcome measurement, sample size, analytic methods and reporting of results. Each study is scored based on pre-specified criteria (i.e., "yes" = 2, "partial" = 1, "no/not applicable" = 0; see Appendix C), with item scores summed and divided by the total possible score (see Appendix D). The percentage of included studies that met each criterion was additionally calculated. This quality assessment was undertaken by the student researcher (A.C). This same person re-

rated all 10 studies after 4 weeks in order to determine intra-rater reliability of these scores. The percentage of agreement between the scores assigned to the 14 individual criteria on both occasions was then calculated. Intra-rater agreement was high, with 94% agreement between the reporting quality scores assigned to the 14 individual criteria on the two separate occasions.

Effect Size Calculations

Comprehensive Meta-analysis software (CMA Version 3; Borenstein et al., 2013) was used to compute the primary estimate, Hedges' g , for each study. The larger the g value, the greater the difference in anxiety outcomes between the intervention and control groups (Ellis, 2010). A random effects model, which accounts for heterogeneity within and between studies, was chosen to analyse the data given the various yoga interventions examined in addition to the different anxiety measures used by the included studies (Fiske, 2018). A random effects model is considered appropriate for the vast majority of meta analyses as it is likely to yield results that are can be generalised in a wider context, enhancing the external validity of a meta-analysis (Chimiklis, et al., 2018).

To calculate g , a pre-post correlation is required (Hedges & Olkin 1985). As studies did not provide this data for their anxiety measure, a conservative estimate of 0.7 was imputed: a value that simulates common correlations in applied settings with a repeated measures design (Estrada, Ferrer & Pardo, 2019). Effect sizes were grouped by anxiety measure and pooled across studies, weighted by the study's inverse variance (g_w). Cohen's guidelines were used to interpret g , with 0.2, 0.5 and 0.8 representing small, medium and large treatment effects. For the purpose of this meta-analysis, the effect direction was standardised so that a positive g reflected greater improvement (i.e. reduced anxiety symptoms) among children that accessed yoga in comparison to controls.

In order to establish the accuracy of each effect size, 95% confidence intervals (CIs) were calculated. The confidence interval provides a more precise evaluation of the true effect of the intervention. A confidence interval that does not contain the value of zero suggests a significant group difference or, for this meta-analysis, a significant treatment effect associated with yoga (Cumming, 2012). The statistical significance of g was then determined with p values.

Between-study heterogeneity was examined using Cochran's Q , I^2 and tau. The Q test, which is based on a chi-square distribution, analyses the ratio of the observed variation to within-study error. A large Q value, along with a significant p value ($p < .05$), indicates greater variation across studies than within subjects within a study (Borenstein et al., 2009). The I^2 statistic expresses between-study heterogeneity as a percentage rather than chance, with 25%, 50% and 75% suggesting a small to substantial amount of variance, respectively (Higgins, Thompson, Deeks and Altman, 2003). Finally, tau (τ), akin to the standard deviation of an effect estimate, was calculated to determine the range in which we would expect to find the true effect (Borenstein et al., 2009).

Publication bias, considered the greatest threat to the validity of a meta-analysis, was considered. This bias is common in the research literature as studies that fail to reject the null hypothesis (i.e. studies with non-significant results) are less likely to be published than those that produce a statistically significant result (Fragkos, Tsagris and Frangos, 2014). Orwin (1983) proposed a calculation, or a 'fail-safe number' (N_{fs}), which represents the number of assumed non-significant studies that are necessary to reduce an individual or pooled g to a trivial effect (i.e. $g = 0.2$). A result was considered to be robust to publication bias if the N_{fs} value surpassed the number of studies included in this meta-analysis ($N_{fs} > 10$).

Sensitivity and Subgroup Analyses

A one-study removed sensitivity analysis was conducted to identify potential outlier effects. Results were considered to be meaningful if the removal of any single study changed the magnitude of the overall pooled g_w or the associated p value (Bornstein et al., 2009). Additionally, a subgroup analysis was conducted, using a random effects model, to examine the potential moderating effect of yoga duration (defined as no. of weeks of intervention). Each study was categorised into either short (< 9 weeks) or longer (\geq 9 weeks) duration, derived via median split of mean number of intervention weeks across the included studies.

Chapter 3

Results

Study Selection

Database searching yielded 1698 records, of which 384 duplicate articles were removed. The remaining 1314 titles and abstracts were screened against the eligibility criteria with 98 potentially eligible records identified and their full texts reviewed. Authors of two studies were emailed for additional details, although neither responded and the two studies subsequently excluded. The final sample included 10 independent studies (see Figure 1).

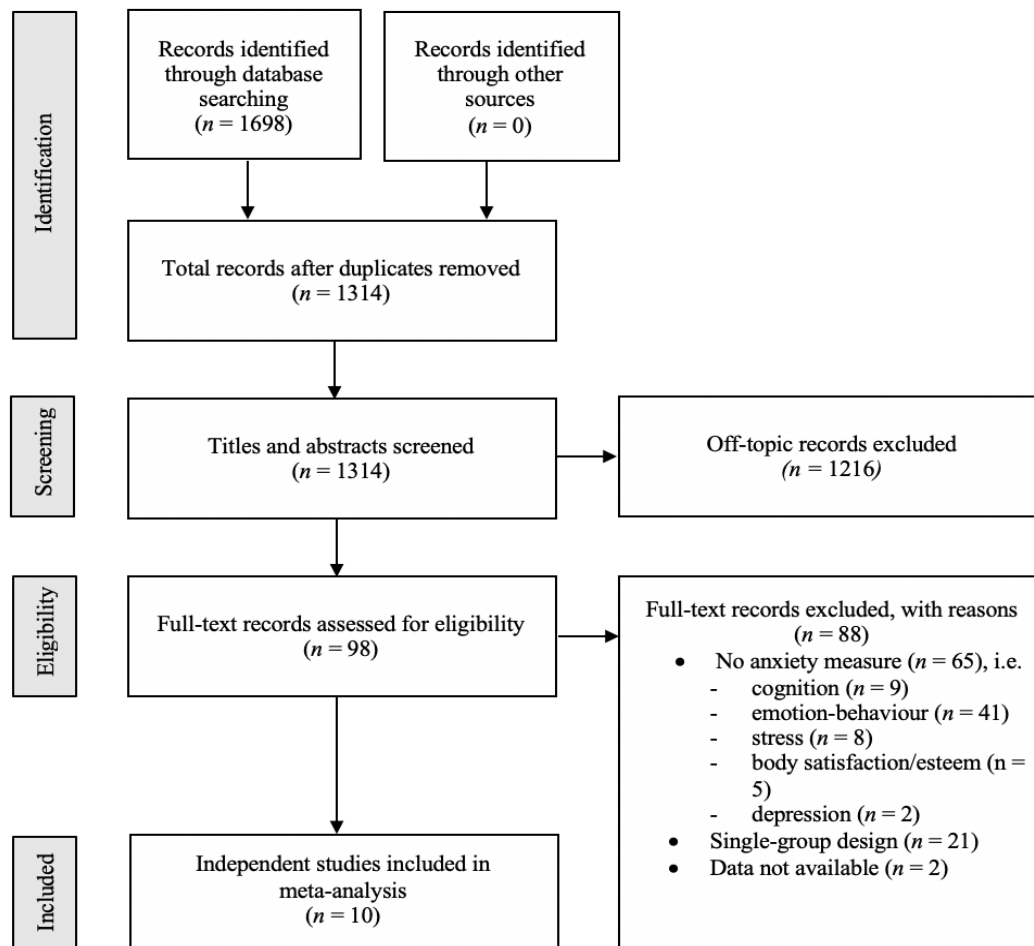


Figure 1. Flowchart for Study Selection Process Adapted from PRISMA (Moher et al., 2009).

Sample Characteristics

Ten studies, comprising a pooled sample of 3,879 children and adolescents, contributed data to this meta-analysis. The mean age was 13 years old ($SD = 3.34$). A single study included adolescents aged from 11 to 21 years receiving outpatient care (Carei et al., 2010). Both the intervention and control groups were comparable in key sample characteristics (age $t(10) = 0.01, p = 0.99$; sex $\chi^2 = 0.95, p = 0.32$), with a higher proportion of females represented (see Table 1). Most studies were conducted in a school setting, with a single study undertaken in an inpatient hospital setting (Moody et al., 2017). In three studies, participants had pre-existing health conditions (i.e. eating disorders; irritable bowel syndrome; sickle cell vaso-occlusive crisis; Carei et al., 2010, Kuttner et al., 2006, Moody et al., 2017). The majority of children had no previous exposure to yoga as an intervention.

Table 1
Pooled Sample Characteristics ($N_{\text{studies}} = 10$)

	Yoga intervention				Control group			
	N_{studies}	$N_{\text{participants}}$	Mean (SD) or %	Median	N_{studies}	$N_{\text{participants}}$	Mean (SD) or %	Median
Sample size	10	1932	193.2 (490.9)	35.5	10	1860	186.0 (492.9)	31
Age (years)	6	3475	13.3 (4.03)	14.6	6	3475	13.3 (3.66)	13.9
Gender								
Male	9	822	43.5%		9	822	45.0%	
Female	9	1069	56.5%		9	1002	54.9%	

Abbreviations: N_{studies} : number of studies providing this data; $N_{\text{participants}}$: number of participants providing this data, SD: standard deviation.

Study Characteristics

The majority of studies were randomised controlled trials (RCTs; $N_{studies} = 8$), with two studies allocating participants to their yoga or control groups depending on their class schedule (i.e., outside of class time). Studies originated primarily from the United States ($N_{studies} = 6$), with single studies from Canada, India, Germany, and Colombia. Participants were recruited mainly from primary or high schools, with two studies recruiting their participants from hospital clinics (Kuttner et al., 2006; Moody et al., 2017) and Pandya (2018) recruiting a child sample from a Hindu organisation.

Anxiety symptoms were measured, typically as a secondary outcome, by eight individual measures. Self-reported measures commonly included the State Trait Anxiety Scale (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) and the Short Form Profile of Mood States – Anxiety/Tension subscale (McNair et al, 1981). Only Pandya (2018) used a clinician-rated measure; the Paediatric Anxiety Rating Scale (Research Units on Pediatric Psychopharmacology Anxiety Study Group, 2002). Quach et al (2016) used the youth version of the Screen for Child Anxiety and Related Emotional Disorders (Birmaher, 1999).

Table 2
Individual Study Characteristics ($N_{studies} = 10$)

Lead author (date)	Sample			Yoga Intervention									Control
	N			Country	Recruitment source	Anxiety measure	Attrition*	Framework	Therapist	Format	Sessions	Weeks	
Total	Yoga	C											
Carei (2010)	54	26	27	US	Outpatient clinic	STAI	4%	Viniyoga	Registered instructor	Individual	Weekly x 1 hr	8	Standard care
Haden (2014)	30	15	15	US	6 th graders	PANAS	(-)	Ashtanga	Qualified instructor	Group	Twice week x 1.5hrs	12	PE as usual
Khalsa (2012)	121	74	47	US	11 th - 12 th graders	POMS-SF	6%	KRIPALU	Qualified instructor	Group	2-3 week x 30-40 mins	11	PE as usual
Kuttner (2006)	28	14	14	Canada	Outpatient clinic	RCMAS	3%	Hatha & Iyengar	Certified instructor	Group	Daily x 1 hr	4	Waitlist
Moody (2017)	73	35	35	US	Inpatient clinic	STAI	0%	Asanas	Qualified instructor	Individual	4 x 30 mins	1	Audio CD (nature sounds)
Noggle (2012)	51	36	15	US	11 th -12 th graders	POMS-SF	1%	KRIPALU	Qualified instructors	Group	2-3 week (28 total)	10	PE as usual
Pandya (2018)	3178	1589	1589	India	Hindu organization	PARS	(-)	Bala Vihar	Qualified instructors	Group	Weekly x 1 hr	104	Chanting, religious education
Quach (2016)	198	65	53	US	11 th graders	SCARED	12%	Hatha	Trained instructors	Group	Twice week x 45 mins	4	Waitlist
Richter (2016)	24	12	12	Germany	Catholic school	BAV 3-11	1%	Asanas	Certified instructor	Group	Twice week x 45 mins	6	Physical skills training
Velasquez (2015)	125	68	57	Colombia	5 th , 8 th , 9 th graders	SDQ	11%	Satyananda	Certified instructors	Group	Twice week	12	Waitlist

Abbreviations: N= number of participants at baseline; C = control or comparison group. *attrition based on number of participants that completed yoga; (-) data/detail not reported. PE = physical education, State Trait Anxiety Inventory (STAI), Positive and Negative Affect Scales (PANAS), Profile of Mood States Short-Form (POMS-SF), Revised Child Manifest Anxiety Scale (RCMAS), Pediatric Anxiety Rating Scale (PARS), The Screen for Child and Anxiety Related Emotional Disorders (SCARED), Bochumer angstverfahren fur Kinder im Vor- und Grundschulalter (BAV 3-11); Strengths and Difficulties Questionnaire (SDQ).

Risk of Bias Assessment

The average QualSyst score was 0.79 (range = .75-.86; see Figure 2 and Appendix D). All ten studies therefore met the conservative threshold of .75 for inclusion in this meta-analysis, as specified by Kmet et al (2004). Specifically, studies clearly outlined their objectives, methodological design and method of participant selection (Criteria 1-3; 100% met). Key sample descriptives (e.g. age, gender) were reported by studies (Criterion 4; 100% met) in addition to detail relating to their randomisation procedures, where applicable (e.g. computer-generated random assignment; Criterion 5; 80% met). Given the physical nature of yoga, it was not possible to blind instructors and participants to group allocation (Criteria 6-7; < 50% met). Well-validated measures of anxiety were used by all studies – as per the eligibility requirements of this meta-analysis (Criterion 8; 100% met). However, sample sizes were not sufficiently powered in seven studies, with many described as pilot or feasibility trials (Criterion 9; 30% met). Statistical analyses, which typically included intention-to-treat analyses, were appropriate for the controlled designs used (Criterion 10; 90% met). Estimates of variance (i.e., SDs) were also provided (Criterion 11; 100% met). However, potential confounding factors - including social distractions from peers in a group setting or time of day when the yoga intervention was scheduled - were difficult to control (Criterion 12; 100% not met). Results were clearly reported (Criterion 13; 100% met) and studies were careful not to generalise their findings to the broader population of school-aged children (Criterion 14; 70% met). Overall, the included studies in this meta-analysis provided satisfactory information regarding potential risk of methodological bias.

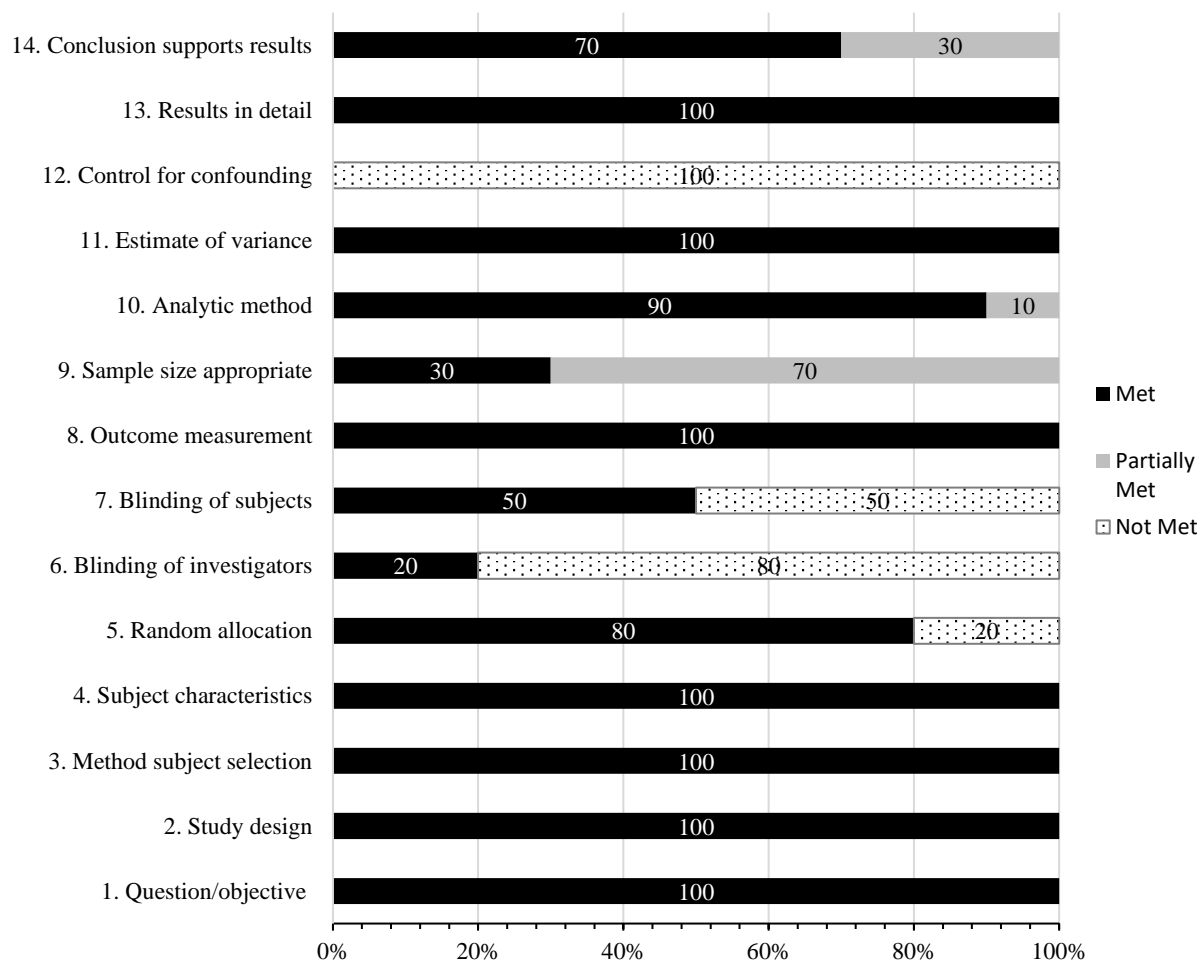


Figure 2. Proportion of Included Studies Meeting Each QualSyst Criterion (Kmet et al., 2004).

Intervention Characteristics

Whilst anxiety was a key outcome across all studies, studies typically included multiple treatment targets, from managing emotional and behavioural functioning and mental health in general ($N_{studies} = 7$) to promoting working memory capacity in adolescents (Quach et al., 2016) or even physical self-perceptions in school-aged children (Richter, Tietjens, Zierels, Querfurth & Jansen, 2016; see Table 2).

Yoga interventions were typically delivered as twice weekly sessions over 7 weeks ($SD = 4.0$), although this varied considerably across studies: from a brief 1-week program

(Moody et al., 2017) to a 2-year course (Pandya, 2018). Individual sessions ranged from 30 minutes to 1.5 hours in duration. Most studies utilised a group-based format for yoga ($N_{studies} = 8$) and all interventions were conducted by a trained or certified yoga instructor.

Importantly, participant engagement was high, with an average attrition rate of 5% (SD = 4.5). Competing school commitments were commonly cited as a reason for study withdrawal. All studies included the yogic element of physical postures. Breathing, relaxation techniques and meditation were also used alongside non-verbal and verbal components such as visualisation, imagery and chanting. No adverse effects (e.g., yoga-associated injuries) were cited.

Control conditions typically included physical education classes as usual ($N_{studies} = 5$) or a waitlist control condition ($N_{studies} = 3$). The remaining studies used an attention control condition, involving an audio relaxation CD ($N_{studies} = 1$) or standard medical care ($N_{studies} = 1$).

Effectiveness of Yoga

Individual and pooled effect sizes for the 10 studies are grouped by anxiety outcome and rank ordered from highest to lowest in Table 3. The effects are also visually displayed with a forest plot. The overall pooled effect was large and robust, but not significant: the therapeutic effects of yoga, as reported by children and adolescents, did not differ from wait-listed peers or those who accessed standard medical care or another form of physical exercise. However, there was substantial variation in the benefits reported by individual studies, as indicated by the heterogeneity statistics. Indeed, of the 10 studies, only five reported significant results (Haden et al., 2014; Noggle et al., 2012; Pandya, 2018; Richter et al., 2016; Velasquez et al., 2015). These findings are discussed in more detail below.

Two studies, in particular, reported very large and significant between-group differences. Yoga participants reported reduced feelings of anxiety, as measured by the PANAS, in comparison to peers who accessed physical activity over 12 weeks (Haden et al., 2014). Pandya (2018) replicated this finding using a clinician-based rating (PARS): Hindu children involved in a 2-year yoga program reported significant improvements compared to a religious education group (Pandya, 2018). Both results were unlikely to be characterised by publication bias ($N_{fs} > N_{studies}$). Similarly, Richter et al., (2016) and Velasquez et al., (2015) reported medium to large improvements in behavioural and emotional symptoms, more generally (as assessed by the BAV 3-11 and Strengths and Difficulties Questionnaire), following their 6 to 12-week yoga programs – although these results were not robust.

The remaining studies reported variable findings, despite using the same self-report measures. Khalsa et al., (2012) and Noggle et al (2012) both implemented Yoga-Ed at 2-3 sessions per week. However, whilst Khalsa et al (2012) reported no significant improvements after 4 weeks, as assessed by the short-form POMS ($g = 0.107$, $CI = [-0.256, 0.471]$, $p = 0.563$), Noggle et al (2012) did report a significant treatment effect for their yoga group at 10 weeks ($g = 1.046$, $CI = [0.419, 1.673]$, $p = 0.001$). Conversely, state-anxiety (STAI) did not decrease for either the yoga or standard care groups examined in Carei et al's 8-week study (2010) ($g = 0.085$, $CI = [-0.446, 0.616]$, $p = 0.754$). Moody et al (2017) also reported negligible change for paediatric patients who accessed either a 1-week yoga program or a relaxation CD ($g = 0.174$, $CI = [-0.290, 0.638]$, $p = 0.463$). Small and non-significant group differences were additionally reported by Kuttner et al (2006), using the Revised Child Manifest Anxiety Scale (RCMAS). This same study reported a significant ($p < .10$) within-group change: children who practiced daily yoga reported less anxiety symptoms after 4 weeks (Kuttner et al., 2006). Finally, Quach et al (2016), using The Screen

for Child Anxiety and Related Emotional Disorders (SCARED), reported no statistically significant group differences pre- to -post yoga. However, the authors did report a significant main effect of time: both their groups (yoga vs. waitlist) self-reported reduced anxiety during their course of their 4-week study.

Sensitivity and Subgroup Analyses

A one-study removed sensitivity analysis identified a single outlier: the very large effect reported by Pandya (2018). Removing this study from the overall analysis partially reduced the heterogeneity (from $I^2 = 98\%$ to 84%) and, importantly, changed the pooled g_w from a large to a medium treatment effect in favour of yoga ($g_w = .59$ [CI: 0.16 to 1.03], $p = .01$).

Subgroup analysis revealed no significant group differences in anxiety between children who accessed brief yoga interventions (< 9 weeks) and peers assigned to the control group ($g_w = .31$ [CI = -1.18 to 1.79], $p = .69$). In comparison, a significant and positive effect was associated with yoga interventions delivered beyond 9 weeks ($g_w = 1.81$ [CI = .32 to 3.29], $p = .02$): these children reported very large reductions in anxiety, compared to wait-listed peers. Differences between these two subgroups were, however, not statistically significant ($Q(1) = 1.964$, $p = 0.161$). Notably, the > 9-week subgroup was characterised by significant between-study heterogeneity ($I^2 = 99.14$, $\text{Tau} = 2.06$), likely reflecting the diverse post-assessment time intervals (range: 10 to 102 weeks) across these primary studies.

Table 3
Pre-post treatment effects associated with yoga

Measure	$N_{studies}$	$N_{participants}$	g/g_w	95% CI		Forest plot $g \pm 95\% CI$	p	N_{fs}	Heterogeneity				Lead author (date)
				L	U				Q	p	I^2	T	
PANAS	1	30	4.185*	2.918	5.452		0.000	19					Haden (2014)
PARS	1	3178	3.540*	3.367	3.712		0.000	17					Pandya (2018)
BAV 3-11	1	24	1.214*	0.244	2.185		0.014	5					Richter (2016)
POMS-SF	2	172	0.504	-0.136	1.143		0.123	10	6.451	0.011	84.498	0.610	Khalsa (2012), Noggle (2012)*
SDQ	1	125	0.424*	0.070	0.778		0.019	1					Velasquez (2015)
STAI	2	127	0.131	-0.510	0.773		0.689	1	0.061	0.805	0.000	0.000	Carei (2010), Moody (2017)
RCMAS	1	25	0.081	-0.683	0.845		0.835	0					Kuttner (2006)
SCARED	1	198	0.037	-0.242	0.315		0.797	1					Quach (2016)
Total	10	3879	1.065	-0.140	2.270		0.083	43	812.65	0.000	98.893	1.915	

-1 0 1 2 3 4 5 6
Improvement with yoga

Abbreviations: $N_{studies}$ = number of studies providing this data, $N_{participants}$ = number of participants; g = Hedges' g (note: weighting only applies when two or more studies are pooled), CI = 95% confidence interval (with lower and upper limits), N_{fs} = fail safe N; Q = chi-squared test of heterogeneity; I^2 = proportional estimate of true effect variance over sampling error observed; T = equivalent to SD of g_w . State Trait Anxiety Inventory (STAI), Positive and Negative Affect Scales (PANAS), Profile of Mood States Short-Form (POMS-SF), Revised Child Manifest Anxiety Scale (RCMAS), Pediatric Anxiety Rating Scale (PARS), The Screen for Child and Anxiety Related Emotional Disorders (SCARED), Bochumer angstverfahren für Kinder im Vor- und Grundschulalter (BAV 3-11); Strengths and Difficulties Questionnaire (SDQ). *indicates significant finding, i.e. CI \neq 0, $p < 0.5$

Chapter 4

Discussion

Overview

This meta-analysis examined the effects of yoga as an alternative intervention in the management of anxiety symptoms in children and adolescents. Ten studies, comprising a pooled sample of 3,879 participants, were identified. The findings are promising, albeit preliminary: 50% of the interventions examined reported significant reductions in anxiety symptoms with the intervention of yoga, in comparison to controls that were provided with alternatives including those wait-listed, or those who received either standard care, physical education or training, an audio CD or religious education. Subgroup analyses suggested a possible dose-response effect, with significant group differences noted for yoga interventions that extend beyond 9 weeks. The results need to be considered in the context of the overall methodological quality of included studies. This included potential bias due to the lack of blinding of subjects and investigators as well as difficulty controlling potential sample and intervention confounders. The findings will be discussed and critically analysed in this chapter. Finally, implications for research and clinical practice will be explored.

Key Findings

Overall, studies that showed significant improvements in anxiety involved interventions with a longer duration (> 9 weeks) is effective in reducing anxiety. Whilst future research is needed to determine the optimal dosage, the findings are consistent with systematic reviews conducted by James-Palmer et al (2020) and Weaver and Darragh (2015) who both found that longer duration is associated with more significant outcomes in the reduction of anxiety. Although yoga appears to be an overall effective intervention, no

adverse outcomes were stated across studies. Low attrition rates were reported (5%), suggesting that yoga is both popular and acceptable for children. Although, this may be due to children having less choice in disengaging when yoga is conducted in a school setting as they become a captive audience and may lead to coercive recruitment. Group-based formats for yoga sessions were used for 8 out of the 10 studies, suggesting that this is the preferred mode of yoga interventions. Interestingly, the two remaining studies that did use an individual based format did not show significant results. On this basis, group sessions can be recommended as an effective format when designing a yoga intervention with the aim of significant outcomes.

The mean age, sex and health status of participants were quite diverse across the ten studies, making it difficult to compare based on children's developmental age and medical conditions. Additionally, attention span and concentration are likely to vary across different ages (Gaertner et al., 2008). In order to understand how the effectiveness of a yoga intervention differs across developmental stages for children, a cohesive age range may give a clearer indication of which age groups respond better to yoga. Overall, there was a higher number of female participation (55%) across studies in comparison to males (45%). Future research should consider potential differences for gender in responding to a yoga intervention as this is not yet clear (Kang et al., 2018). Tailoring a yoga intervention towards each sex group, as well as exploring mixed groups, will provide a more detailed account of how yoga as an intervention is effective for both males and females.

In this meta-analysis three studies used participants with specific health conditions including irritable bowel syndrome (Kuttner et al., 2006), eating disorders (Carei et al., 2010) and children hospitalised with sickle cell vaso-occlusive crisis (Moody et al., 2017). While each study did show overall positive effects from the yoga intervention, no significant

improvements in anxiety were reported. These physical illnesses present potential confounding effects and can be a barrier to significant reductions in anxiety for this group of studies (Remes et al., 2016). Identifying and making statistical adjustments for these confounding measures are suggested improvements that could be made for future studies using yoga as an intervention for children with comorbid clinical diagnoses. A potential area for development in clinical practice is to consider the effectiveness of yoga for children with specific health conditions and to consider what characteristics can be improved in order to target alternative supportive treatments.

In terms of feasibility and translation, integrating yoga into the school curriculums as part of physical education classes is a reasonable way forward, as it is a low-cost activity and easy to access. Minor attrition or dropout rates were reported for 8 out of the 10 studies. The average rate of dropout was 5%, indicating that the yoga classes were likely to have been a positive experience and confirms yoga is a feasible intervention that can be recommended for children. The high rates of acceptance found in children is inconsistent with the high attrition rates noted in adult studies (Kirkwood, Rampes, Tuffrey, Richardson & Pilkington, 2005; Becker, 2000).

No adverse events were identified. Cramer et al (2015) stated that whilst yoga appears to be a safe exercise, it is highly important for studies to diligently report adverse events. However, Cramer et al (2019) added that practising yoga without supervision is associated with higher risk of adverse events. As the treatment of yoga was led by a trained instructor in each of the studies reviewed, this decreased the risk of injuries and other adverse events occurring from the yoga intervention. Furthermore, the presence and availability of a certified yoga instructor in each of the studies represented, may have enhanced the motivation of students to remain engaged throughout the duration of the study.

Five studies demonstrated significant improvements in anxiety, four conducted in a school setting, and one from a worldwide Hindu organisation across multiple continents. There was a wide range of yoga styles implemented. Yoga styles included Viniyoga ($N_{studies} = 1$), Ashtanga ($N_{studies} = 1$), KRIPALU ($N_{studies} = 2$), Hatha and Iyengar ($N_{studies} = 1$), Asanas ($N_{studies} = 2$), Bala Vihar ($N_{studies} = 1$), Hatha ($N_{studies} = 1$), and Satyanada ($N_{studies} = 1$). Styles that demonstrated a significant effect included Ashtanga, KRIPALU, Bala Vihar, Asanas and Satyananda. All studies included the physical posture aspect of yoga, and some studies included breathing, meditation and/or relaxation. However, the variation in yoga interventions make it difficult to generalise the findings, and therefore, there is not enough evidence to recommend a specific type of yoga (James-Palmer et al., 2020).

The findings are consistent with other studies which found that the number of sessions attended has an impact on reducing feelings of anxiety (Weaver and Darragh, 2015). Therefore, the more sessions attended, the more impact the intervention has on the outcome of anxiety. A variety of positive emotional responses to yoga have also been identified among children, including relaxation, anger control, self-acceptance, attention and emotional competence (Mendelson 2010; Broderick & Metz 2009; Flook et al 2010; Schonert-Reichl & Lawlor 2010). More discerning research that explores the separate effects of yoga postures, breath control and relaxation techniques to determine which technique is the most effective in reducing anxiety would provide a greater insight into the critical components of yoga.

Although all studies used certified yoga instructors, the teaching styles, and the teaching context that the instructors used may have varied and are potential confounders, resulting in participants potentially receiving different exposure to yoga practices. This is a factor that may have impacted the overall findings on the anxiety outcome measures. Yoga

instructor training may be a mediating variable that can distinguish between significant effects of a successful or unsuccessful yoga intervention. The instructors play a large role in the atmosphere for the children and to motivate students to complete the yoga session (Hartley et al., 2014). Without detailed reporting of the teaching style and context, it is difficult to understand the impact that instructors have on the overall outcome of the findings. These findings are consistent with Weaver and Darragh's (2015) systematic review. It is important for future intervention research to carefully select trained instructors and to report this information. Standardised training is preferred in order to increase the likelihood of replication for future studies (Weaver & Darragh, 2015).

Four out of the ten studies had participants in their control group engaging in physical activity. The findings suggest that yoga was no more effective in reducing anxiety than the actively engaged control group. The lack of difference may be explained by recognising that learning a new activity such as yoga may be challenging for some, but also that any form of exercise is an effective treatment for reducing anxiety (Kaley-Isley et al., 2010). When comparing across interventions this way, it may be worth considering including a third arm of non-intervention, waiting list group, or usual care group. Furthermore, Kaley-Isley et al (2010) reported that increasing self-awareness through introducing a new activity may indeed present the risk of lowering self-esteem and lead to increased anxiety levels. Additionally, Benavides and Caballerro (2009) outlined that yoga can be effective, however in their study found that a child's confidence can determine the impact of the benefits and outcomes, which in turn may play a role in the overall findings.

The duration and frequency of the yoga interventions ranged from 1 week to 104 weeks. This limits the ability to compare the effects of anxiety across studies. Overall, studies that showed improvements in anxiety involved interventions with a longer duration (>

9 weeks) and participants engaging in sessions at least 2-3 times per week. However, considering the practicality and attention span for children, it is suggested that an intervention should last approximately for at least 30 minutes duration, 2-3 times a week for around 6-12 weeks (James-Palmer et al., 2020). Richter et al (2016) conducted a yoga intervention under this time frame (6 weeks) and showed significant improvements in anxiety, therefore making it problematic to determine what is a suitable dosage in relation to the desired outcome effect. Many of the reported findings could be due to the differing yogic elements, setting, method of delivery used in the intervention and other contextual dynamics. Consistency of study design in future research is needed to determine what 'dosage' is required to achieve optimal functioning and improvements in anxiety.

Anxiety can be a daily struggle for children and adolescents, therefore involving the repetition and practice times recommended could be a more effective application of yoga (Weaver and Darragh, 2015). Additionally, yoga skills are likely to improve over time with practice and therefore the benefits may improve for those who commit to engaging more frequently in this intervention, thereby increasing their competency (Moody et al., 2017). The overall findings are consistent with systematic reviews by Weaver and Darragh (2015) and James-Palmer et al (2020) who agree that interventions of longer duration are typically associated with better outcomes for anxiety in children. Furthermore, Telles et al (2015) found that the number of sessions attended is likely to have an impact on reducing feelings of anxiety. The optimal amount of sessions therefore could be a focus for future research.

Clinical Implications

The findings may have clinical implications for yoga therapists and instructors as well as other health professionals in working with children in their aim to reduce anxiety. Anxiety disorders are highly prevalent among children and adolescents, and this can persist into

adulthood, affecting functioning in daily life. It is therefore important to understand how yoga can be effective as an intervention, and if it could be a suitable alternative approach to other treatments for anxiety in children. It could help to avoid the use of powerful medications such as anxiolytics, which have a high risk of uncomfortable side effects (Kodish, Rockhill & Varley, 2011). Although cognitive behavioural therapy (CBT) has been recognised as an effective treatment for anxiety disorders, there is room for other supportive interventions (Hoffman & Smits, 2008). Research suggests that CBT should only be applied once the child has reached a certain level of cognitive development, and that young children are more responsive to the behavioural aspect of CBT rather than the equally important cognitive elements of this approach (Essau, 2014). Furthermore, parental involvement is important in the treatment of anxiety disorders in children as studies have reported positive outcomes for parent-only CBT, however there are inconsistent findings with child only treatment (Monga, 2015; Waters, 2009).

With 50% of studies showing improvements in anxiety from a yoga intervention, it should be considered as a potential low risk treatment option. Foa, Keane, Friedman and Cohen (2009) suggest that combining yoga as an adjunct with other current evidence-based treatments such as CBT would be a useful approach. However, additional research is needed to assess which combined approaches are best suited and whether combinatorial treatments are more effective than a phased approach of offering yoga first, followed by an exposure or cognitive processing style treatment (Foa, Keane, Friedman & Cohen, 2009).

Future studies should consider utilising a larger sample size in order to examine the benefits of yoga for a larger population, have a higher dose of the intervention and measure of anxiety as their primary outcome. Yoga is a low-cost intervention that can be applied in most settings, at school, home, community groups or in a treatment centre such as hospital.

Although the findings suggest longer intervention duration demonstrates the best chance of improvement, further research is needed to gain a deeper understanding of other factors that are likely to be effective in reducing anxiety in children. Additionally, future studies should focus on improving the planning and methodological quality of studies and aim to conduct intervention studies with rigorous methodology with detailed protocol descriptions of the yoga intervention, environment and reporting of results.

Ideally, the same assessment tools to measure the effectiveness of the outcome should be consistent used across studies. Longitudinal follow-up would be helpful to see how yoga benefits anxiety outcomes in the long term, providing evidence for the longevity of results. It is recommended that future studies provide a greater understanding of the physiologic and psychological mechanisms that may underlie change following yoga interventions, considering changes in biological phenomena like pulse, blood pressure, and physiological stress symptoms (Greenberg & Harris, 2012; Larun, Nordheim, Ekeland, Hagen & Heain, 2009).

The majority of research on yoga intervention studies have primarily been conducted in India. Although yoga is becoming increasingly popular in many new countries, it is possible that the cultural context and meaning of yoga practice may have an important influence on positive outcomes (Greenberg & Harris, 2012). Furthermore, the increase in publications of yoga studies in recent years, does suggest that both the interest in yoga and yoga research is increasing in many areas of the world. Further research is recommended to investigate how various countries accept and interpret yoga in their respective cultures (Greenberg & Harris, 2012). A study by Pandya (2018) recruited participants through a Hindu organisation and showed significant positive outcomes for anxiety in children. The

cultural meaning and religious style setting of the intervention for each study may have played a role in influencing the overall findings and determining a significant effect.

Limitations

There were several limitations encountered in this study, and therefore, the present findings should be interpreted with caution. Firstly, a methodological limitation was the restrictive inclusion and exclusion criterion that was used to search the databases. This methodological aspect may have impacted the number and types of studies, as well as failing to capture all possible relevant studies. The evidence for yoga and anxiety may differ if a broader search was used with less restrictive criteria, and therefore including alternative definitions of yoga and yoga-based intervention studies. The parameters included the requirement of studies to make reference specifically to ‘yoga’, ‘children’, and ‘anxiety’, in their aims or intervention description. However, to minimise this limitation, these search terms were used across multiple databases, in addition to the search strategy of manually searching reference lists of studies and contacting authors if data were unavailable. Additionally, only studies published in peer reviewed journals which were also available in the English language were included. This may have increased the likelihood of publication bias and the findings being subject to some degree of language bias, in that studies from other cultures and languages may have offered new insights, particularly since most yoga studies were completed in India.

In order to reduce risk of publication bias, Orwin’s N_{fs} statistics were calculated. Although, the inclusion of this statistic minimises risk, it does not entirely alleviate this problem (Orwin, 1983). The choice of using a random-effects model is another limitation, and this was used due to study measures being different across studies. Although the random effects model is typically the appropriate model for conducting a meta-analysis, with a small

number of studies, the estimate between study variance can have poor precision (Borenstein, Hedges, Higgins & Rothstein, 2010). Between-study heterogeneity was analysed using the Q -test based on an analysis of variance where the null hypothesis states that there is no significant group difference in anxiety based on the subgroup. However, this test suffers from poor power and may detect clinically unimportant heterogeneity when studies are pooled. Due to the small number of studies collected, the Q statistic estimator of between-study variance cannot be used to compare the degree of heterogeneity between different meta-analyses (Hardy and Thompson, 1998; Jackson, 2006). Future studies should consider exploring potential sources of between-study heterogeneity.

Another limitation is that the definition and use of the word yoga was quite specific, and therefore excluded studies that included similar relaxation techniques (e.g., mindfulness-based stress reduction) which could be considered to incorporate aspects of yoga. A major limitation in terms of outcome measures, was that there were multiple self-report measures included which differ in their psychometric properties and their ability to detect changes in anxiety. In each measure, the baseline levels of anxiety may differ and therefore observing the differences in anxiety from pre- to post-intervention is difficult to compare between studies. The Strength and Difficulties Questionnaire (SDQ) and the Positive and Negative Affect Scale (PANAS) measured broad constructs and do not directly measure anxiety. However, both the State Trait Anxiety Inventory (STAI; Carei et al., 2010; Moody et al., 2017) and the Profile of Mood States Short-Form (POMS-SF; Khalsa et al., 2012; Noggle et al., 2012), was used in more than one study, although the remaining outcome measures varied. It would be more reliable in future studies if one measure was used consistently across studies. Additionally, using a clinician rated measure would be beneficial to minimise any bias.

No adverse events were stated or reported across studies, and it is therefore difficult to conclude about the assessment of safety for children and adolescents with anxiety in relation to these interventions. As noted earlier, the lack of reporting of adverse events is of concern. Collecting data by a variety of outcome measures may impact on results, as specific yoga elements should be named as part of the intervention protocol with a brief description for further clarity in the studies, method and setting should also be clearly identified, and any adverse events or the absence of adverse events should be clearly documented (Paulhus & Vazire, 2007).

Ideally the potential role of age and gender should be explored to provide a deeper understanding of what mechanisms or aspects of yoga reduce anxiety. It is recommended that further analysis of the effects specifically in relation to sex, existing medical health disorders and age may yield in order to achieve better results and a deeper understanding of what aspects of yoga may most effectively reduce anxiety (Hoffman, Sawyer, Witt, & Oh, 2010). Intensity was operationalised in this study by focusing on the duration of the intervention, however ideally this should also be combined with frequency (i.e., frequency plus duration). Future research is needed to further define the optimal dosage, that is program duration required to reduce anxiety symptoms in children. Despite these limitations, this meta-analysis provides a screening and summary of the current available evidence-based research for yoga interventions for anxiety in children and can assist in directing future studies.

Conclusion

This meta-analysis explored how yoga interventions can have an impact on anxiety outcomes in children. There is evidence that suggests yoga interventions have a positive impact on anxiety in children, however the effectiveness is dependent on the duration of the

intervention. A 'dose' effect was found, indicating that the longer duration, the more significant the outcomes. There was no significant aspect of yoga or specific style of yoga proving to be more effective than other types of physical exercise. In order for the impact of yoga to be understood as an evidence-based intervention and applied appropriately, more research is needed to further determine the effectiveness of yoga as an alternative intervention for children. Future research can benefit and extend on these findings by considering these recommendations and limitations. A key takeaway is that researchers using yoga as an intervention need to operate with greater methodological rigour, focusing on interventions that have a longer duration and a higher frequency, whilst measuring these factors with a consistent outcome measure. Furthermore, precise protocols with a more specific framework is needed to investigate both the process, context, and the impact of yoga interventions.

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Note: References marked with an asterisk indicate studies included in the meta-analysis.

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Appendices

Appendix A: Logic Grids Developed per Database

Logic grids for each database, informing overall search strategy.

Table A1.

Logic grid for PubMed

Yoga	AND	Anxiety	AND	Children
“Yoga” [mh]		“Anxiety” [mh]		“children” [mh]
OR		OR		OR
“Mindfulness”[mh]		Anxiet*[tw]		“pediatric” [mh]
OR		OR		OR
mindful*[tw]		“anxiety		pediatric*[tw]
OR		disorders” [mh]		OR
“Meditation”[mh]				paediatric*[tw]
OR				OR
yogi [tw]				“child” [mh]
OR				OR
Yoga [tw]				child*[tw]
				OR
				minor*[tw]
				OR
				“adolescent”
				[mh]
				OR
				adolescen*[tw]
				OR
				teen*[tw]
				OR
				Youth [tw]
				Juvenil* [tw]

Note: Search was conducted on March 29, 2019. Search yielded 434 studies. No date or language filters were applied.

Table A2.

Logic grid for PsycINFO

Yoga	AND	Anxiety	AND	Children
exp yoga		exp anxiety/		exp pediatrics/
OR		OR		OR
mindful*.mp		anxiety.mp		p?ediatric*.mp
OR		OR		OR
meditation*.mp		anxiety dis*.mp		child*.mp
OR				OR
yoga.mp				adolescen*.mp
				OR
				teen*.mp
				OR
				youth*.mp
				OR
				juvenil*.mp
				OR
				minor*.mp

Note: Searched conducted on March 29, 2019. Search yielded 283 results. No date or language filters were applied.

Table A3.

Logic grid for Embase

Yoga	AND	Anxiety	AND	Children
'yoga'/exp		'anxiety'/exp		'pediatrics'/exp
OR		OR		OR
mindful*		anxiety*		p\$ediatric*
OR		OR		OR
mindful/exp		anxiety dis*		juvenile*
OR				OR
meditation*				'child'/exp
OR				OR
meditation/exp				child*
OR				OR
yog*				'adolescent'/exp
OR				OR
yog/exp				adolescen*
				OR
				'youth'/exp
				OR
				youth*
				OR
				teen*
				OR
				'minor'/exp
				OR
				minor*

Note: Search conducted on March 29, 2019. Search yielded 981 results. No date or language filters were applied.

Appendix B: PRISMA Checklist

Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Checklist (Moher et al., 2009).

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	5
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	9
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	18-19
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	-
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	20
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	20
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	20-21
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	21
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	22
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	22
Risk of bias in individual	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was	22-23

studies		done at the study or outcome level), and how this information is to be used in any data synthesis.	
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	23-24
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I ²) for each meta-analysis.	23-24
Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	22-23
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	25
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	26
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	27-28
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	29
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	31-34
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	31-33
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	29-30
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	33
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	35
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	43-45
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	45-46
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	N/A

Appendix C: QualSyst Reporting Quality Criteria

Criterion	Yes (Score 2)	Partial (Score 1)	No (Score 0)
1. Question or objective sufficiently described	Study aims and/or research questions are easily identified in the Introduction (or first paragraph of Methods).	Vaguely/incompletely reported (e.g. “describe the effect of” or “examine the role of”)	Study aims and/or research questions not reported.
2. Design evident and appropriate to answer study question	Explicit mention of study design	Design not clearly identified but appears appropriate.	Design is not appropriate to answer study question.
3. Method of subject selection Is described and appropriate.	Described and appropriate. Selection strategy designed to obtain an unbiased sample of the relevant target population or the entire target population.	Selection methods not completely described, but no obvious inappropriateness, but likely to introduce bias	No information provided about the selection procedures.
4. Sample characteristics sufficiently described	Sufficient relevant baseline/demographic information clearly characterizing the participants is provided.	Poorly defined criteria or incomplete relevant baseline / demographic information	No demographic information provided.
5. Random allocation	True randomization done - requires a description of the method used (e.g., use of random numbers).	Randomization mentioned, but method is not (i.e. it may have been possible that randomization was not true).	Random allocation not mentioned although it would have been feasible and appropriate (and was possibly done).
6. Blinding of investigators	Blinding reported.	Blinding reported but it is not clear who was blinded.	Blinding would have been possible but not reported.
7. Blinding of subjects	Blinding reported.	Blinding reported but it is not clear who was blinded.	Blinding would have been possible but not reported.
8. Outcome well defined and robust.	Defined measured according to reproducible, “objective” criteria.	Definition of measures leaves room for subjectivity, or not sure	Measures not defined or are inconsistent throughout the paper.
9. Sample size appropriate	Reasonable with respect to the outcome under study and the study design.	Insufficient data to assess sample size.	Obviously inadequate, statistically non-significant results and standard errors > ½ effect size.
10. Analysis described and appropriate	Analytic methods are described (e.g. “chi square”/ “t-tests”/“Kaplan-Meier with log rank tests”, etc.) and appropriate.	Analytic methods are not reported and have to be guessed at but are probably appropriate. Or minor flaws or some tests appropriate, some not.	Analysis methods not described and cannot be determined. Or obviously inappropriate analysis methods.
11. Some estimate of variance is reported for main outcomes	Appropriate variances estimate(s) is/are provided (e.g., range, distribution, confidence intervals, etc.).	Variance estimates provided for some, but not all main results/outcomes.	No information regarding uncertainty of the estimates.
12. Controlled for confounding	Randomized study, with comparability of baseline characteristics reported	Incomplete control of confounding. Or control of confounding reportedly done but not completely described.	Confounding not considered and may have seriously distorted the results.
13. Results reported in sufficient detail	Both primary and secondary outcomes reported	Quantitative results reported only for some outcomes.	Quantitative results reported for a subsample, or results for some major or outcomes only.
14. Results support the conclusions	Conclusions are supported by the data. Authors acknowledge limitations of study/	Some of the conclusions are supported by the data, some are not.	No conclusions or negative findings (due to low power) are reported as definitive evidence.

Appendix D: Individual Risk of Bias Assessment*Table B1: Reporting quality of included studies based on QualSyst ($N_{studies} = 10$)*

Lead author (date)	1. Question/objective	2. Study design	3. Method subject selection	4. Subject characteristics	5. Random allocation	6. Blinding of investigators	7. Blinding of subjects	8. Outcome measurement	9. Sample size appropriate	10. Analytic method	11. Estimate of variance	12. Control for confounding	13. Results in detail	14. Conclusion supports results	Sum Score	Total Sum ÷ Total Possible Sum
Carei (2010)	2	2	2	2	2	0	2	2	1	2	2	0	2	2	23	0.82
Haden (2014)	2	2	2	2	2	2	2	2	1	2	2	0	2	1	24	0.86
Khalsa (2012)	2	2	2	2	2	0	2	2	1	1	2	0	2	1	21	0.75
Kuttner (2006)	2	2	2	2	2	0	0	2	1	2	2	0	2	2	21	0.75
Moody (2017)	2	2	2	2	2	2	0	2	1	2	2	0	2	2	23	0.82
Noggle (2012)	2	2	2	2	2	0	2	2	1	2	2	0	2	1	22	0.79
Pandya (2018)	2	2	2	2	2	0	2	2	2	2	2	0	2	2	24	0.85
Quach (2016)	2	2	2	2	2	0	0	2	2	2	2	0	2	2	22	0.79
Richter (2016)	2	2	2	2	2	0	0	2	1	2	2	0	2	2	21	0.75
Velasquez (2015)	2	2	2	2	2	0	0	2	2	2	2	0	2	2	22	0.78

Scoring note: 2 = criterion met; 1 = criterion partially met; 0 = criterion not met or unclear.