Psychiatry Research 340 (2024) 116098

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Review article

Efficacy of yoga for posttraumatic stress disorder: A systematic review and meta-analysis of randomized controlled trials

Seyed Aria Nejadghaderi [a,b], Seyed Ehsan Mousavi [c,d], Asra Fazlollahi [e], Kimia Motlagh Asghari [c], Dana Rose Garfin [f,*]

[a] HIV/STI Surveillance Research Center, and WHO Collaborating Center for HIV Surveillance, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran
[b] Systematic Review and Meta-analysis Expert Group (SRMEG), Universal Scientific Education and Research Network (USERN), Tehran, Iran
[c] Neurosciences Research Center, Aging Research Institute, Tabriz University of Medical Sciences, Tabriz, Iran
[d] Social Determinants of Health Research Center, Department of Community Medicine, Faculty of Medicine, Tabriz University of Medical Sciences, Tabriz, Iran
[e] Student Research Committee, Tabriz University of Medical Sciences, Tabriz, Iran
[f] Community Health Sciences, Fielding School of Public Health, University of California, 560 Charles E Young Drive South, Box 951772, Los Angeles, CA 90095, USA

ARTICLE INFO

Keywords:
PTSD
Mindfulness
Complementary health
Meditation
Traumatic stress
Randomized controlled trial
Pooled analysis
Integrative health

ABSTRACT

Yoga is an increasingly popular complementary intervention to reduce posttraumatic stress disorder (PTSD) symptoms and related comorbidities, but its safety and treatment efficacy are not firmly established. We conducted a systematic review and meta-analysis of existing randomized control trials (RCTs) of yoga interventions for PTSD and related secondary outcomes (e.g., depression). Initial search results found over 668 potential papers. Twenty met inclusion criteria (e.g., RCTs on adult participants with PTSD that evaluated safety or efficacy outcomes). Meta-analysis indicated that, compared to control interventions, participation in yoga interventions significantly improved self-report PTSD (standardized mean difference [SMD]: -0.51; 95 % confidence interval [CI]: -0.68, -0.35) and immediate (SMD: -0.39; 95 % CI: -0.56, -0.22) and long-term (SMD: -0.44; 95 % CI: -0.74, -0.13) depression symptoms. However, using clinician-reported assessments, yoga interventions were not associated with improved PTSD symptoms. Type of yoga differentially predicted outcomes. Sensitivity analysis showed consistent effect sizes when omitting each study from main analyses. Six studies reported whether any serious adverse events occurred. None were indicated. No publication bias was found, although individual intervention studies tended to be high in bias. Results suggest yoga is likely a safe and effective complementary intervention for reducing PTSD and depressive symptoms in individuals with PTSD. More rigorous RCTs are warranted.

1. Introduction

Posttraumatic stress disorder (PTSD) is an often debilitating psychiatric condition that can occur in individuals who have experienced or witnessed a traumatic event (Criterion A) (American Psychiatric Association, 2013) and includes a constellation of four symptoms, which must be present for more than one month: re-experiencing or intrusive symptoms such as unwanted thoughts, flashbacks, and nightmares (Criterion B); avoidance (Criterion C); negative changes in thinking, mood, and angry outbursts (Criterion D); and marked alterations in arousal and reactivity, irritability, reckless or self-destructive behavior, hypervigilance, an exaggerated startle response, problems with concentration, and sleep disturbances (Criterion E) (Pai et al., 2017). PTSD also negatively impacts an individual's overall well-being and social and occupational functioning (Criterion F) (American Psychiatric Association, 2013).

A recent systematic review indicated a 3.4 %–26.9 % lifetime prevalence of PTSD among civilian populations in the United States (Schein et al., 2021). Prevalence of PTSD in mental health treatment facilities is estimated at nearly 50 % (Maercker et al., 2022). First-line treatments for PTSD typically involve trauma-focused psychotherapy, with pharmacotherapy recommended as a second-line treatment (Lee et al., 2016; National Collaborating Centre for Mental Health, 2005; World Health Organization, 2013). Yet pharmacotherapy and psychotherapy for PTSD

* Corresponding author.
E-mail address: dgarfin@ucla.edu (D.R. Garfin).

https://doi.org/10.1016/j.psychres.2024.116098
Received 3 August 2023; Received in revised form 24 April 2024; Accepted 21 July 2024
Available online 22 July 2024

can be expensive and may not always provide satisfactory outcomes; symptoms are often recalcitrant (Haagen et al., 2015; Sonis and Cook, 2019; Watkins et al., 2018; Williams et al., 2022). For example, pharmacotherapy has a response rate of about 55 % for those in PTSD treatment (Gu et al., 2016). A recent systematic review estimated the annual direct costs of PTSD treatment as high as $19,500 per person (provided in purchasing power parities [PPP] for cross-national standardization of cost), with medication only regimens tending to be much lower and inpatient treatment increasing costs (von der Warth et al., 2020). Further, the additional indirect costs (e.g., lost productivity, informal caregiving) of PTSD treatment were estimated at over United States $5,000 PPP per person (von der Warth et al., 2020). While medication management of PTSD may lower costs (von der Warth et al., 2020), such interventions often come with side effects including gastrointestinal (e.g., diarrhea) and neurological (e.g., headache) problems and may not address the underlying causes of PTSD such as impairments in emotion regulation, maladaptive behaviors, and other neurobehavioral/contextual mechanisms (Williams et al., 2022).

Psychotherapy, while effective for many individuals, can be a lengthy and costly process (Watkins et al., 2018). For example, a systematic review estimated the costs of prolonged exposure therapy and cognitive processing therapy (CPT) for PTSD at $2,300 and $2,100, respectively (Tran et al., 2016). Since many individuals with PTSD experience persistent symptoms despite receiving conventional treatments, there has been a growing interest in complementary and integrative treatments (Haagen et al., 2015) such as yoga, which has emerged as a potentially beneficial and cost-effective adjunct to traditional care (Kim et al., 2013b; Strauss et al., 2011; Wynn, 2015). In addition to other therapeutic options for PTSD like pharmacotherapy and psychotherapy, yoga tends to be a low cost and minimally invasive intervention (Chawla et al., 2023). Additionally, since patient choice is important when working with trauma survivors, such alternatives to traditional trauma therapy (including medication management) are important to investigate. Yet, despite the growing interest in yoga as a PTSD treatment, there is need for an up-to-date systematic evaluation of yoga for PTSD.

1.1. Yoga for PTSD

Yoga is an ancient practice originating in India approximately 3,000 years ago and combines physical postures, breath control, meditation, and mindfulness techniques to promote physical, mental, and emotional well-being (Iyengar, 1965; Woodyard, 2011). Yoga has been increasingly used as a complementary and integrative therapy for mental health conditions including PTSD (Kamraju, 2023). Yoga may help address PTSD symptoms by improving emotion and sympathetic nervous system regulation, reducing hyperarousal and enhancing vagal activity, a key component of the parasympathetic nervous system (Kamraju, 2023; Riley and Park, 2015). Yoga may facilitate self-regulation by increasing parasympathetic control, reducing physiological responses to stress and lowering prolonged emotional reactivity and related autonomic responses (Roche, 2018). This may occur acutely (during or immediately after a yoga session) and gradually through the adjustment of an individual's physiological baseline reactivity over consistent, long-term yoga practice (Voss et al., 2023).

Communication between the hypothalamic-pituitary-adrenal axis and brainstem vagal efferents (i.e., nerve fibers that transmit signals from the central nervous system), which are both parts of the parasympathetic system affected by yoga, can help regulate and maintain homeostasis across various bodily systems (Voss et al., 2023). Hence, yoga may affect physiological indicators associated with PTSD symptom onset and maintenance, including blood pressure, heart rate, cortisol, or cytokine levels; these benefits may help improve mood, emotion regulation, and functioning across multiple brain regions (Pascoe et al., 2021). Further, engaging in yoga practices may improve cognitive and behavioral adjustment by enhancing awareness of the mind and body, increasing participation in enjoyable activities, improving emotion-regulation skills, and reducing re-experiencing and avoidance symptoms (Van Der Kolk et al., 2014a; Yi et al., 2022a). This mind-body connection is especially useful for individuals with PTSD as it addresses both the physiological and psychological aspects of many PTSD symptoms (Kim et al., 2013a; Zhu et al., 2021).

There are a variety of yoga types, drawing from four overarching lineages including Jnana, Bhakti, Karma, and Raja. These modalities target intellectual processes, emotion regulation, performance of beneficial action without attachment (e.g., selfless acts to help others), and conscious control of will, respectively (Govindaraj et al., 2016). From these, a variety of specific yoga programs have emerged, a number of which have been evaluated as possible complementary and integrative treatments to address symptoms of PTSD. These include the following:

- Kundalini, a dynamic yoga that combines physical postures, breathwork, meditation, and chanting to awaken dormant energy (Shannahoff-Khalsa, 2004).
- Sudarshan Kriya Yoga (SKY), which is focused on breath control techniques;
- Patanjali Ashtanga, which focuses on contemplative and purification practices (Govindaraj et al., 2016; Zope and Zope, 2013).
- Kripalu yoga, which focuses on the integration of physical postures, breathwork, and meditation and emphasizes dynamic meditation (Reinhardt et al., 2018).
- Hatha yoga, a general form that encompasses various elements such as physical postures (asanas), breath control techniques (pranayama), meditation (dhyana), and relaxation, as well as guidance on nutrition and lifestyle aspects (Tew et al., 2017).

Some yoga programs have been specifically designed to address symptoms of PTSD. These include Yoga Therapy for Trauma and PTSD (Lang et al., 2021a; Morrison and Dwarika, 2022; Van Der Kolk et al., 2014c) and Trauma Sensitive Yoga (e.g., Trauma Center Trauma-Sensitive Yoga [TCTSY]), which is a type of Hatha yoga that employs a gentle teaching style and provides a safe space for individuals to develop compassionate awareness of their body's sensations in the present moment (West et al., 2017). These divergent programs may exhibit differential efficacy for reducing PTSD symptoms. However, despite the growing popularity of yoga, an updated examination of the relative efficacy of these interventions for addressing PTSD has not been conducted.

1.2. Previous evidence on the efficacy of yoga for PTSD

A previous systematic review assessed the evidence of yoga for reducing PTSD symptoms (Cramer et al., 2018a) and another systematic review evaluated the effects of yoga, mindfulness, and integrative exercise on consequences of psychological trauma (Taylor et al., 2020). Yet there are several limitations in the prior reviews that necessitate an update and expansion. The review by Cramer et al. (2018a) completed its search in 2017, did not report publication bias, did not perform subgroup and sensitivity analyses on type of yoga or diagnostic methods of PTSD, included studies with primarily self-report measures for PTSD diagnosis, included only three studies that reported safety-related data, and included only ten studies with a total sample size of 284 participants (Cramer et al., 2018a). The Taylor et al. (2020) review included only ten studies that focused on yoga and combined different outcomes, including PTSD symptoms, stress, and anxiety. Moreover, it was not focused on patients with specific PTSD diagnoses and completed its search in 2018 (Taylor et al., 2020). Since 2017, yoga has been growing in popularity in clinical practice and research (Gupta et al., 2023). Thus, more recent research, which may have improved upon the limitations identified in previous reviews, had not yet been synthesized. Additionally, although PTSD can increase the risk of other psychiatric disorders like major depression and anxiety (Breslau, 2002), the prior reviews did

not comprehensively evaluate such relevant secondary outcomes as independent constructs.

1.3. The present study

To address these limitations, we conducted a systematic review and meta-analysis of randomized controlled trials (RCTs) of yoga for PTSD to provide an updated, comprehensive, and robust evaluation of the current evidence on the efficacy, trial retention, and safety of yoga-based interventions for reducing PTSD symptoms. Although there have been previous systematic reviews exploring the benefit of yoga for treating PTSD, our report sought to expand the prior literature in several ways. We updated the literature search from previous reports, including more recent studies, and examined variability in efficacy across type of yoga (Cramer et al., 2018a). We performed PTSD-specific sensitivity and subgroup analyses, and evaluated publication bias. We separated self- and clinician-report assessment tools. We also examined the potential benefit of yoga on relevant secondary outcomes including depression, anxiety, emotion-regulation, mindfulness, quality of life, quality of sleep, and trial retention. In sum, we sought to present the most current and comprehensive review of yoga for PTSD based on the extant literature.

2. Method

Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were implemented (Page et al., 2021). All procedures were registered in the PROSPERO database under the registration number CRD42023404708 on March 14, 2023 (Garfin et al., 2023). PICO (patient, problem, or population, intervention, comparison or control, and outcome) framework, outcome definitions, and subgroups of interest were decided a-priori and included in the PROSPERO registration. Our PICO framework included population (adult patients aged at least 18 years old with PTSD); intervention (yoga - regardless of style, frequency, and duration); comparison (no treatment, received placebo, or interventions for controlling attention of therapists without any therapeutic effectiveness); and outcomes (changing symptoms of PTSD, anxiety, depression, emotion-regulation, mindfulness, quality of life, quality of sleep, retention in the trial, and adverse events).

2.1. Search strategy

PubMed, Scopus, Embase, Cochrane Central Register of Controlled Trials, PsycINFO, and Web of Science databases were searched for articles reporting any RCTs investigating the efficacy or safety of yoga on individuals with PTSD published prior to March 5, 2023. Subsequently, the top 300 results of the Google Scholar search engine were manually searched for all entries prior to April 10, 2023. No filters (including date, study type, or language) were set to any search fields. Retrospective and prospective citation searches of all included articles were performed to find other qualified studies. Studies included in prior systematic reviews that were found in our database searching or by hand searching were screened to identify any additional publications meeting our inclusion criteria. The search was conducted in duplicate by two independent authors (SAN and SEM). The following primary keywords were used in the search strategy: ("yoga" OR "asana*" OR "pranayama" OR "dhyana" OR "Hatha" OR "Jivamukti") AND ("post-traumatic stress disorder" OR "PTSD" OR "Stress Disorder" OR "Post-Traumatic Neuroses" OR "Moral Injury"). The detailed search strategy is indicated in Table S1.

2.2. Study selection

Studies were included if they: (1) were an RCT assessing the effectiveness or safety of yoga on adult participants with PTSD or PTSD associated physical or mental health comorbidities, (2) included adult participants with PTSD who were diagnosed using a validated clinician-administered or a self-report instrument [e.g., Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), International Classification of Diseases (ICD) criteria], (3) had a control arm that received no treatment, a placebo treatment, or other non-yoga-based comparator group (e.g., CPT), and (4) evaluated the efficacy of yoga according to changes in symptoms of validated clinician-administered- or self-report instruments.

Studies were excluded if they: (1) were not RCTs, (2) included participants without PTSD, (3) used a PTSD diagnosis derived from a physician diagnosis ascertained without a validated instrument (e.g., by a physician or researcher asking the participants "do you have PTSD?" or "have you ever been told by a doctor or personally thought you had PTSD?" without confirmation from a validated instrument), (4) if the article assessed PTSD symptoms in the absence of a diagnosis, (5) did not include yoga as a treatment strategy, and (6) used a pre-test/post-test design. Studies that included different groups of patients with other mental disorders were included as long as the study also reported the safety or efficacy outcomes separately for those with PTSD. Studies that included only participants with subclinical/partial PTSD or that reported posttraumatic stress symptoms rather than a PTSD diagnosis were excluded.

All articles found via electronic and manual searches were exported to EndNote 20; duplicates were eliminated using the de-duplication of database search results feature (Bramer et al., 2016). Two authors (SAN and KMA) independently screened the title and abstract of the articles; studies that did not meet inclusion criteria were eliminated. Then, the same authors reviewed the full texts of remaining articles to confirm they met inclusion criteria. Any disagreements were settled through discussion; additional authors were consulted if necessary.

2.3. Data extraction

Data extraction was conducted using pre-designed Microsoft Office Excel sheets. Two authors (SEM and AF) independently retrieved the following information from each included study: first author, year of publication, study country, trial identifier, phase of clinical trial, study design (e.g., parallel, cross-over, or factorial), number of arms, total number of participants, number of participants in each arm, mean (and standard deviation) or median (interquartile range) age of participants in each arm, number of males in each arm, race/ethnicity of participants in each arm, number of participants that completed the trial in each arm, PTSD diagnostic instrument, duration of follow-up assessment (immediate post-intervention follow-up and secondary follow-up were analyzed separately), type of yoga and its characteristics, type of control group (e.g., wait-list or CPT), mean and standard deviation of each non-PTSD measurement in each arm, total number of any grade adverse events in each arm, and adverse events reported by study (yes/no). Adverse events were defined as negative clinical occurrences that occurred in research subjects following the administration of yoga. Any disagreements were settled through discussion or consultation with other authors.

2.4. Quality assessment

Using Version 2 of the Cochrane risk-of-bias instrument for randomized trials (RoB 2), two reviewers (SAN and AF) independently assessed the risk of bias and the quality of the included articles (Sterne et al., 2019). RoB 2 uses the following five potential areas of bias to classify studies as having high, low, or some concerns: randomization method, variations from the intended interventions, missing outcome data, measurement of the outcome, and selection of the reported outcomes. Each study's total (overall) risk of bias was also estimated. Any disagreements were settled through discussion or consultation with other authors. The robvis package in R software was utilized to create risk of bias graphs (McGuinness and Higgins, 2021).

2.5. Statistical analysis

The meta-analysis was performed in R studio 4.3.0 (R Foundation for Statistical Computing) (R Core Team, 2023) using meta (Balduzzi et al., 2019) and metafor (Viechtbauer, 2010) packages. A random-effect model was utilized to pool the effect sizes of included studies due to methodological heterogeneity among studies (i.e., all RCTs) (Deeks JJ, 2019). For continuous outcomes, within each individual study, the standardized mean difference (SMD) was calculated as *Hedges' g* to correct for possible small sample sizes (Higgins et al., 2019). Between-study variance was estimated with the restricted maximum-likelihood estimator (Langan et al., 2019; Viechtbauer, 2005); I^2statistics using Q-statistics were reported. For analyses of retention in the trials, the odds ratio (OR) for each study was calculated; the between-study variance was estimated with the Paule-Mandel estimator (Langan et al., 2019).

The Knapp and Hartung technique was used to generate the confidence interval (CI) around the pooled effect based on the *t*-distribution to account for uncertainty in our estimate of between-study heterogeneity (Hartung and Knapp, 2001). When the number of trials is restricted, the Knapp and Hartung technique reduces the probability of false positives (Langan et al., 2019). The prediction interval was generated to show the extent of heterogeneity in our meta-analysis if at least ten studies met the inclusion criteria (Riley et al., 2011). The prediction interval is defined as the range of effect sizes within which a potential new study would fall if it were chosen at random from the same population of studies included in the meta-analysis (Ades et al., 2005). The type of yoga used in the intervention was evaluated in subgroup analysis. A drapery plot was built to display each study's confidence curve, pool effect, and prediction range for different values of *p* (Rücker and Schwarzer, 2021).

Since ten or more studies were ultimately included in the meta-analysis (Sterne et al., 2011), publication bias was assessed by funnel plot asymmetry, the corrected Begg and Mazumdar rank correlation test (Begg and Mazumdar, 1994; Kendall, 1990), and the Egger regression test (Egger et al., 1997). Furthermore, a sensitivity analysis was performed to assess the robustness of the pooled estimate and to compute the metrics after the influential study was removed. Analyses were conducted separately for studies that used clinician administered measures of PTSD compared to studies that used self-report questionnaires, consistent with Cochrane guidelines.

3. Results

3.1. Literature search

The search identified 1,506 records from PubMed (*n*=187), Scopus (*n*=371), Web of Science (*n*=266), Embase (*n*=381), PsycINFO (*n*=193), and Cochrane Central Register of Controlled Trials (*n*=108). One additional study was found using Google Scholar. Among them, 668 remained after the removal of 839 duplicates. After screening the title and abstracts, 639 additional articles were excluded. Most of these articles were excluded because they were not RCTs or they were not conducted on patients with PTSD. After assessing the 29 remaining articles for eligibility, six studies did not evaluate PTSD (Bhandari, 2022; Clark et al., 2014; Huberty et al., 2019; Mueller, 2014; Stoller et al.,

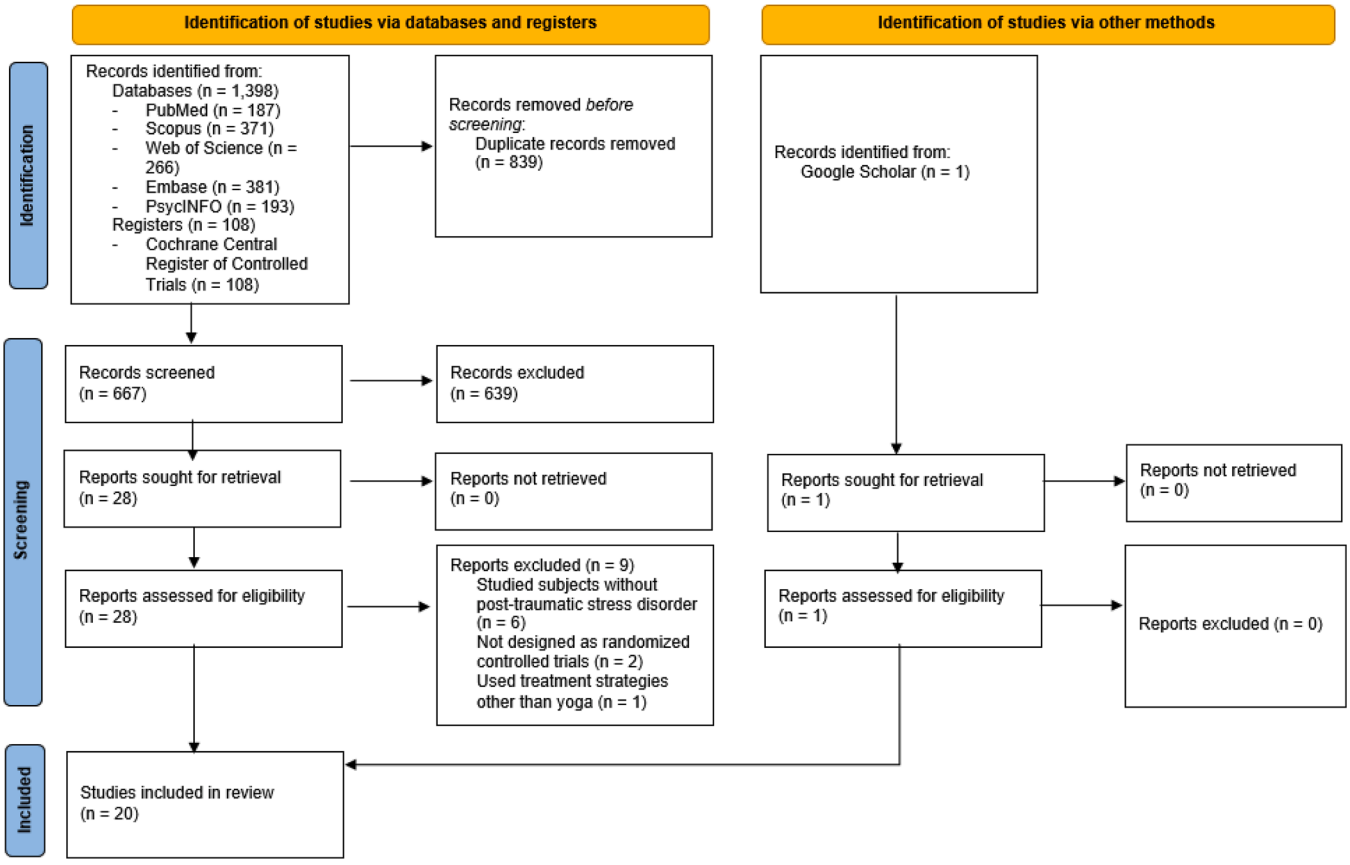

Fig. 1. Study selection process. The search identified 1,506 records from PubMed (n=187), Scopus (n=371), Web of Science (n=266), Embase (n=381), PsycINFO (n=193), and Cochrane Central Register of Controlled Trials (n=108). One additional study was found using Google Scholar. After the removal of 839 duplicates, 668 articles remained. After title and abstract screening, 639 additional articles were excluded. Most articles were excluded because they were not randomized controlled trials (RCTs) or they were not conducted on participants with posttraumatic stress disorder (PTSD). After assessing the 29 remaining articles for eligibility, six studies were excluded as they did not evaluate PTSD, two were not RCTs, and one study used treatment strategies other than yoga.

2012; Telles et al., 2010), two were not designed as RCTs (Lang et al., 2021b; Thordardottir et al., 2014), and one study used treatment strategies other than yoga (Polusny et al., 2015). These were excluded. Twenty studies met the predefined eligibility criteria and were included in the present meta-analysis (see Fig. 1).

3.2. Study characteristics

The included studies represented a total of 954 participants. The mean age of the participants was 51.26; the majority identified as female (59.6 %). All included trials were published between 2013 and 2022 and implemented a parallel design. Sixteen studies were conducted in the United States (Bayley et al., 2022; Davis et al., 2020; Dick et al., 2014; Huberty et al., 2020; Kelly et al., 2021; Martin et al., 2015; Mathersul et al., 2022; Mitchell et al., 2014; Nguyen-Feng et al., 2020; Reddy et al., 2014; Reinhardt et al., 2018; Rhodes et al., 2016; Schulz-Heik et al., 2022; Seppälä et al., 2014; Van Der Kolk et al., 2014b; Zaccari et al., 2022), one in Australia (Carter et al., 2013), one in Canada (Jindani et al., 2015), one in Colombia (Quiñones et al., 2015), and one in China (Yi et al., 2022b). Twelve studies included adult veterans (Bayley et al., 2022; Carter et al., 2013; Davis et al., 2020; Dick et al., 2014; Kelly et al., 2021; Mathersul et al., 2022; Mitchell et al., 2014; Reddy et al., 2014; Reinhardt et al., 2018; Schulz-Heik et al., 2022; Seppälä et al., 2014; Zaccari et al., 2022), two included women with chronic PTSD (Rhodes et al., 2016; Van Der Kolk et al., 2014a), two included individuals with PTSD in community samples (Jindani et al., 2015; Martin et al., 2015), and four included participants with PTSD from other populations such as survivors of a vehicle motor accident (Yi et al., 2022a), those with childhood interpersonal trauma histories (Nguyen-Feng et al., 2020), women who experienced stillbirth (Huberty et al., 2020), and reintegrating adults with PTSD (Quiñones et al., 2015). Length of the interventions assessed in the RCTs ranged from one week (Seppälä et al., 2014) to six months (Carter et al., 2013).

The shortest follow-up duration was one month (Dick et al., 2014; Martin et al., 2015; Mitchell et al., 2014; Reddy et al., 2014) and the longest was 1.5 years (Rhodes et al., 2016). Seven studies included only one post-intervention assessment without any follow-ups (Jindani et al., 2015; Mathersul et al., 2022; Nguyen-Feng et al., 2020; Quiñones et al., 2015; Reinhardt et al., 2018; Schulz-Heik et al., 2022; Van Der Kolk et al., 2014b), eight studies included only one post-intervention assessment and one follow-up (Davis et al., 2020; Dick et al., 2014; Huberty et al., 2020; Martin et al., 2015; Mitchell et al., 2014; Reddy et al., 2014; Rhodes et al., 2016; Yi et al., 2022b), and four studies included one post intervention assessment and two independent follow-ups (Bayley et al., 2022; Kelly et al., 2021; Seppälä et al., 2014; Zaccari et al., 2022). In one study, participants in the intervention arm were assessed at two independent follow-ups, while the control arm was re-evaluated at three time points post-intervention (Carter et al., 2013). All twenty included studies used self-report questionnaires for PTSD. Nine also used clinician-administered assessments (Carter et al., 2013; Davis et al., 2020; Jindani et al., 2015; Kelly et al., 2021; Nguyen-Feng et al., 2020; Reinhardt et al., 2018; Rhodes et al., 2016; Van Der Kolk et al., 2014b; Zaccari et al., 2022) (Table 1).

Six studies utilized Kripalu Yoga (Dick et al., 2014; Martin et al., 2015; Mitchell et al., 2014; Reddy et al., 2014; Reinhardt et al., 2018; Yi et al., 2022b), five used SKY (Bayley et al., 2022; Carter et al., 2013; Mathersul et al., 2022; Schulz-Heik et al., 2022; Seppälä et al., 2014), five used TCTSY (Kelly et al., 2021; Nguyen-Feng et al., 2020; Rhodes et al., 2016; Van Der Kolk et al., 2014b; Zaccari et al., 2022), and four studies administered other types of yoga, including Kundalini yoga (Jindani et al., 2015), Satyananda Yoga (Quiñones et al., 2015), Holistic Yoga Program (HYP) (Davis et al., 2020), and Hatha yoga (Huberty et al., 2020).

A wait-list control was implemented in four studies (Carter et al., 2013; Jindani et al., 2015; Quiñones et al., 2015; Seppälä et al., 2014), while five studies used a strictly passive control and assessed the mental and behavioral status of participants in the control arm without offering a comparator intervention (Dick et al., 2014; Martin et al., 2015; Mitchell et al., 2014; Reddy et al., 2014; Reinhardt et al., 2018). Comparator groups varied: three studies used supportive women's health education (Nguyen-Feng et al., 2020; Rhodes et al., 2016; Van Der Kolk et al., 2014b), one instructed participants to share daily life experiences and play board games in a group (Yi et al., 2022b), one administered a wellness lifestyle program (Davis et al., 2020), one used stretch-and-tone classes (Huberty et al., 2020), and the remaining five studies compared yoga with CPT (Bayley et al., 2022; Kelly et al., 2021; Mathersul et al., 2022; Schulz-Heik et al., 2022; Zaccari et al., 2022). Three out of five studies that used SKY as an intervention had CPT as a comparison group (Bayley et al., 2022; Mathersul et al., 2022; Schulz-Heik et al., 2022) (Table 1). Table S2 and Table S3 present the race/-ethnicity and relationship status of participants in the included studies, respectively.

3.3. Quality assessment

Risk of bias was high in all of the included studies (Fig. 2). The most common bias was outcome measurement, which was high in all the included studies. The lowest risk of bias was in the selection of the reported results: with one exception (Huberty et al., 2020), all studies were low on this bias (Fig. 2 and Table S4).

There is some concern that Cochrane RoB 2 guidelines (specifically Domain 4) are overly stringent for behavioral interventions (Crocker et al., 2023; Minozzi et al., 2020). There are three questions that dictate this risk of bias: (4.3) "Were outcome assessors aware of the intervention received by study participants?", (4.4) "Could assessment of the outcome have been influenced by knowledge of intervention received?", and (4.5.) "Is it likely that assessment of the outcome was influenced by knowledge of intervention received?" If yes/partially yes on all of these questions for an included study, that study would be categorized as having a high risk of bias for this specific domain. Also, if there was a high risk of bias in at least one domain, the overall judgment would be high. To address this issue, in a post-hoc analysis, we reprocessed the risk of bias data in the absence of Domain 4. This secondary analysis found that 18 studies still exhibited high risk of bias, while two studies had "some concerns" (Nguyen-Feng et al., 2020; Van Der Kolk et al., 2014c).

3.4. Primary outcomes

3.4.1. PTSD

When measured using self-report questionnaires, pooled results indicated that yoga significantly reduced PTSD symptoms compared to comparison groups at immediately post-intervention (SMD: -0.51; 95 % CI: -0.68, -0.35; prediction interval: -0.71, -0.32) (Fig. 3A), although differences were not sustained when measured at a secondary follow-up assessment (SMD: -0.17; 95 % CI: -0.34, 0.01) (Fig. 3B). When assessed using clinician-reported assessments, yoga did not improve PTSD symptoms compared to comparison groups at immediate post-intervention (SMD: -0.39; 95 % CI: -1.02, 0.25) (Fig. 3C) or secondary follow-ups (SMD: -0.06; 95 % CI: -0.85, 0.74) (Fig. 3D). A visual summary of the confidence level for individual studies and pooled estimates for immediate post-intervention self-report questionnaires as the outcome are presented in a drapery plot (Fig. S1).

3.4.2. Retention in the trial

Trial retention was comparable in yoga compared to control group in nearly all included studies (OR: 0.89; 95 % CI: 0.36, 2.19; prediction interval: 0.07, 12.07). Trial retention was higher for yoga when compared to CPT (OR: 1.44; 95 % CI: 1.01, 2.05) (Fig. 4).

Table 1
Characteristics of included studies.

Study	Country	Study population	Sample size, n			Yoga type	Type of control	Male, n (%)	Age, mean (SD)	Treatment length	Follow-up duration	PTSD measurement instrument(s)
			Total	Yoga group	Control group							
Carter et al. (2013)	Australia	Male Vietnam veterans classified as disabled due to service-related PTSD	25	14	11	SKY	Wait-list control	Yoga: 14 (100) Control: 11 (100)	Yoga: 58.5 (3.8) Control: 58.4 (4.8)	Six months	6 months	CAPS for DSM-IV and PCL-M for DSM-IV
Dick, et al. (2014)	USA	Veteran and civilian women	38	20	18	Kripalu	Weekly assessment sessions in groups of approximately five participants each	Yoga: 0 Control: 0	NA	Yoga: weekly for 12 wks or twice-weekly for 6 wks; Control: 12 wkswks	1 month	PCL-C for DSM-IV and PSS-I for DSM-IV
Mitchell et al. (2014)	USA	Veteran and civilian women	38	20	18	Kripalu	Weekly assessment sessions in groups of approximately five participants each	Yoga: 0 Control: 0	Yoga: 45.5 (12.1) Control: 43.2 (12.9)	Yoga: weekly for 12 wks or twice-weekly for 6 swks; Control: 12 wks	1 month	PCL-C for DSM-IV and PSS-I for DSM-IV
Reddy et al. (2014)	USA	Veteran and civilian women	38	20	18	Kripalu	Weekly assessment sessions in groups of approximately five participants each	Yoga: 0 Control: 0	Yoga: 45.5 (12.1) Control: 43.2 (12.9)	Yoga: weekly for 12 wks or twice-weekly for 6wks; Control: 12 wkswks	1 month	PCL-C for DSM-IV and PSS-I for DSM-IV
Seppälä et al. (2014)	USA	U.S. male veterans of the Iraq or Afghanistan war	21	11	10	SKY	Wait-list control	Yoga: 11 (100) Control: 10 (100)	Yoga: 28.09 (2.91) Control: 29.2 (6.66)	7 days	1 year	PCL-M for DSM-IV
Van Der Kolk et al. (2014)	USA	Women with chronic, treatment-resistant PTSD	64	32	32	TCTSY	Supportive women's health education	Yoga: 0 Control: 0	Yoga: 41.5 (12.2) Control: 44.3 (11.9)	10 wks	NA	CAPS for DSM-IV and DTS
Jindani et al. (2015)	Canada	Adults living within the community and score above 57 on the PCL-17 and 18+ years of age	80	59	21	Kundalini	Wait-list control	Yoga: 4 (7) Control: 5 (24)	NA	8 wks	NA	PCL for DSM-IV and PSS
Martin et al. (2015)	USA	Eligible women in a diagnostic interview using the PSS-I and the Structured Clinical Interview for the DSM	38	20	18	Kripalu	Assessment-only (no intervention)	Yoga: 0 Control: 0	NA	12 wks or 6 wks	1 month	PCL-C for DSM-IV and PSS-I
Quiñones et al. (2015)	Colombia	PTSD diagnosed reintegrating adults	100	50	50	Satyananda Yoga	Wait-list control	Yoga: 35 (70) Control: 38 (76.2)	NA	16 wks	NA	PCL-C for DSM-IV
Rhodes et al. (2016)	USA	Adult Women with Chronic PTSD	49	NA	NA	TCTSY	Supportive women's health education	Yoga:0 Control: 0	NA	10 wks	1.5 years (ranging from 0.75 to 2.75 years)	CAPS for DSM-IV and DTS

(*continued on next page*)

Table 1 (*continued*)

Study	Country	Study population	Sample size, n			Yoga type	Type of control	Male, n (%)	Age, mean (SD)	Treatment length	Follow-up duration	PTSD measurement instrument(s)
			Total	Yoga group	Control group							
Reinhardt et al. (2018)	USA	Military veterans with PTSD	51	26	25	Kripalu	Assessment-only (no intervention)	Yoga: 24 (92.3) Control: 21 (84)	Yoga: 44.12 (13.97)	10 wks	NA	CAPS for DSM-IV, PCL-M for DSM-IV, PCL-C for DSM-IV, and IES-R for DSM-IV
Davis et al. (2020)	USA	Veterans and Civilians	209	108	101	HYP	WLP	Yoga: 70 (64.8) Control: 68 (67.3)	Yoga: 49.9 (12.6) Control: 51.2 (13.3)	16 wks	7 months	CAPS for DSM-5 and PCL for DSM-5
Huberty et al. (2020)	USA	Women who have experienced stillbirth	90	60	30	Hatha	STC	Yoga:0 Control: 0	NA	12 wks	20 wks	IES-R for DSM-IV
Nguyen-Feng et al. (2020)	USA	Women with childhood Interpersonal trauma histories and PTSD	64	32	32	TCTSY	Supportive women's health education	Yoga: 0 Control: 0	Yoga: 41.5 (12.2) Control: 44.3 (11.9)	10 wks	NA	CAPS for DSM-IV and DTS
Kelly et al. (2021)	USA	Women veterans with PTSD related to military sexual trauma	104	58	46	TCTSY	CPT	Yoga:0 Control: 0	NA	Yoga: 10 wks Control: 12 wks	3 months	CAPS for DSM-5 and PCL for DSM-5
Bayley et al. (2022)	USA	US military veterans with symptoms of PTSD	85	41	44	SKY	CPT	Yoga: 34 (83) Control: 41 (93)	Yoga: 57.4 (12.6) Control: 56.4 (12.9)	6 wks	1 year	PCL-C for DSM-IV, PCL for DSM-5, and CAPS for DSM-5
Mathersul et al. (2022)	USA	US military veterans with symptoms of PTSD	59	30	29	SKY	CPT	Yoga: 23 (76.7) Control: 27 (93.1)	Yoga: 60.67 (11) Control: 58.21 (13.04)	6 wks	NA	PCL for DSM-IV and CAPS for DSM-5
Schulz-Heik et al. (2022)	USA	US military veterans with symptoms of PTSD	59	30	29	SKY	CPT	Yoga: 23 (77) Control: 27 (93)	Yoga: 60.7 (11) Control: 58.2 (13)	6 wks	NA	PCL-C for DSM-IV, PCL for DSM-5, and CAPS for DSM-5
Yi et al. (2022)	China	Women survived in vehicle motor accident	76	37	39	Kripalu	Exchanging daily life experiences and playing board games in a group	Yoga: 0 Control: 0	Yoga: 40.8 (13.2) Control: 42.1 (15.9)	12 wks	3 months	IES-R for DSM-IV
Zaccari et al. (2022)	USA	Women veterans who were diagnosed with PTSD or met criteria for PTSD upon clinical assessment by the research team and who identified MST as the index trauma.	41	17	24	TCTSY	CPT	Yoga: 0 Control: 0	Yoga: 46.1 (12.4) Control: 44.2 (7.9)	Yoga: 10 wks Control: 12 wks	3 months	CAPS for DSM-IV and PCL for DSM-IV

Abbreviations: PTSD: posttraumatic stress disorder; SKY: Sudarshan Kriya Yoga; TCTSY: Trauma Center Trauma-Sensitive Yoga; HYP: Holistic Yoga Program; WLP: wellness lifestyle program; STC: stretch-and-tone control; CPT: Cognitive Processing Therapy; DSM: The Diagnostic and Statistical Manual of Mental Disorders; PCL: PTSD Checklist; PCL-M: PTSD Checklist- Military Version; PCL-C: PTSD Checklist-Civilian Version; CAPS: Clinician-Administered PTSD Scale for DSM; MINI: The Mini-International Neuropsychiatric Interview; IES-R: The Impact of Event Scale-Revised; PSS-I: PTSD Symptom Scale-Interview for DSM; DTS: Davidson Trauma Scale; DASS: Depression, Anxiety and Stress Scale; NA: not available; USA: United States of America; Wks: Weeks

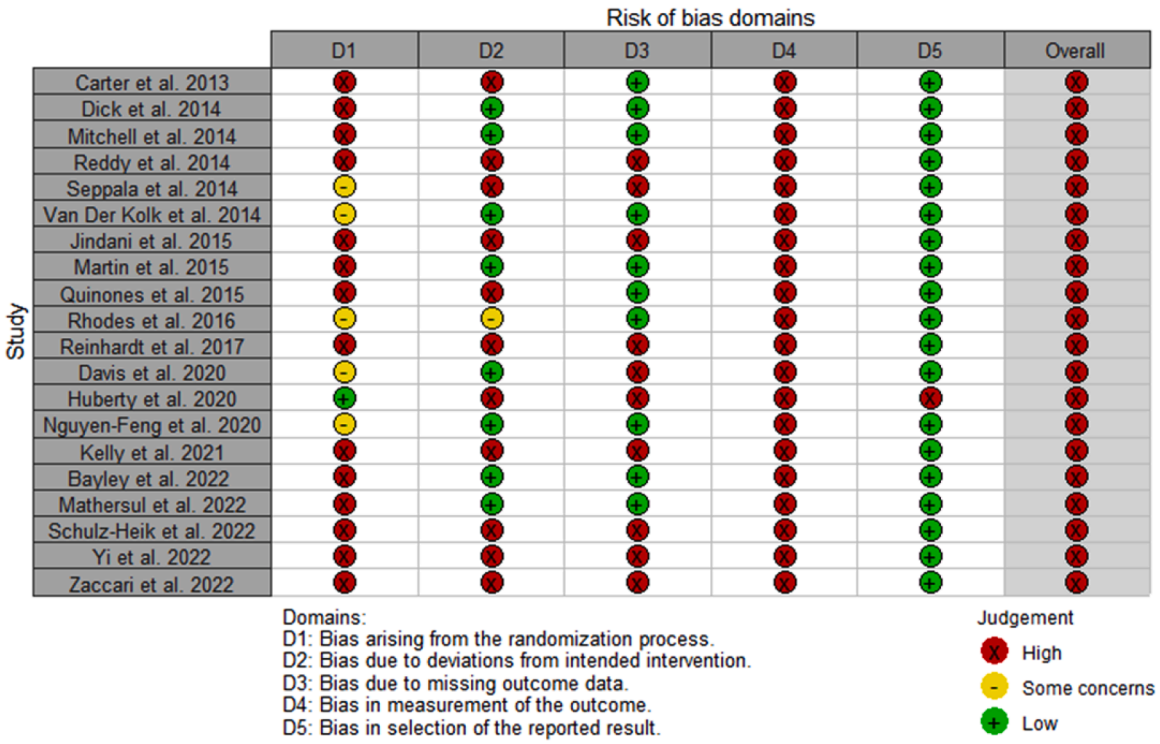

Fig. 2. Summary of the risk of bias assessment for the included studies, based on the Cochrane Collaboration's risk of bias assessment tool 2 (RoB 2).

3.5. Secondary outcomes

Pooled results demonstrated that compared to those in the comparison group, individuals with PTSD who were assigned to the yoga group reported reduced depression symptoms at immediate post-intervention (SMD: -0.39; 95 % CI: -0.56, -0.22) (Fig. 5C) and secondary follow-up (SMD: -0.44; 95 % CI: -0.74, -0.13) (Fig. 5D) assessments. However, significant reductions in anxiety symptoms were not exhibited at immediate post-intervention (SMD: -0.28; 95 % CI: -0.71, 0.15) (Fig. 5A) or secondary follow-up (SMD: -0.28; 95 % CI: -0.59, 0.02) (Fig. 5B) assessments.

Compared to comparison groups, for individuals with PTSD, assignment to a yoga group was not associated with improvements in other secondary outcomes, including emotion regulation (SMD: -0.09; 95 % CI: -0.30, 0.12) (Fig. 6A), mindfulness (SMD: -0.32; 95 % CI: -3.02, 2.38) (Fig. 6B), quality of life (SMD: 0.03; 95 % CI: -0.35, 0.42) (Fig. 6C), or quality of sleep (SMD: -0.50; 95 % CI: -1.49, 0.50) (Fig. 6D). Data on secondary follow-up assessments or self- or clinician-report questionnaires for these outcomes were not reported in any included study.

Six studies reported adverse events of yoga for PTSD (Bayley et al., 2022; Carter et al., 2013; Kelly et al., 2021; Mitchell et al., 2014; Quiñones et al., 2015; Seppälä et al., 2014). Among studies that reported unanticipated adverse events, no serious events occurred in the yoga groups (Mitchell et al., 2014; Quiñones et al., 2015; Seppälä et al., 2014). Carter et al. reported transient mild psychological discomfort in the yoga group (Carter et al., 2013). Kelly et al. (2021) reported that two participants in the comparison group (i.e., CPT) experienced increased psychological distress. Bayley et al. (2022) reported that in the comparison group (i.e., CPT), one participant reported distress from the assignments and another reported suicidal ideation.

3.6. Subgroup analysis of type of yoga

Subgroup analysis was only conducted for outcomes reported by least ten studies. Pooled analysis by yoga type showed that PTSD symptoms significantly improved for those assigned to yoga groups including TCTSY, Kundalini, Satyananda yoga, and HYP compared to a comparison group (SMD: -0.58; 95 % CI: -0.95, -0.21) (Fig. S2). However, no significant differences in immediate post-intervention PTSD symptoms were noted for participants assigned to SKY, Kripalu, and Hatha yoga groups compared to comparison groups. Pooled results demonstrated that retention in trials did not differ according to the type of yoga group (Fig. S3).

3.7. Sensitivity analysis

When each study was eliminated one at a time, the direction of the combined estimates did not change substantially for immediate post-intervention PTSD symptoms measured by self-report (Fig. S4) and for the retention in the trial (Fig. S5), suggesting that the meta-analysis was reliable and that no particular study had a statistically significant impact on the outcome. Of note, there were not enough studies (i.e., ten or more) to perform sensitivity analyses on clinician-assessed symptoms.

3.8. Publication bias

Contour-enhanced funnel plot analysis evaluated publication bias for outcomes with at least ten included studies. The patterns in the funnel plots were symmetric for PTSD symptoms measured by self-report post-intervention questionnaires (Fig. S6) and retention in the trial (Fig. S7). The findings were confirmed by Egger's test (p=0.93) and Begg's test (p=0.94) for PTSD symptoms measured by self-report post-intervention questionnaires and for retention in the trial (Egger's test: p=0.81 and Begg's test: p=0.82).

4. Discussion

Results suggest that yoga may help address symptoms of depression and PTSD in individuals with PTSD. Improvements in PTSD were generally limited to immediate post-intervention assessments, while improvements in depression were generally sustained at secondary follow-up assessments. Participation in yoga groups was not associated

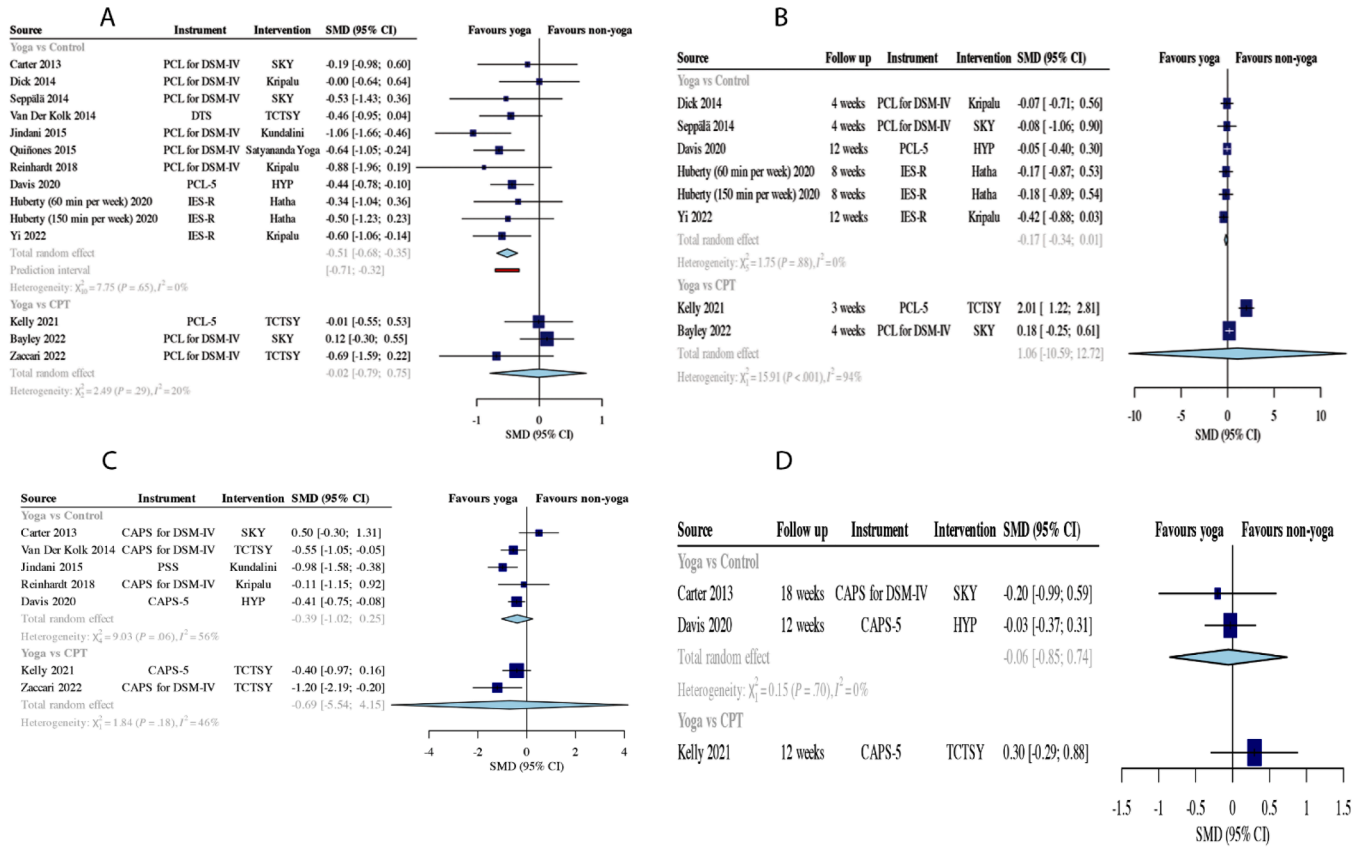

Fig. 3. Forest plot of the standardized mean difference (SMD) of posttraumatic stress disorder (PTSD) post-intervention self-report questionnaires (A), self-report questionnaires for follow-up (B), post-intervention clinician-reported questionnaires (C), and clinician-reported questionnaires (D) for follow-up for yoga as compared to the controls or cognitive processing therapy (CPT). PCL: PTSD Checklist for DSM; DSM: diagnostic and statistical manual of mental disorders; IES-R: impact of event scale – Revised; DTS: distress tolerance scale; CAPS: clinician-administered PTSD scale; PSS: perceived stress scale; TCTSY: Trauma Center Trauma Sensitive Yoga. The study by Huberty et al. (2020) was mentioned twice as it used yoga for 60 and 150 min per week. Note the negative values are in favour of yoga and the positive values are in favour of non-yoga/control.

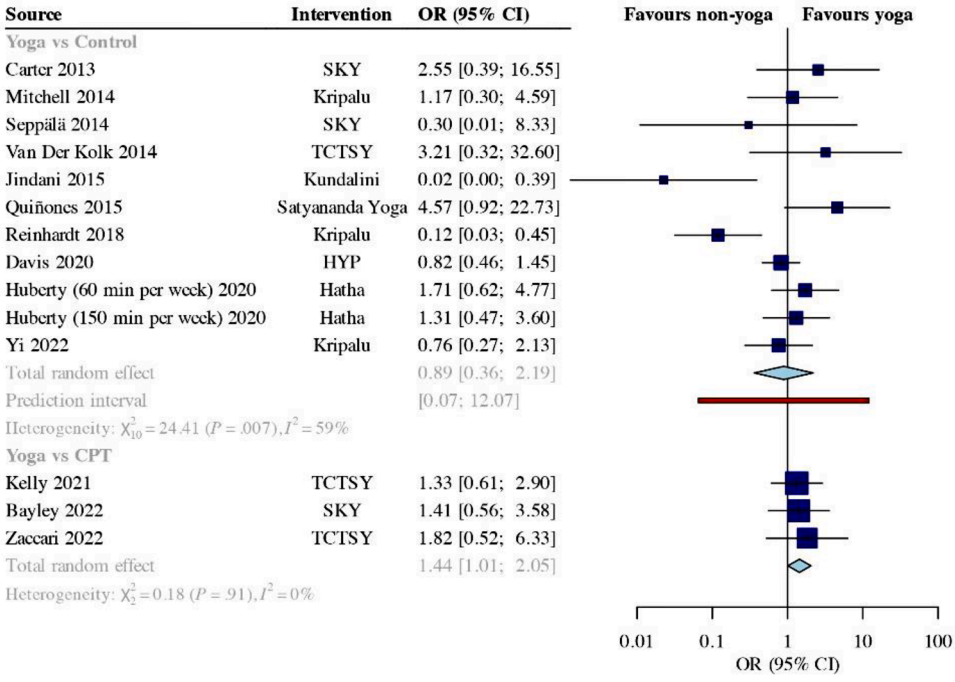

Fig. 4. Forest plot of the odds ratio (OR) of retention in trials of yoga compared with controls or cognitive processing therapy (CPT) in those with posttraumatic stress disorder (PTSD). TCTSY: Trauma Center Trauma Sensitive Yoga.

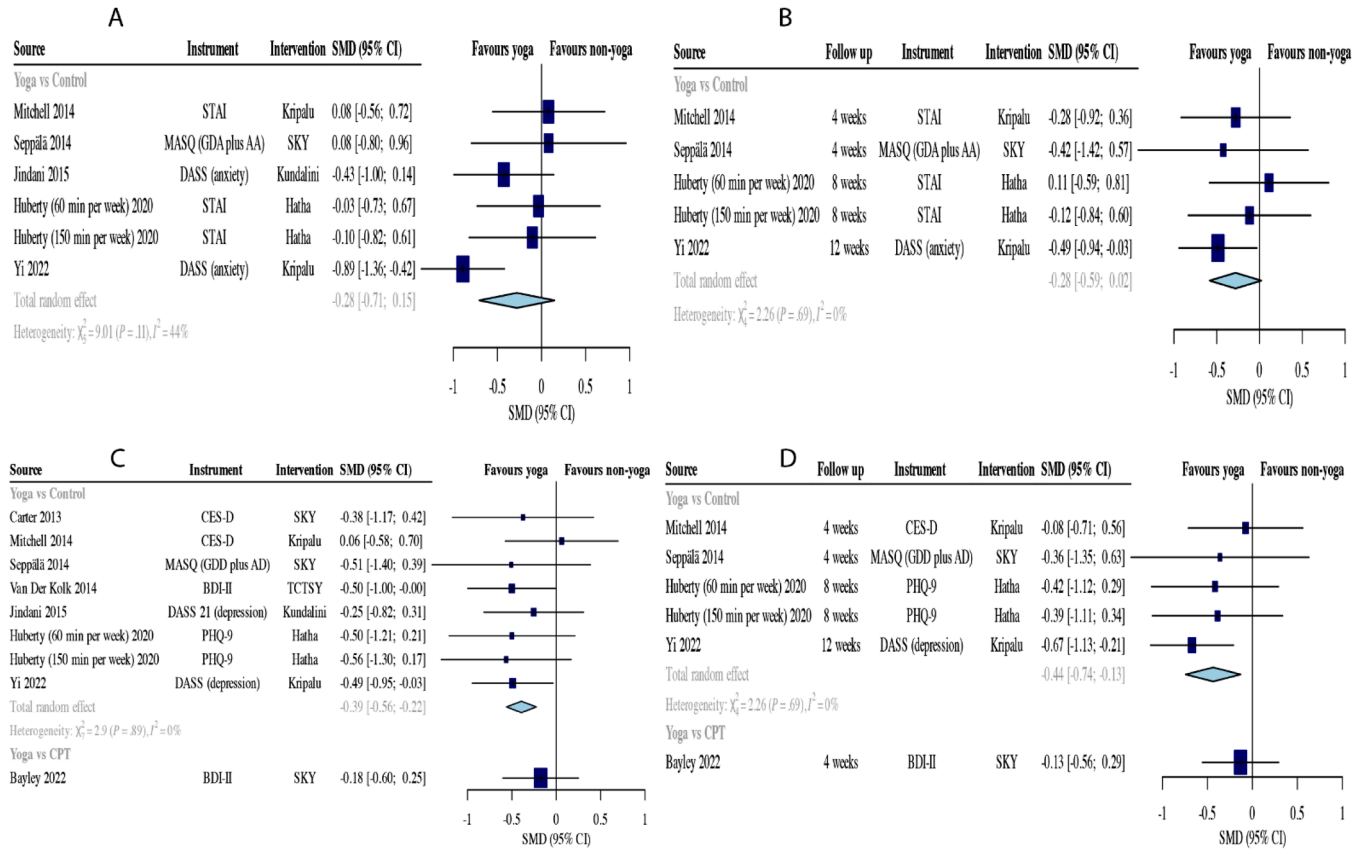

Fig. 5. Forest plot of the standardized mean difference (SMD) of post-intervention anxiety symptoms (A), anxiety symptoms after follow-up (B), post-intervention depressive symptoms (C), and depressive symptoms after follow-up (D) for yoga as compared to the controls or cognitive processing therapy (CPT). CES-D: center for epidemiological studies depression scale, BDI: Beck's depression inventory, MASQ: Mood and anxiety symptom questionnaire; GDD: general distress depressive; AD: anhedonic depression; PHQ: patient health questionnaire; DASS: depression anxiety and stress scale, AA: anxious arousal; GDA: general distress anxious symptoms; STAI: state-trait anxiety inventory. Note the negative values are in favour of yoga and the positive values are in favour of non-yoga/control.

with significant improvements in anxiety symptoms, emotion-regulation, mindfulness, quality of life, or sleep.

Our results bolstered those from a previous systematic review and meta-analysis that found significant improvements in PTSD symptoms for those in a yoga group compared to a comparison group (SMD: −1.10; 95 % CI: −1.72, −0.47) (Cramer et al., 2018a). However, our results differed by assessment tool, finding that while yoga was associated with PTSD symptom improvement in studies using self-report inventories, symptoms did not improve in studies using clinician-administered assessments. This could be because clinician-administered assessments may focus more on objectively observed aspects of PTSD, while self-report questionnaires may draw more from subjective symptom perceptions, leading to these differences. Our results highlight that this discrepancy should be an area for future research, and emphasize the need for increased rigor in RCTs examining yoga for PTSD. Moreover, our results provide greater context to a previous meta-analysis conducted by Taylor and colleagues that revealed clinical efficacy of yoga for combined PTSD, anxiety, and stress outcomes (g=0.46; 95 % CI: 0.26, 0.66) (Taylor et al., 2020). Our findings showed that efficacy was outcome specific, with improvements in symptoms of PTSD and depression, but not anxiety.

A previous systematic review of twelve studies and 791 participants showed that effect sizes ranged between 0.40 and 1.06 for the efficacy of yoga on reducing symptoms of anxiety and depression in participants exposed to traumatic events, suggesting weak, if any, effects (Nguyen-Feng et al., 2019). Another meta-analysis of eight RCTs that evaluated the effects of yoga on anxiety and depression revealed improvements in anxiety (SMD: −0.43; 95 % CI: −0.74, −0.11) and depression (SMD: −0.35; 95 % CI: −0.66, −0.04) compared with no treatment (Cramer et al., 2018b). While our meta-analysis did not find significant improvements in anxiety in participants with PTSD assigned to a yoga group compared to those assigned to a comparison group, our results found significant improvements in depression symptoms. Such differences could be because Cramer et al. (2018b) included participants without clinically significant PTSD symptoms, limiting power. Furthermore, the treatment duration of the studies included in our review varied widely, ranging from seven days to six months. This variability in timeframe of assessments may be an important factor affecting the estimates of intervention efficacy and thus may be an important source of heterogeneity. These inconsistent findings suggest further studies to examine the efficacy of yoga for reducing symptoms of anxiety and depression in those with PTSD are warranted.

In general, we did not find that yoga had an effect on secondary outcomes including emotion regulation, mindfulness, quality of life, or sleep. Our meta-analysis did not find significant effects of yoga on sleep quality of participants with PTSD. Although yoga has been associated with improved sleep quality in healthy elderly populations (Bandyopadhyay et al., 2023) and in individuals with breast cancer (Zhu et al., 2023), our findings suggests pharmacotherapy and psychotherapy interventions may be better modalities to address sleep disturbances in individuals with PTSD symptoms. For example, a recent review on sleep interventions for individuals with PTSD found pharmacotherapy and psychotherapy in those with PTSD showed both improved sleep (SMD: −0.56; 95 % CI: −0.75, −0.37) and PTSD symptoms (SMD: -0.48; 95 % CI: -0.67, −0.29) (Maher et al., 2021).

We found that participation in a yoga group was not associated with improvements in emotion regulation or mindfulness in adults with PTSD, in contrast to other studies on healthy adolescents and young

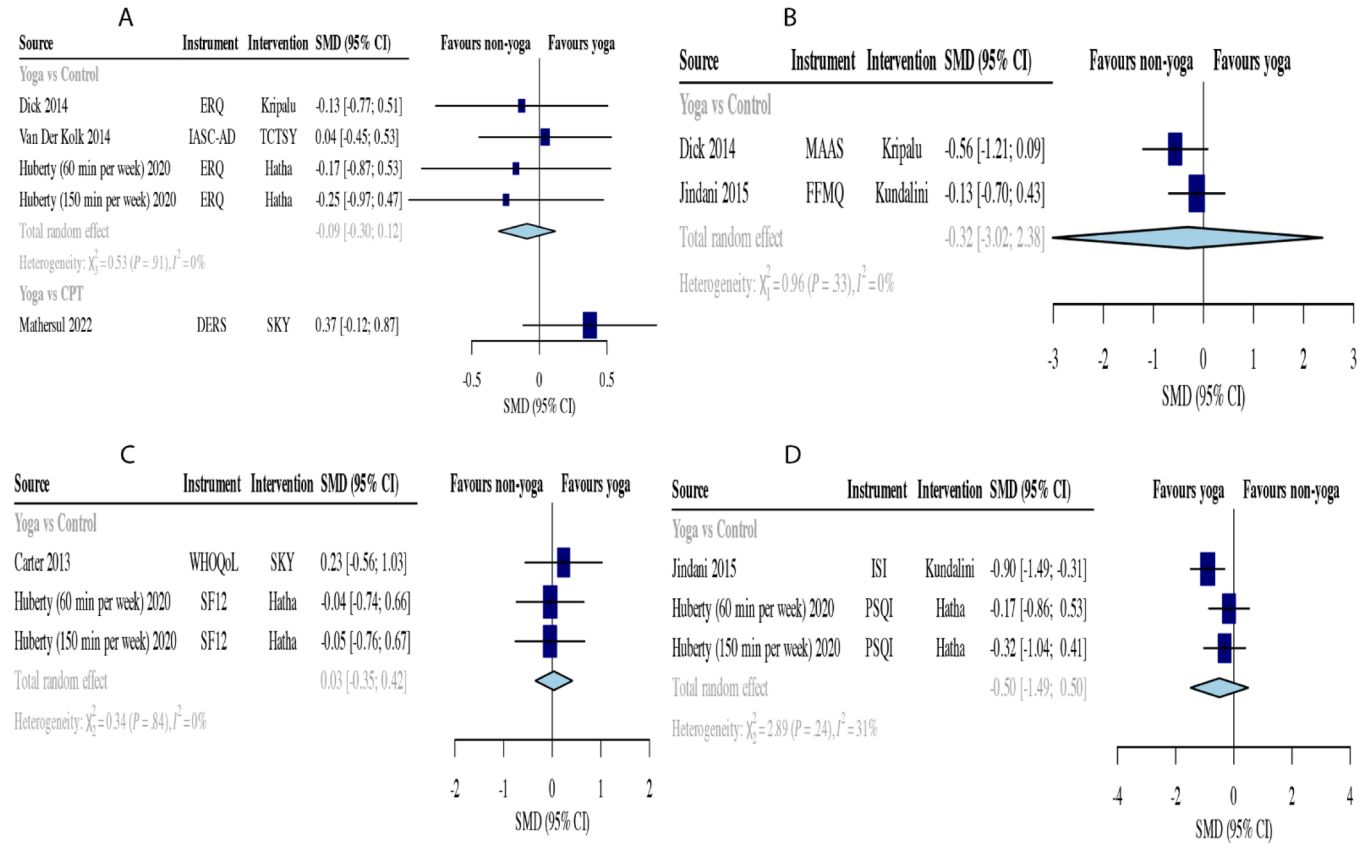

Fig. 6. Forest plot of the standardized mean difference (SMD) of efficacy of yoga compared with controls or cognitive processing therapy (CPT) on emotion-regulation (A), mindfulness (B), quality of life (C), and quality of sleep (D) of those with post-traumatic stress disorder (PTSD). MAAS: mindful attention awareness scale; FFMQ: five facet mindfulness questionnaire; WHOQoL: World Health Organization quality-of-life; SF-12: 12-item short form survey; ISI: insomnia severity index; PSQI: Pittsburgh sleep quality index. Note the negative values are in favour of yoga for panel D.

adults that showed yoga was associated with significant improvements in emotion regulation (Janjhua et al., 2020; Patel et al., 2018). Our null findings could be due to a focus on adult samples, differential effects in individuals with PTSD, or a restricted number of studies. Further studies that evaluate potential age differences in outcomes might be useful. While prior research suggests mindfulness and emotion regulation could be mechanisms by which yoga could be helpful for reducing PTSD, our findings did not generally support this. Yet, the included studies evaluating the efficacy of yoga on emotional regulation, mindfulness, and quality of life and sleep of participants with PTSD were generally limited and heterogeneous, potentially explaining the lack of efficacy for yoga to improve these outcomes in those with PTSD.

Given our null findings for most potential mechanisms (e.g., mindfulness, emotion regulation), future research should explore potential alternative mechanisms (e.g., cortisol levels or reactivity, heart rate variability) by which yoga improves outcomes in those with PTSD. For example, yoga may help downregulate the hypothalamic–pituitary–adrenal axis, reducing cortisol levels, improving neurotrophic factors, and reducing inflammation (Kelly et al., 2017). These combined physiological effects may counteract the stress response, leading to reduced anxiety and associated symptoms while improving mood and response to trauma (Kelly et al., 2017).

In general, those in a yoga group compared to other types of comparisons groups did not significantly differ on treatment completion; participants in yoga groups were more likely to complete the intervention compared to CPT. This finding is similar to a prior meta-analysis that did not find differences in treatment completion between participation in a yoga group compared to no treatment (OR: 0.68; 95 % CI: 0.06, 7.72) or a yoga group compared to an attention control group (OR: 0.66; 95 % CI: 0.10, 4.46) (Cramer et al., 2018a). Further, these results did not differ by type of yoga. This suggests that, in general, yoga is well-tolerated by individuals with PTSD, supporting the reports of low adverse events that were reported across the studies.

Results found that studies did not report any serious or life-threatening adverse events associated with yoga. This aligns with prior meta-analysis showing no serious adverse events for participation in a yoga intervention for those with PTSD, except for breathing problems in those with underlying respiratory diseases (Cramer et al., 2018a). Furthermore, a meta-analysis of 94 studies (not specific to PTSD) with 8,430 participants revealed no significant differences in the frequency of intervention-related adverse events, nonserious or serious adverse events, or dropouts because of adverse events when comparing yoga with routine care/no treatment (Cramer et al., 2015). Overall, results suggest that yoga can be used as a safe add-on or adjunctive modality for PTSD (Büssing et al., 2012) and likely other mental health ailments as well.

4.1. *Limitations and future directions*

Overall, there was a high risk of bias and generally low methodological quality of the included studies. This may be partially due to high risk of bias in Domain 4 of Cochrane RoB 2, which is an evaluation of the risk of bias in the measurement of outcome(s). However, our secondary reprocessing analyses found that risk of bias still remained high after eliminating this factor. Since yoga is a behavioral intervention, participants were aware of the intervention being administered and, in many instances, the outcome assessors were aware of the intervention. We maintain this may be due to features of the quality assessment tool that may be overly stringent when applied to a behavioral intervention (Crocker et al., 2023; Minozzi et al., 2020). In other words, because the

studies did not use blinding and used questionnaires to assess outcomes, they received high risk of bias scores across key domains and an overall high risk of bias judgment. Similarly, a previous systematic review on the efficacy of yoga for PTSD symptoms that used the Version 1 of the Cochrane risk of bias tool also found weaknesses for performance and selection biases (Cramer et al., 2018a). Nevertheless, taken together, this suggests the need for more rigorous studies of yoga for PTSD, particularly given our overall findings suggesting yoga may help reduce PTSD and related symptoms.

We acknowledge several other limitations to our study. First, the results should be interpreted with caution due to a relatively low number of studies included in the meta-analysis. Second, our meta-analysis combined different assessment tools, which may introduce additional bias. For example, a study showed that the associations of sociodemographic factors on quality of life was related to whether the World Health Organization Quality-of-Life or 12-Item Short Form Survey instrument was used (Gobbens and Remmen, 2019), an issue that has also been evident when evaluating quality of sleep with the Insomnia Severity Index compared to the Pittsburgh Sleep Quality Index (Omachi, 2011). We included studies that used a self-report instrument for PTSD diagnoses. For example, Huberty et al. (2020) used a cutoff score on a self-report instrument, which indicates a positive screen for PTSD rather than a diagnosis per se. Third, SKY combines breathing techniques, yoga postures, and meditation and involves elements of mindfulness, potentially utilizing different mechanisms of action from other types of yoga that were included in the studies (Zope and Zope, 2013). Fourth, data on adverse events were not reported in most studies and thus we could not conduct meta-analysis to compare the safety measures between yoga and controls. Those that did report adverse events were limited to samples of male and female military personnel and veterans who recently returned from active duty. Therefore, future studies that evaluate the effects of yoga on PTSD should include reports of adverse events. Fifth, despite searching six databases and conducting a forward and backwards hand search of the references, it is possible some studies were not included. Sixth, we did not calculate and report the interrater reliability (e.g., kappa statistics) for data extraction and coding; instead, we used discussion or consultation with a third author to resolve any discrepancies. Seventh, 12 out of 20 studies included in the review were on veterans; the mean age of participants was about 51 years. This suggests that while yoga may be suitable and effective in clinical and community-based context serving veterans or older individuals (e.g., the United States Veteran Affairs clinics). Yet, less is known about contexts where populations are more demographically variable. Future research should expand target populations to increase generalizability. Finally, we focused on studies that concentrated on individuals with probable PTSD. Future studies should evaluate the effects of yoga on burnout and subthreshold posttraumatic stress in specific populations like healthcare workers, especially in light of the COVID-19 pandemic.

5. Conclusions

Findings demonstrate yoga is generally a safe and well-tolerated intervention that may improve depressive symptoms in participants with PTSD and, to a lesser degree, also improve PTSD symptoms. Results suggest TCTSY, Kundalini, Satyananda Yoga, and HYP may be particularly efficacious compared to other types of yoga interventions and should be targeted in future research. Moreover, due to the high risk of bias in the extant literature, further high quality RCTs that use randomization and more rigorous measurement of outcomes should be considered. The costs of yoga per individual with PTSD should be evaluated and considered in future studies. This could further support the utility of a low-cost integrative intervention – yoga – for addressing PTSD and related symptomatology in those with PTSD.

Funding

National Institute on Minority Health and Health Disparities Award: K01 MD013910

CRediT authorship contribution statement

Seyed Aria Nejadghaderi: Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **Seyed Ehsan Mousavi:** Writing – original draft, Investigation, Formal analysis. **Asra Fazlollahi:** Writing – review & editing, Writing – original draft, Investigation. **Kimia Motlagh Asghari:** Writing – review & editing, Writing – original draft, Investigation. **Dana Rose Garfin:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors confirm that there are no conflicts of interest. The authors do not have any financial interests to disclose.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2024.116098.

References

Ades, A.E., Lu, G., Higgins, J.P., 2005. The interpretation of random-effects meta-analysis in decision models. Med. Decis. Making 25 (6), 646–654.

American Psychiatric Association, 2013. Diagnostic and statistical manual of mental disorders: DSM-5. American Psychiatric Association Washington, DC.

Bandyopadhyay, N., Das, T., Biswas, A., Koley, A., 2023. Effects of yogic intervention on sleep quality of healthy elderly: a systematic review. Univers. J Public Health 11, 78–88.

Bayley, P.J., Schulz-Heik, R.J., Tang, J.S., Mathersul, D.C., Avery, T., Wong, M., Zeitzer, J.M., Rosen, C.S., Burn, A.S., Hernandez, B., Lazzeroni, L.C., Seppälä, E.M., 2022. Randomised clinical non-inferiority trial of breathing-based meditation and cognitive processing therapy for symptoms of post-traumatic stress disorder in military veterans. BMJ Open 12, e056609.

Begg, C.B., Mazumdar, M., 1994. Operating characteristics of a rank correlation test for publication bias. Biometrics 50 (4), 1088–1101.

Bhandari, R., 2022. Online yoga and ayurveda intervention as tertiary prevention of psychological comorbidities in COVID-19 survivors: A randomized controlled trial. Ann. Neurosci. 9 (4), 233–244.

Bramer, W.M., Giustini, D., de Jonge, G.B., Holland, L., Bekhuis, T., 2016. De-duplication of database search results for systematic reviews in EndNote. J. Med. Libr. Assoc. 104 (3), 240–243.

Breslau, N., 2002. Epidemiologic studies of trauma, posttraumatic stress disorder, and other psychiatric disorders. Can. J. Psychiatry 47 (10), 923–929.

Büssing, A., Michalsen, A., Khalsa, S.B.S., Telles, S., Sherman, K.J., 2012. Effects of yoga on mental and physical health: A short summary of reviews. Evid. Based Complement. Altern. Med. 2012, 165410.

Carter, J., Gerbarg, P.L., Brown, R.P., Ware, R.S., D'ambrosio, C., 2013. Multi-component yoga breath program for Vietnam veteran post traumatic stress disorder: Randomized controlled trial. J. Trauma. Stress Disord. Treat. 2 (3).

Chawla, V., Brems, C., Freeman, H., Ravindran, A., Noordsy, D.L., 2023. The future of yoga for mental health care. Int. J. Yoga 16 (1), 38–41.

Clark, C.J., Lewis-Dmello, A., Anders, D., Parsons, A., Nguyen-Feng, V., Henn, L., Emerson, D., 2014. Trauma-sensitive yoga as an adjunct mental health treatment in group therapy for survivors of domestic violence: A feasibility study. Complement. Ther. Clin. Pract. 20 (3), 152–158.

Cramer, H., Anheyer, D., Saha, F.J., Dobos, G., 2018a. Yoga for posttraumatic stress disorder – a systematic review and meta-analysis. BMC Psychiatry 18 (1), 72.

Cramer, H., Lauche, R., Anheyer, D., Pilkington, K., de Manincor, M., Dobos, G., Ward, L., 2018b. Yoga for anxiety: A systematic review and meta-analysis of randomized controlled trials. Depress. Anxiety 35 (9), 830–843.

Cramer, H., Ward, L., Saper, R., Fishbein, D., Dobos, G., Lauche, R., 2015. The safety of yoga: a systematic review and meta-analysis of randomized controlled trials. Am. J. Epidemiol. 182 (4), 281–293.

Crocker, T.F., Lam, N., Jordão, M., Brundle, C., Prescott, M., Forster, A., Ensor, J., Gladman, J., Clegg, A., 2023. Risk-of-bias assessment using Cochrane's revised tool for randomized trials (RoB 2) was useful but challenging and resource-intensive: observations from a systematic review. J. Clin. Epidemiol. 161, 39–45.

Davis, L.W., Schmid, A.A., Daggy, J.K., Yang, Z., O'Connor, C.E., Schalk, N., Do, A.N.L., Maric, D., Lazarick, D., Knock, H., 2020. Symptoms improve after a yoga program

designed for PTSD in a randomized controlled trial with veterans and civilians. Psychol. Trauma Theory Res. Pract. Policy 12 (8), 904–912.
Deeks JJ H.J., Altman D.G., Cochrane Statistical Methods Group, 2019. Analysing data and undertaking meta-analyses. Cochrane handbook for systematic reviews of interventions.
Dick, A.M., Niles, B.L., Street, A.E., DiMartino, D.M., Mitchell, K.S., 2014. Examining mechanisms of change in a yoga intervention for women: The influence of mindfulness, psychological flexibility, and emotion regulation on PTSD symptoms. J. Clin. Psychol. 70 (12), 1170–1182.
Egger, M., Smith, G.D., Schneider, M., Minder, C., 1997. Bias in meta-analysis detected by a simple, graphical test. BMJ 315 (7109), 629–634.
Garfin D.R., Nejadghaderi S.A., Fazlollahi A., Motlagh-Asghari K., Mousavi S.E., 2023. Efficacy and safety of yoga for post-traumatic stress disorders: A systematic review and meta-analysis of randomized controlled trials. PROSPERO 2023 CRD42023404708 Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42023404708.
Gobbens, R.J., Remmen, R., 2019. The effects of sociodemographic factors on quality of life among people aged 50 years or older are not unequivocal: Comparing SF-12, WHOQOL-BREF, and WHOQOL-OLD. Clin. Interv. Aging 14, 231–239.
Govindaraj, R., Karmani, S., Varambally, S., Gangadhar, B.N., 2016. Yoga and physical exercise – a review and comparison. Int. Rev. Psychiatry 28 (3), 242–253.
Gu, W., Wang, C., Li, Z., Wang, Z., Zhang, X., 2016. Pharmacotherapies for posttraumatic stress disorder: A meta-analysis. J. Nerv. Ment. Dis. 204 (5), 331–338.
Gupta, A., Om, A.R., Verma, R., Vashisht, A., Bhatt, M., Dabas, A., Gowda, P., Arya, V., 2023. Global research trend on yoga and Yagya intervention on mental illness: A bibliometric attributes of five decades (1972–2021). Yoga Mimamsa 55 (1), 40–48.
Haagen, J.F.G., Smid, G.E., Knipscheer, J.W., Kleber, R.J., 2015. The efficacy of recommended treatments for veterans with PTSD: A metaregression analysis. Clin. Psychol. Rev. 40, 184–194.
Hartung, J., Knapp, G., 2001. On tests of the overall treatment effect in meta-analysis with normally distributed responses. Stat. Med. 20 (12), 1771–1782.
Higgins, J.P., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M.J., Welch, V.A., 2019. Cochrane Handbook for Systematic Reviews of Interventions. John Wiley & Sons.
Huberty, J., Green, J., Gold, K.J., Leiferman, J., Cacciatore, J., 2019. An iterative design process to develop a randomized feasibility study and inform recruitment of minority women after stillbirth. Pilot Feasibility Stud. 5 (1), 1–15.
Huberty, J., Sullivan, M., Green, J., Kurka, J., Leiferman, J., Gold, K., Cacciatore, J., 2020. Online yoga to reduce post traumatic stress in women who have experienced stillbirth: A randomized control feasibility trial. BMC Complement. Med. Ther. 20 (1), 173.
Iyengar B.K.S., 1965. Light on yoga: The definitive guide to yoga practice.
Janjhua, Y., Chaudhary, R., Sharma, N., Kumar, K., 2020. A study on effect of yoga on emotional regulation, self-esteem, and feelings of adolescents. J. Family. Med. Prim. Care 9 (7), 3381–3386.
Jindani, F., Turner, N., Khalsa, S.B.S., 2015. A yoga intervention for posttraumatic stress: A preliminary randomized control trial. Evid. Based Complement. Altern. Med. 2015, 51746.
Kamraju, M., 2023. The impact of yoga on mental health. Indones. J. Community Spec. Needs Educ. 3 (2), 141–146.
Kelly, U., Haywood, T., Segell, E., Higgins, M., 2021. Trauma-sensitive yoga for post-traumatic stress disorder in women veterans who experienced military sexual trauma: interim results from a randomized controlled trial. J. Altern. Complement. Med. 27 (S1), S45–S59.
Kelly, U.A., Evans, D.D., Baker, H., Noggle Taylor, J., 2017. Determining psychoneuroimmunologic markers of yoga as an intervention for persons diagnosed with PTSD: a systematic review. Biol. Res. Nurs. 20 (3), 343–351.
Kendall, M.A.G.,J.D., 1990. Rank correlation methods, 5th edition. Edward Arnold, London.
Kim, S.H., Schneider, S.M., Kravitz, L., Mermier, C., Burge, M.R., 2013. Mind-body practices for posttraumatic stress disorder. J. Investig. Med. 61 (5), 827–834.
Lang, A.J., Malaktaris, A., Maluf, K.S., Kangas, J., Sindel, S., Herbert, M., Bomyea, J., Simmons, A.N., Weaver, J., Velez, D., Liu, L., 2021. A randomized controlled trial of yoga vs nonaerobic exercise for veterans with PTSD: understanding efficacy, mechanisms of change, and mode of delivery. Contemp. Trials Commun. 21, 100719.
Langan, D., Higgins, J.P.T., Jackson, D., Bowden, J., Veroniki, A.A., Kontopantelis, E., Viechtbauer, W., Simmonds, M., 2019. A comparison of heterogeneity variance estimators in simulated random-effects meta-analyses. Res. Synth. Methods 10 (1), 83–98.
Lee, D.J., Schnitzlein, C.W., Wolf, J.P., Vythilingam, M., Rasmusson, A.M., Hoge, C.W., 2016. Psychotherapy versus pharmacotherapy for posttraumatic stress disorder: systemic review and meta-analyses to determine first-line treatments. Depress. Anxiety 33 (9), 792–806.
Maercker, A., Cloitre, M., Bachem, R., Schlumpf, Y.R., Khoury, B., Hitchcock, C., Bohus, M., 2022. Complex post-traumatic stress disorder. Lancet 400 (10345), 60–72.
Maher, A.R., Apaydin, E.A., Hilton, L., Chen, C., Troxel, W., Hall, O., Azhar, G., Larkin, J., Motala, A., Hempel, S., 2021. Sleep management in posttraumatic stress disorder: A systematic review and meta-analysis. Sleep Med. 87, 203–219.
Martin, E.C., Dick, A.M., Scioli-Salter, E.R., Mitchell, K.S., 2015. Impact of a yoga intervention on physical activity, self-efficacy, and motivation in women with PTSD symptoms. J. Altern. Complement. Med. 21 (6), 327–332.
Mathersul, D.C., Dixit, K., Schulz-Heik, R.J., Avery, T.J., Zeitzer, J.M., Bayley, P.J., 2022. Emotion dysregulation and heart rate variability improve in US veterans undergoing treatment for posttraumatic stress disorder: Secondary exploratory analyses from a randomised controlled trial. BMC Psychiatry 22 (1), 268.
McGuinness, L.A., Higgins, J.P.T., 2021. Risk-of-bias VISualization (robvis): An R package and Shiny web app for visualizing risk-of-bias assessments. Res. Synth. Methods 12 (1), 55–61.
Minozzi, S., Cinquini, M., Gianola, S., Gonzalez-Lorenzo, M., Banzi, R., 2020. The revised cochrane risk of bias tool for randomized trials (RoB 2) showed low interrater reliability and challenges in its application. J. Clin. Epidemiol. 126, 37–44.
Mitchell, K.S., Dick, A.M., DiMartino, D.M., Smith, B.N., Niles, B., Koenen, K.C., Street, A., 2014. A pilot study of a randomized controlled trial of yoga as an intervention for PTSD symptoms in women. J. Trauma Stress 27 (2), 121–128.
Morrison, K., Dwarika, V., 2022. Trauma survivors' experiences of Kundalini Yoga in fostering posttraumatic growth. J. Child Adolesc. Trauma 15 (3), 821–831.
Mueller B.A., 2014. The effects of bikram-style hot yoga on posttraumatic stress and depressive symptoms in a military population. ProQuest Information & Learning (Disseration).
National Collaborating Centre for Mental Health, 2005. Post-traumatic stress disorder: The management of PTSD in adults and children in primary and secondary care.
Nguyen-Feng, V.N., Clark, C.J., Butler, M.E., 2019. Yoga as an intervention for psychological symptoms following trauma: A systematic review and quantitative synthesis. Psychol. Serv. 16 (3), 513–523.
Nguyen-Feng, V.N., Hodgdon, H., Emerson, D., Silverberg, R., Clark, C.J., 2020. Moderators of treatment efficacy in a randomized controlled trial of trauma-sensitive yoga as an adjunctive treatment for posttraumatic stress disorder. Psychol. Trauma Theory Res. Pract. Policy 12 (8), 836–846.
Omachi, T.A., 2011. Measures of sleep in rheumatologic diseases: epworth sleepiness scale (ESS), functional outcome of sleep questionnaire (FOSQ), insomnia severity index (ISI), and Pittsburgh sleep quality index (PSQI). Arthritis Care Res. 63 (Suppl 11 (0 11)), S287–S296 (Hoboken).
Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P., Moher, D., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 372, n71.
Pai, A., Suris, A.M., North, C.S., 2017. Posttraumatic stress disorder in the DSM-5: controversy, change, and conceptual considerations. Behav. Sci. 7 (1), 7.
Pascoe, M.C., de Manincor, J., Hallgren, M., Baldwin, M., Tseberja, P.A., Parker, J., G, A., 2021. Psychobiological mechanisms underlying the mental health benefits of yoga-based interventions: a narrative review. Mindfulness 12 (12), 2877–2889..
Patel, N.K., Nivethitha, L., Mooventhan, A., 2018. Effect of a yoga based meditation technique on emotional regulation, self-compassion and mindfulness in college students. Explore 14 (6), 443–447.
Polusny, M.A., Erbes, C.R., Thuras, P., Moran, A., Lamberty, G.J., Collins, R.C., Rodman, J.L., Lim, K.O., 2015. Mindfulness-based stress reduction for posttraumatic stress disorder among veterans a randomized clinical trial. JAMA J. Am. Med. Assoc. 314 (5), 456–465.
Quiñones, N., Maquet, Y.G., Vélez, D.M., López, M.A., 2015. Efficacy of a satyananda yoga intervention for reintegrating adults diagnosed with posttraumatic stress disorder. Int. J. Yoga Therap. 25 (1), 89–99.
R Core Team, 2023. RStudio: Integrated Development Environment for R. Posit Software, PBC, Boston, MA. URL. http://www.posit.co/.
Reddy, S., Dick, A.M., Gerber, M.R., Mitchell, K., 2014. The effect of a yoga intervention on alcohol and drug abuse risk in veteran and civilian women with posttraumatic stress disorder. J. Altern. Complement. Med. 20 (10), 750–756.
Reinhardt, K.M., Noggle Taylor, J.J., Johnston, J., Zameer, A., Cheema, S., Khalsa, S.B.S., 2018. Kripalu Yoga for military veterans with PTSD: A randomized trial. J. Clin. Psychol. 74 (1), 93–108.
Rhodes, A., Spinazzola, J., Van Der Kolk, B., 2016. Yoga for adult women with chronic PTSD: A long-term follow-up study. J. Altern. Complement. Med. 22 (3), 189–196.
Riley, R.D., Higgins, J.P., Deeks, J.J., 2011. Interpretation of random effects meta-analyses. BMJ 342, d549.
Riley, K.E., Park, C.L., 2015. How does yoga reduce stress? A systematic review of mechanisms of change and guide to future inquiry. Health Psychol. Rev. 9 (3), 379–396.
Roche, L.T., 2018. Yoga: A self-regulation process. Yoga Mimamsa 50 (1), 16–19.
Rücker, G., Schwarzer, G., 2021. Beyond the forest plot: The drapery plot. Res. Synth. Methods 12 (1), 13–19.
Balduzzi S., Rucker G., & Schwarzer G. 2019. How to perform a meta-analysis with {R}: a practical tutorial. 22, 153-160.
Schein, J., Houle, C., Urganus, A., Cloutier, M., Patterson-Lomba, O., Wang, Y., King, S., Levinson, W., Guérin, A., Lefebvre, P., Davis, L.L., 2021. Prevalence of post-traumatic stress disorder in the United States: a systematic literature review. Curr. Med. Res. Opin. 37 (12), 2151–2161.
Schulz-Heik, R.J., Lazzeroni, L.C., Hernandez, B., Avery, T.J., Mathersul, D.C., Tang, J.S., Hugo, E., Bayley, P.J., 2022. Valued living among veterans in breath-based meditation treatment or cognitive processing therapy for posttraumatic stress disorder: Exploratory outcome of a randomized controlled trial. Glob. Adv. Health Med. 11, 2164957X221108376.
Seppälä, E.M., Nitschke, J.B., Tudorascu, D.L., Hayes, A., Goldstein, M.R., Nguyen, D.T., Perlman, D., Davidson, R.J., 2014. Breathing-based meditation decreases posttraumatic stress disorder symptoms in U.S. military veterans: A randomized controlled longitudinal study. J. Trauma Stress. 27 (4), 397–405.
Shannahoff-Khalsa, D.S., 2004. An introduction to Kundalini Yoga meditation techniques that are specific for the treatment of psychiatric disorders. J. Altern. Complement. Med. 10 (1), 91–101.

Sonis, J., Cook, J.M., 2019. Medication versus trauma-focused psychotherapy for adults with posttraumatic stress disorder: a systematic review and meta-analysis. Psychiatry Res. 282, 112637.
Sterne, J.A., Sutton, A.J., Ioannidis, J.P., Terrin, N., Jones, D.R., Lau, J., Carpenter, J., Rücker, G., Harbord, R.M., Schmid, C.H., Tetzlaff, J., Deeks, J.J., Peters, J., Macaskill, P., Schwarzer, G., Duval, S., Altman, D.G., Moher, D., Higgins, J.P., 2011. Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials. BMJ 343, d4002.
Sterne, J.A.C., Savović, J., Page, M.J., Elbers, R.G., Blencowe, N.S., Boutron, I., Cates, C. J., Cheng, H.Y., Corbett, M.S., Eldridge, S.M., Emberson, J.R., Hernán, M.A., Hopewell, S., Hróbjartsson, A., Junqueira, D.R., Jüni, P., Kirkham, J.J., Lasserson, T., Li, T., McAleenan, A., Reeves, B.C., Shepperd, S., Shrier, I., Stewart, L.A., Tilling, K., White, I.R., Whiting, P.F., Higgins, J.P.T., 2019. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ 366, l4898.
Stoller, C.C., Greuel, J.H., Cimini, L.S., Fowler, M.S., Koomar, J.A., 2012. Effects of sensory-enhanced yoga on symptoms of combat stress in deployed military personnel. Am. J. Occup. Ther. 66 (1), 59–68.
Strauss, J.L., Coeytaux, R., McDuffie, J., Nagi, A., Williams, J., 2011. Efficacy of complementary and alternative medicine therapies for posttraumatic stress disorder. VA-ESP Project #09-010.
Taylor, J., McLean, L., Korner, A., Stratton, E., Glozier, N., 2020. Mindfulness and yoga for psychological trauma: systematic review and meta-analysis. J. Trauma Dissociation 21 (5), 536–573.
Telles, S., Singh, N., Joshi, M., Balkrishna, A., 2010. Post traumatic stress symptoms and heart rate variability in Bihar flood survivors following yoga: A randomized controlled study. BMC Psychiatry 10, 1–10.
Tew, G.A., Howsam, J., Hardy, M., Bissell, L., 2017. Adapted yoga to improve physical function and health-related quality of life in physically-inactive older adults: a randomised controlled pilot trial. BMC Geriatr. 17 (1), 131.
Thordardottir, K., Gudmundsdottir, R., Zoëga, H., Valdimarsdottir, U.A., Gudmundsdottir, B., 2014. Effects of yoga practice on stress-related symptoms in the aftermath of an earthquake: A community-based controlled trial. Complement. Ther. Med. 22 (2), 226–234.
Tran, K., Moulton, K., Santesso, N., Rabb, D., 2016. Cognitive processing therapy for post-traumatic stress disorder: a systematic review and meta-analysis. Can. Agency Drugs Technol. Health.
Van Der Kolk, B.A., Stone, L., West, J., Rhodes, A., Emerson, D., Suvak, M., Spinazzola, J., 2014. Yoga as an adjunctive treatment for posttraumatic stress disorder: A randomized controlled trial. J. Clin. Psychiatry 75 (6), e559–e565.
Viechtbauer, W., 2005. Bias and efficiency of meta-analytic variance estimators in the random-effects model. J. Educ. Behav. Stat. 30 (3), 261–293.
Viechtbauer, W., 2010. Conducting meta-analyses in {R} with the {metafor} package 36, 1–48.
von der Warth, R., Dams, J., Grochtdreis, T., König, H.H., 2020. Economic evaluations and cost analyses in posttraumatic stress disorder: a systematic review. Eur. J. Psychotraumatol. 11 (1), 1753940.
Voss, S., Cerna, J., Gothe, N.P., 2023. Yoga impacts cognitive health: neurophysiological changes and stress regulation mechanisms. exercise and sport. Sci. Rev. 51 (2), 73–81.
Watkins, L.E., Sprang, K.R., Rothbaum, B.O., 2018. Treating PTSD: a review of evidence-based psychotherapy interventions. Front. Behav. Neurosci. 12, 258.
West, J., Liang, B., Spinazzola, J., 2017. Trauma sensitive yoga as a complementary treatment for posttraumatic stress disorder: A qualitative descriptive analysis. Int. J. Stress. Manag. 24 (2), 173–195.
Williams, T., Phillips, N.J., Stein, D.J., Ipser, J.C., 2022. Pharmacotherapy for post traumatic stress disorder (PTSD). Cochrane Database Syst. Rev. 3 (3), Cd002795.
Woodyard, C., 2011. Exploring the therapeutic effects of yoga and its ability to increase quality of life. Int. J. Yoga 4 (2), 49–54.
World Health Organization, 2013. Guidelines for the management of conditions that are specifically related to stress.
Wynn, G.H., 2015. Complementary and alternative medicine approaches in the treatment of PTSD. Curr. Psychiatry Rep. 17, 1–7.
Yi, L., Lian, Y., Ma, N., Duan, N., 2022. A randomized controlled trial of the influence of yoga for women with symptoms of post-traumatic stress disorder. J. Transl. Med. 20 (1), 162.
Zaccari, B., Sherman, A.D.F., Febres-Cordero, S., Higgins, M., Kelly, U., 2022. Findings from a pilot study of Trauma Center Trauma-Sensitive Yoga versus cognitive processing therapy for PTSD related to military sexual trauma among women veterans. Complement. Ther. Med. 70, 102850.
Zhu, J., Chen, X., Zhen, X., Zheng, H., Chen, H., Chen, H., Liao, H., Zhu, J., Wang, C., Zheng, Z., Chen, R., Wang, Y., 2023. Meta-analysis of effects of yoga exercise intervention on sleep quality in breast cancer patients. Front. Oncol. 13, 1146433.
Zhu, L., Li, L., Li, X.Z., Wang, L., 2021. Mind-body exercises for PTSD symptoms, depression, and anxiety in patients with PTSD: A systematic review and meta-analysis. Front. Psychol. 12, 738211.
Zope, S.A., Zope, R.A., 2013. Sudarshan Kriya Yoga: Breathing for health. Int. J. Yoga 6 (1), 4–10.