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Yoga for asthma: a systematic review and meta-analysis

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ABSTRACT

Background: Although yoga is frequently used by patients with asthma, its efficacy in alleviating asthma remains unclear.
Objective: To systematically assess and meta-analyze the available data on efficacy and safety of yoga in alleviating asthma.
Methods: MEDLINE/PubMed, Scopus, the Cochrane Central Register of Controlled Trials, PsycINFO, CAM-Quest, CAMbase, and IndMED were searched through January 2014. Randomized controlled trials of yoga for patients with asthma were included if they assessed asthma control, symptoms, quality of life, and/or pulmonary function. For each outcome, standardized mean differences (SMDs) or risk ratios (RRs) and 95% confidence intervals (CIs) were calculated. Risk of bias was assessed using the Cochrane tool.
Results: Fourteen randomized controlled trials with 824 patients were included. Evidence for effects of yoga compared with usual care was found for asthma control (RR, 10.64; 95% CI, 1.98 to 57.19; $P = .006$), asthma symptoms (SMD, −0.37; 95% CI, −0.55 to −0.19; $P < .001$), quality of life (SMD, 0.86; 95% CI, 0.39 to 1.33; $P < .001$), peak expiratory flow rate (SMD, 0.49; 95% CI, 0.32 to 0.67; $P < .001$), and ratio of forced expiratory volume in 1 second to forced vital capacity (SMD, 0.50; 95% CI, 0.24 to 0.75; $P < .001$); evidence for effects of yoga compared with psychological interventions was found for quality of life (SMD, 0.61; 95% CI, 0.22 to 0.99; $P = .002$) and peak expiratory flow rate (SMD, 2.87; 95% CI, 0.14 to 5.60; $P = .04$). No evidence for effects of yoga compared with sham yoga or breathing exercises was revealed. No effect was robust against all potential sources of bias. Yoga was not associated with serious adverse events.
Conclusion: Yoga cannot be considered a routine intervention for asthmatic patients at this point. It can be considered an ancillary intervention or an alternative to breathing exercises for asthma patients interested in complementary interventions.

Introduction

Asthma is a chronic inflammatory airways disorder characterized by hypersensitivity to various stimuli and widespread episodic airway obstruction.[1] It is typically associated with symptoms of wheezing, coughing, chest tightness, and dyspnea. The prevalence of asthma is 10% in children and 8% in adults. Although boys are more likely than girls to have asthma, women are more likely than men.[2]

Rooted in Indian philosophy, yoga has been a part of traditional Indian spiritual practice for millennia.[3] Traditional yoga is a complex intervention that comprises advice for ethical lifestyle, spiritual practice, physical activity, breathing exercises, and meditation. Although the ultimate goal of traditional yoga has been described as uniting mind, body, and spirit, yoga has become a popular means to promote physical and mental well-being.[3,4] In North America and Europe, yoga is most often associated with physical postures (asanas), breathing techniques (pranayama), and meditation (dhyana), and different yoga forms have emerged that put varying focus on physical and mental practices.[3] Although yoga is frequently used by patients with asthma,[5] prior systematic reviews have not supported its efficacy in alleviating asthma.[6,7] Since the publication of those reviews, a considerable number of new studies have been published that warrant an update. Moreover, until now no meta-analysis has been available. Thus, the aim of this review is to systematically evaluate and meta-analyze the available data on efficacy and safety of yoga in improving asthma control, symptoms, quality of life, and pulmonary function in patients with asthma.

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[8] and recommendations of the

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Cochrane Collaboration[9] were used to lend a framework for the reporting structure of this review.

Eligibility Criteria

Randomized controlled trials (RCTs), randomized crossover studies, and cluster-randomized trials were eligible. No language restrictions were applied. Participants included both adults and children with asthma. Interventions included (1) yoga breathing interventions (based on yoga theory and/or traditional yoga practices) without physical postures, meditation, or lifestyle advice; (2) complex yoga interventions, including yoga breathing and at least 1 of the following: physical postures, meditation, and/or lifestyle advice (based on yoga theory and/or practices); and (3) other yoga interventions, including at least 1 of the following: physical postures, meditation, and/or lifestyle advice (based on yoga theory and/or practices) but not yoga breathing. No restrictions were made regarding yoga tradition, length or frequency of the yoga sessions, or duration of the program. Studies that allowed individual cointerventions were eligible. Studies that compared yoga with usual care, sham yoga, or any active control intervention were eligible as controls.

To be eligible for inclusion, RCTs had to assess at least 1 primary outcome:[10] (1) asthma control assessed by validated instruments, frequency of medication use, or asthma attacks[11]; (2) asthma symptoms assessed by validated instruments[12]; (3) quality of life assessed by validated asthma-specific[13] or generic instruments (where available, disease-specific instruments were preferred); or (4) pulmonary function assessed by validated measures such as spirometry.[14] Secondary outcomes included safety of the intervention assessed as number of patients with adverse events (AEs).

Search Methods

Seven electronic databases were searched from their inception through January 15, 2014: MEDLINE/PubMed, Scopus, the Cochrane Central Register of Controlled Trials, PsycINFO, CAM-Quest, CAMbase, and IndMED. The literature search was constructed around search terms for *yoga* and *asthma* and adapted for each database as necessary. The complete search strategy for MEDLINE is given in Table 1. To locate gray literature, the System for Information on Grey Literature in Europe (http://www.opengrey.eu/) and ResearchGate (www.researchgate.net) were additionally searched. In addition, reference lists of identified original articles or reviews and the tables of contents of the *International Journal of Yoga Therapy* and the *Journal of Yoga & Physical Therapy* were searched manually.

The abstract screening and selection process was conducted independently by 2 reviewers (H.C. and P.P.). Potentially eligible articles were read in full by 2 reviewers. Disagreements about whether to include an article were settled through a discussion with a third reviewer (J.L. or G.D.) until consensus was reached. If necessary, additional information was obtained from the authors of the primary study.

Table 1
Complete search strategy for MEDLINE

1	"Asthma" [MESH] OR "Asthma" [Title/Abstract]
2	"antiasthmatic" [Title/Abstract] OR "anti-asthmatic" [Title/Abstract]
3	"Respiratory Sounds" [MESH] OR "wheezing" [Title/Abstract]
4	"Bronchoconstriction" [MESH] OR "Bronchoconstriction" [Title/Abstract] OR "Bronchial Spasm" [MESH] OR "Bronchopasm" [Title/Abstract] OR ("Bronchial" [Title/Abstract] AND ("Constriction" [Title/Abstract] OR "Spasm" [Title/Abstract])
5	"Respiratory Hypersensitivity" [MESH] OR "Bronchial Hyperreactivity" [MESH]
6	("mites" [MESH] OR "mite" [Title/Abstract] OR "dust" [MESH] OR "dust" [Title/Abstract]) AND ("Hypersensitivity" [MESH] OR "Hypersensitivity" [Title/Abstract] OR "Allergy" [Title/Abstract])
7	1 OR 2 OR 3 OR 4 OR 5 OR 6
8	"Yoga" [MESH] OR "Yoga" [Title/Abstract] OR "Yogic" [Title/Abstract] OR "Asana" [Title/Abstract] OR "Pranayama" [Title/Abstract] OR "Dhyana" [Title/Abstract]
9	7 AND 8

Abbreviation: MeSH, medical subject heading.

Data Extraction and Management

Two reviewers (H.C. and P.P.) independently extracted data on patients (eg, age, sex, and ethnicity), methods (eg, randomization and allocation concealment), interventions (eg, yoga type, frequency, and duration), control interventions (eg, type, frequency, and duration), outcomes (eg, outcome measures and assessment time points), and results using an a priori developed data extraction form. Discrepancies were discussed with a third reviewer until consensus was reached.

Assessment of ROB in Individual Studies

Risk of bias (ROB) was assessed by 2 authors (H.C. and P.P.) independently using the Cochrane ROB tool.[9] This tool assesses ROB using 7 criteria: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other sources of bias. For each criterion, ROB was assessed as (1) low, (2) unclear, or (3) high ROB. Discrepancies were rechecked with a third reviewer (J.L. or G.D.) and consensus achieved by discussion.

Statistical Analysis

Separate meta-analyses were conducted for different control conditions. If at least 2 studies assessing a specific outcome were available, meta-analyses were conducted using Review Manager software (version 5.1; The Nordic Cochrane Centre, Copenhagen, Denmark) by random-effects model using the generic inverse variance method. For continuous outcomes, standardized mean differences (SMDs) with 95% confidence intervals (CIs) were calculated as the difference in means between groups divided by the pooled SD.[9,15] SMDs were calculated as Hedge's g using a standardized Excel spreadsheet. For dependent samples (ie, crossover trials or matched pairs), the calculation was adapted for intercorrelations between groups. Where no correlation was reported, it was estimated as 0.7.[16] Where no SDs were available, they were calculated from SEs, CIs, or *t*-values,[9] or attempts were made to obtain the missing data from the trial authors by e-mail.

A positive SMD was defined to indicate beneficial effects of yoga compared with the control intervention for all outcomes (ie, increased asthma control, quality of life, and pulmonary function) except for asthma symptoms where a negative SMD was defined to indicate beneficial effects (ie, decreased symptoms).

Cohen's categories were used to evaluate the magnitude of the overall effect size as follows: SMD of 0.2 to 0.5, small; SMD of 0.5 to 0.8, medium; and SMD greater than 0.8, large effect sizes.[15] For dichotomous outcomes, risk ratios (RRs) with 95% CIs were calculated by dividing the risk of event in the experimental group (ie, the number of participants with the respective outcome divided by the total number of participants) by the risk of event in the control group.[9]

Assessment of Heterogeneity

The magnitude of heterogeneity was analyzed using the I^2 statistics and categorized as follows: I^2 of 0% to 24%, low; I^2 of 25% to 49%, moderate; I^2 of 50% to 74%, substantial; and I^2 of 75% to 100%, considerable heterogeneity.[9,17] The χ^2 test was used to assess whether differences in results are compatible with chance alone. Given the low power of this test when only a few studies or studies

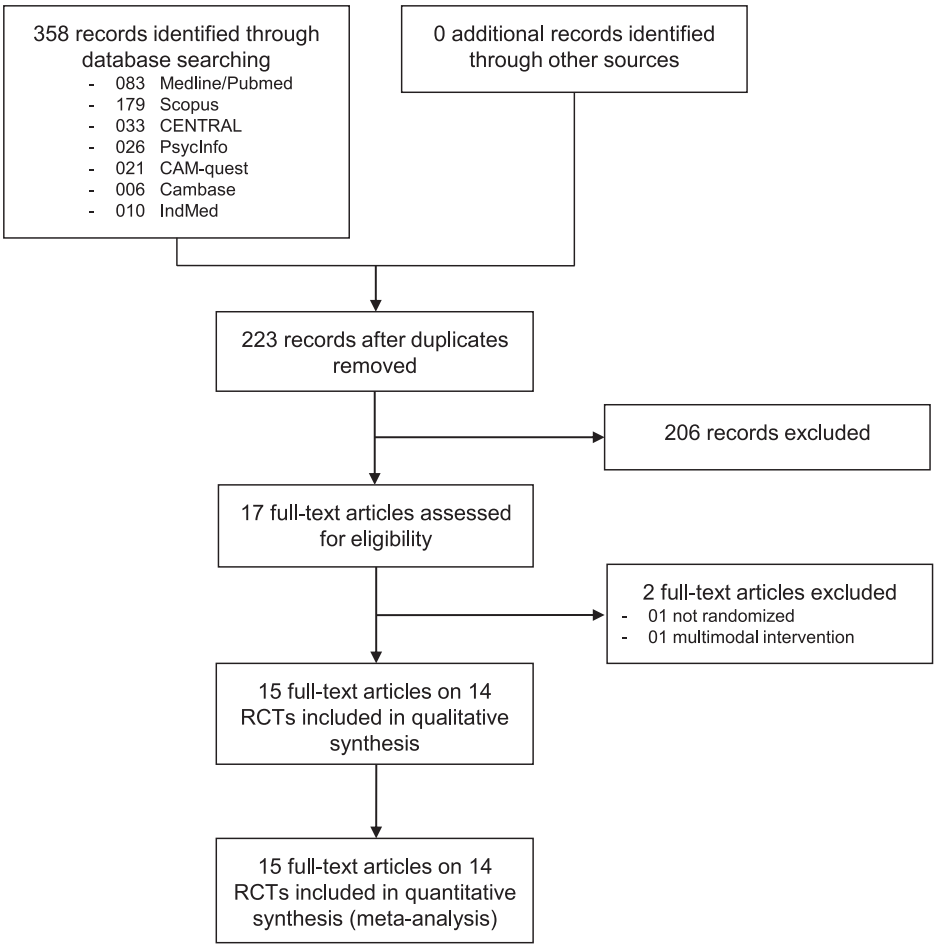


Figure 1. Flowchart of the results of the literature search.

with small sample sizes are included in a meta-analysis, $P \leq .10$ was regarded to indicate significant heterogeneity.[9]

Subgroup and Sensitivity Analyses

Subgroup analyses were conducted for participant age group (adults or adolescents vs children) and type of yoga intervention (yoga breathing interventions vs complex yoga interventions vs other yoga interventions). To test the robustness of significant results, sensitivity analyses were conducted for studies with high vs low ROB at the following domains: selection bias, detection bias, and attrition bias. If statistical heterogeneity was present in the respective meta-analysis, subgroup and sensitivity analyses were also used to explore possible reasons for statistical heterogeneity.

ROB Across Studies

If at least 10 studies were included in a meta-analysis, funnel plots were generated using Review Manager software (version 5.1; The Nordic Cochrane Centre, Copenhagen, Denmark). Publication bias was assessed by visually inspecting funnel plots, with roughly symmetrical indicating low ROB and asymmetrical indicating high ROB.[9,18]

Results

Literature Search

The literature search revealed a total of 223 nonduplicate records of which 17 full-text articles were assessed for eligibility (Fig 1).[19–35] Two articles were excluded because they were not randomized[19] or yoga was part of a multimodal intervention.[20] Fifteen full-text articles reporting on 14 RCTs with a total of 824 patients were included in the qualitative analysis and meta-analysis.[21–35]

Study Characteristics

Characteristics of the included studies are presented in Table 2. Of the 14 RCTs that were included, 2 used dependent samples, 1 of them used a crossover design,[31] and the other used matched pairs of patients (1 from each pair was randomized to each group).[26] Three RCTs originated from the United States,[21,28,34] 1 from Australia,[24] 2 from the United Kingdom,[22,31] 1 from Germany,[23] 1 from Ethiopia,[25] and 6 from India.[26,27,29,30,32,33,35] Nine RCTs included adult and/or adolescent patients,[21,23,25,27–35] one RCT included children, adolescents, and adults,[26] and 2 RCTs did not mention the eligible age group.[22,24] Patients in 10 studies had their conditions diagnosed based on objective pulmonary criteria[22,24,26–31,34,35]; diagnostic criteria were unclear in the remaining studies.[21,23,25,32,33] Sample size ranged from 17 to 120 patients, with a median of 59.5 patients. Patients' mean age ranged from 26 to 51 years, with a median age of 36.9 years. Between 28.2% and 100.0% (median, 51.3%) of patients in each study were female. Where reported, between 0% and 100% of patients in each study were white, with a median of 83.9%.

Five RCTs included yoga breathing interventions without physical postures, meditation, or lifestyle advice.[22,27,29,31–33] Of those, 2 RCTs[22,31] used the Pink City Lung Exerciser (PCLE), a medical device designed to reduce breathing frequency and to prolong expiration.

Table 2
Characteristics of the included studies

Reference	Patients, No./age group, y/mean age, y/female, %/white, %	Cointerventions	Program length, frequency, and duration by intervention group		Assessment time points	Outcome measures
			Treatment	Control		
Bidwell et al,[21] 2012	19/20-65/41.8/100/NR	Usual care	20 1-hour yoga (postures, breathing, meditation) sessions in a group setting (2 per week for 10 weeks) and 10 30-minute home-sessions (1 per week for 10 weeks)	Usual care	10 weeks	SGRQ, FEV_1, FVC, PEFR, tidal volume
Cooper et al,[22] 2013	69/18-70/44.0/44.9/NR	Steroids, β2-agonists	Pink City Lung Exerciser 2 times per day home use for 6 months	(1) Placebo Pink City Lung Exerciser 2 times per day home use for 6 months; (2) eucapnic buteyko technique 2 hour sessions 2 times per day home use for 6 months	3 months, 6 months	Steroid use, symptom score diary, SF-36, AQLQ, FEV_1, FVC
Flüge et al,[23] 1994	36/21-33/44.8/61.1/NR	Usual care	15 3-hour sessions of yoga (postures, breathing, cleansing, relaxation) during 12 weeks	(1) 15 3-hour sessions of breathing exercises for 12 weeks; (2) usual care for 3 weeks	1 month, 2 months, 3 months, 4 months	VC, FEV_1, TLC, FRC, RV, R_{tot}, adverse events
Manocha et al,[24] 2002	59/adults/36.5/52.5/NR	Steroids, β_2-agonists, and/or theophylline	2-hour sessions once a week and 10 to 20 minutes of home use 2 times per day for 4 months of Sahaja yoga mediation	2-hour sessions once a week and 10 to 20 minutes of home use 2 times per day for 4 months of relaxation methods, group discussion, and cognitive behavioral therapy–like exercises	4 months, 6 months	Combined Asthma Score, AQLQ, PD_{20}, FEV_1, PEF, FEV_1 (% predicted), FEV_1/FVC ratio
Mekonnen and Mossie,[25] 2010	24/11-51/30.5/50/0	Salbutamole	50-minute daily sessions of yoga exercise (postures, breathing, relaxation, discussion) for 4 weeks	NR	4 weeks	Asthma attacks per week, rescue inhaler use, symptom score, PEFR
Nagarathna and Nagendra,[26] 1985	106/9-47/26.4/28.3/NR	Bronchodilators	2.5-hour sessions of yoga (postures, breathing, meditation, lectures) daily for 2 weeks; 65 minutes daily home use for 54 months	Usual care	54 months	Asthma attacks per week, severity score, PEFR
Prem et al,[27] 2013	120/18-60/38.1/59.1/NR	Usual care	Pranayama (breathing) 3 to 5 times for 60 minutes per day, then home use 2 times for 15 minutes per day for 3 months	(1) Buteyko 3 to 5 times for 60 minutes per day, then home use 2 times for 15 minutes per day for 3 months; (2) usual care	3 months	Asthma Control Questionnaire, AQLQ, FEV_1, and FEV_1/FVC ratio
Sabina et al,[28] 2005	62/18-76/51/74.2/83.9	Usual care	90-minute sessions twice weekly for 4 weeks of Iyengar yoga (postures, breathing, meditation)	60-minutes sessions twice weekly for 4 weeks; sham yoga (stretching)	4 weeks, 16 weeks	Rescue inhaler use, Asthma Symptom Score, mini AQLQ, FEV_1 and PEFR, adverse events
Saxena and Saxena,[29] 2009	50/18-45/29.3/50/NR	None	20 minutes twice daily for 12 weeks of Pranayama (breathing, chanting)	20 minutes twice daily for 12 weeks of meditation	12 weeks	Asthma Symptoms Score, FEV_1, PEFR
Singh et al,[30] 2012	60/18-60/NR/NR/NR	Usual care	40–50 minutes daily for 2 months of yoga (breathing, postures, meditation and lifestyle modification)	NR	2 weeks	AQLQ, SGRQ, FVC, FEV_1, FEV_1/FVC ratio, MVV, SVC, PEFR
Singh et al,[31] 1990	22/19-54/NR/NR/100	β_2-agonists	15 minutes twice daily for 2 weeks of Pink City Lung Exerciser use	15 minutes twice daily for 2 weeks of placebo Pink City Lung Exerciser use	2 weeks	Rescue inhaler use, Asthma Symptoms Score, FEV_1, PD_{20}, adverse events

Sodhi et al,[32,33] 2009/2014	120/17-50/37.2/40.8/NR	NR	45 minutes per week of yoga breathing for 8 weeks plus 45 minutes twice daily every day at home	NR	4 weeks, 8 weeks	Asthma attacks per week, medication use, severity of asthma attacks, AQLQ, PEFR, FEV_1, FVC, FVC/FEV_1 ratio, $FEF_{25\%-57\%}$
Vedanthan et al,[34] 1998	17/19-52/26.5/52.9/NR	NR	3 times weekly for 16 weeks of yoga (breathing, postures, meditation, discussion, lectures)	NR	16 weeks	Inhalers, steroids, antihistamines, and theophylline use; severity and frequency score; FVC, FEV_1, $FEF_{25\%-75\%}$
Vempati et al,[35] 2009	60/≥18/33.5/42.1/NR	Inhaled corticosteroids	4 hours a day, 5 days a week for 2 weeks of comprehensive yoga-based lifestyle modification and stress management program (postures, breathing, cleansing techniques, meditation, relaxation, lectures, vegetarian diet), at least 1 hour individual consultation	1 session of health education	2 weeks, 4 weeks, 8 weeks	Rescue medication use, AQOL, FEV_1, FVC, FEV_1/FVC ratio, PEFR, $FEF_{25\%-75\%}$

Abbreviations: AQLQ, Asthma Quality of Life Questionnaire; $FEF_{25\%-75\%}$, forced expiratory flow between 25% and 75%; FEV_1, forced expiratory volume in 1 second; FRC, functional residual capacity; FVC, forced vital capacity; MVV, maximum voluntary ventilation; NR, not reported; NS, not significant; PD_{20}, provocation dose causing a 20% reduction in FEV_1; PEFR, peak expiratory flow rate; sig. fav., significant group difference favoring; R_{tot}, total airway resistance; RV, residual volume; SF-36, 36-Item Short-Form Health Survey; SGRQ, St. George's Respiratory Questionnaire; SVC, slow vital capacity; TLC, total lung capacity; TLCO, transfer factor of the lung for carbon monoxide; VC, vital capacity.

This device was meant to mimic typical breathing patterns of yoga breathing techniques. Eight RCTs used complex yoga interventions, including yoga breathing, postures, and meditation.[21,23,25,26,28,30,34,35] One RCT used yoga meditation without a breathing or posture component.[24] The duration of yoga programs ranged from 2 weeks to 54 months, with a median of 12 weeks; frequency of yoga interventions ranged from 1.5 to 15 (median, 14) weekly supervised and/or unsupervised yoga sessions.

Seven RCTs compared yoga with usual care or an unspecified control condition.[21,23,25,26,30,32–34] Three RCTs compared yoga with a sham yoga intervention (an intervention designed to mimic the nonspecific effects of yoga interventions without specific effects), including a placebo PCLE[22,31] and stretching.[28] Three RCTs compared yoga with intensity-matched nonyoga breathing techniques,[22,23,27] and 3 RCTs compared yoga with nonyoga psychological interventions, including intensity-matched psychological group programs[24,29] and a single-session health education program.[35] Where reported, all but 1 RCT[29] allowed self-directed antiasthmatic drugs as cointervention for patients in intervention and control groups. Comedication included β_2-agonists,[22–25,27,31] corticosteroids,[22–24,27,35] and theophylline.[23,24]

Outcome Measures

Asthma control was assessed as frequency of medication use in 7 RCTs,[22,25,28,31–35] as number of asthma attacks in 3 RCTs,[25,26,32,33] and/or by questionnaires in 2 RCTs.[24,27] Asthma symptoms,[22,25,26,28,29,31–34] and quality of life[21,22,24,27,28,30,32,33,35] were assessed with questionnaires in 8 RCTs each. All 14 RCTs assessed parameters of pulmonary function. Only 3 RCTs assessed AEs.[23,28,31] The remaining RCTs did not assess safety-related outcomes.

ROB in Individual Studies

ROB in individual studies is given in Table 3. Four RCTs had low risk of selection bias (ie, adequate random sequence generation and allocation concealment).[22,24,27,28] Six RCT reported blinding of outcome assessors, indicating low risk of detection bias,[22,24,25,27,28,34] and 8 RCTs reported acceptable dropout rates, indicating low risk of attrition bias.[22,24,26–28,31,34,35]

Analysis of Overall Effect

Patient-reported outcomes

Meta-analyses revealed evidence for effects of yoga compared with usual care for asthma control, asthma symptoms, and quality of life and of yoga compared with psychological interventions for quality of life. No effects were found when comparing yoga to sham yoga or breathing exercises (Table 4 and eFigs 1–3).

Pulmonary function

Comparing yoga and usual care, evidence was found of effects on peak expiratory flow rate (PEFR) and ratio of forced expiratory volume in 1 second (FEV_1) to forced vital capacity (FVC). Evidence of the effects of yoga compared with psychological interventions was found for PEFR only. No evidence of the effects of yoga compared with sham yoga or breathing exercises or of the effects on FEV_1, FVC, or forced expiratory flow between 25% and 75% was found (Table 5 and eFigs 4–8).

Safety

Three RCTs reported AEs. In 1 RCT, 3 acute asthma exacerbations occurred in the usual care group compared with none in the yoga or breathing exercise groups.[23] Another RCT reported that no AEs associated with the interventions occurred in either group.[28] In the third RCT, 1 patient in the yoga group reported mild dyspnea while using the PCLE.[31]

Table 3
Risk of bias assessment of the included studies using the cochrane risk of bias Tool

Reference	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Bidwell et al, 2012	Unclear risk	Unclear risk	Unclear risk	Unclear risk	Unclear risk	Unclear risk	Low risk
Cooper et al,[22] 2013	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Flüge et al,[23] 1994	Unclear risk	Unclear risk	Unclear risk	Unclear risk	High risk	Unclear risk	Unclear risk
Manocha et al,[24] 2002	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Mekonnen and Mossie,[25] 2010	Unclear risk	Unclear risk	Unclear risk	Low risk	Unclear risk	Unclear risk	Unclear risk
Nagarathna and Nagendra,[26] 1985	High risk	High risk	High risk	Unclear risk	Low risk	Low risk	Unclear risk
Prem et al,[27] 2013	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Sabina et al,[28] 2005	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Saxena and Saxena,[29] 2009	High risk	High risk	Unclear risk	Unclear risk	Unclear risk	Unclear risk	Unclear risk
Singh et al,[30] 2012	Unclear risk	Unclear risk	Unclear risk	Unclear risk	Unclear risk	Low risk	High risk
Singh et al,[31] 1990	Unclear risk	Unclear risk	Low risk	Unclear risk	Low risk	Low risk	Low risk
Sodhi et al,[32,33] 2009/2014	Unclear risk	Unclear risk	Unclear risk	Unclear risk	Unclear risk	High risk	Unclear risk
Vedanthan et al,[34] 1998	Unclear risk	Unclear risk	Unclear risk	Low risk	Low risk	Unclear risk	Low risk
Vempati et al,[35] 2009	Unclear risk	Unclear risk	High risk	High risk	Low risk	Low risk	Low risk

Subgroup Analyses

In RCTs that used complex yoga interventions, evidence of the effects of yoga compared with usual care was found for asthma control (RR, 10.64; 95% CI, 1.98 to 57.19; $P = .006$), asthma symptoms (SMD, −0.35; 95% CI, −0.56 to −0.14; $P = .001$), and quality of life (SMD, 1.47; 95% CI, 0.86 to 2.08; $P < .001$). Effects of yoga compared with psychological interventions were found for FEV_1 (SMD, 0.53; 95% CI, 0.00 to 1.06; $P = .05$), PEFR (SMD, 0.85; 95% CI, 0.32 to 1.38; $P < .001$), and FEV_1/FVC ratio (SMD, 0.57; 95% CI, 0.04 to 1.10; $P = .03$). Compared with breathing exercises, effects favoring breathing exercises over complex yoga were found for FEV_1 (SMD, −2.24; 95% CI, −3.24 to −1.24; $P < .001$).

In RCTs that compared yoga breathing interventions with usual care, effects were found for asthma symptoms (SMD, −0.43; 95% CI, −0.78 to −0.08; $P = .02$), quality of life (SMD, 0.55; 95% CI, 0.26 to 0.83; $P < .001$), FEV_1 (SMD, 0.60; 95% CI, 0.31 to 0.89; $P < .001$), and FEV_1/FVC ratio (SMD, 0.48; 95% CI, 0.20 to 0.76; $P < .001$). Effects that favored yoga breathing over psychological interventions were found for PEFR (SMD, 8.39; 95% CI, 6.67 to 10.11; $P < .001$). No effects were found for RCTs that only used yoga meditation.

When only RCTs were considered that explicitly only included adults, elderly people, and/or adolescents (but no children younger than 12 years), the effects of yoga compared with psychological interventions on quality of life and PEFR were no longer significant, whereas a significant effect was found for FEV_1/FVC ratio (SMD, 0.57; 95% CI, 0.04 to 1.10; $P = .03$). All other effects did not change substantially.

Sensitivity Analyses

In RCTs with low risk of selection bias,[22,24,27,28] only the effect of yoga compared with usual care on the FEV_1/FVC ratio remained significant (SMD, 0.66; 95% CI, 0.21 to 1.11; $P = .004$). In RCTs with low risk of detection bias,[22,24,25,27,28,34] only the effect of yoga compared with usual care on asthma control remained unchained (SMD, 10.64; 95% CI, 1.98 to 57.19; $P = .006$). In RCTs with low risk of attrition bias,[22,24,26–28,31,34,35] the effects of yoga compared with usual care on PEFR (SMD, 0.54; 95% CI, 0.33 to 0.75; $P < .001$) and compared with psychological interventions on quality of life (SMD, 0.61; 95% CI, 0.22 to 0.99; $P = .002$) reached significance.

ROB Across Studies

The funnel plot for quality of life was asymmetrical, indicating risk of publication bias. The funnel plot for FEV_1 was roughly symmetrical (eFig 9).

Discussion

Summary of Evidence

In this systematic review of 14 RCTs on yoga for asthma, evidence of the positive effects of yoga on patient-reported outcomes and pulmonary function compared with usual care and psychological interventions but not compared with breathing interventions or sham yoga interventions was revealed. Evidence of the effects was only revealed for interventions that included yogic breathing techniques but not for interventions without breathing techniques.[24]

Table 4
Effects of yoga vs controls on patient-reported outcomes

Outcome[a]	No. of studies	No. of patients	Standardized mean difference (95% confidence interval)	*P* (overall effect)	Heterogeneity, $I^2/\chi^2/P$
Asthma control					
Yoga vs usual care	2	41	10.64 (1.98 to 57.19)[b]	.006	0%/0.02/.90
Yoga vs sham yoga[c]	3	139	0.01 (−0.23 to 0.25)	.94	0%/0.99/.61
Asthma symptoms					
Yoga vs usual care	3	243	−0.37 (−0.55 to −0.19)	<.001	0%/0.16/.92
Yoga vs sham yoga[c]	2	77	0.07 (−0.22 to 0.36)	.62	0%/0.01/.93
Quality of life					
Yoga vs usual care	4	246	0.86 (0.39 to 1.33)	<.001	62%/7.84/.05
Yoga vs sham yoga[c]	2	108	−0.05 (−0.42 to 0.32)	.78	0%/0.61/.43
Yoga vs breathing exercise[c]	2	122	−0.34 (−0.69 to 0.02)	.06	0%/0.53/.47
Yoga vs psychological interventions	2	102	0.61 (0.22 to 0.99)	.002	0%/0.25/.61

[a]Outcomes are only shown if sufficient data for meta-analysis were available.
[b]Risk ratio (95% confidence interval).
[c]Additional data by Cooper et al[22] provided on request.

Table 5
Effects of yoga vs controls on pulmonary function

Outcome[a]	No. of studies	No. of patients	Standardized mean difference (95% confidence interval)	*P* (overall effect)	Heterogeneity, $I^2/\chi^2/P$
FEV_1					
Yoga vs usual care	5	264	0.21 (−0.23 to 0.64)	.35	61%/10.36/.03
Yoga vs sham yoga	2	58	0.03 (−0.27 to 0.32)	.86	0%/0.03/.87
Yoga vs breathing exercise	3	140	−0.64 (−1.89 to 0.60)	.31	91%/22.11/<.001
Yoga vs psychological interventions	3	154	1.25 (−0.68 to 3.18)	.20	96%/54.12/<.001
FVC					
Yoga vs usual care	3	164	−0.09 (−0.70 to 0.52)	.78	61%/5.17/.08
PEFR					
Yoga vs usual care	4	264	0.49 (0.32 to 0.67)	<.001	0%/1.74/.63
Yoga vs psychological interventions	3	154	2.87 (0.14 to 5.60)	.04	98%/82.40/<.001
FEV_1/FVC					
Yoga vs usual care	3	226	0.50 (0.24 to 0.75)	<.001	0%/1.08/.58
Yoga vs psychological interventions	2	104	0.20 (−0.53 to 0.94)	.59	72%/3.58/.06
$FEF_{25\%-75\%}$					
Yoga vs usual care	2	134	0.04 (−1.02 to 0.93)	.93	71%/3.44/.06

Abbreviations: $FEF_{25\%-75\%}$, forced expiratory flow between 25% and 75%; FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity.
[a]Outcomes are only shown if sufficient data for meta-analysis were available.

Safety of the intervention was insufficiently reported. However, where reported, yoga was not associated with severe AEs. It is worth bearing in mind that although previous cross-sectional studies[36,37] and systematic efficacy reviews of yoga interventions found no evidence for severe AEs,[38–40] a systematic safety review revealed that yogic breathing techniques can occasionally be associated with severe AEs.[41]

Agreements With Prior Systematic Reviews

The results of the present review are not in line with those of a previously published qualitative systematic review on yoga for asthma. On the basis of 6 RCTs and 1 non-RCTs published up to October 2010, this review found no sound evidence that yoga alleviates asthma.[6] In line with the present review, methodologic quality of the included trials was judged as insufficient. Another recent qualitative systematic review found positive effects in 10 of 15 RCTs and non-RCTs and concluded that yoga can improve asthma symptoms and reduce corticosteroid use.[7] This is in line with the present review where improved asthma control was found in the form of reduced medication use. No previous review included a meta-analytic approach and/or subgroup analyses.

External and Internal Validity

Asthma patients from North America, Europe, Asia, Africa, and Australia were included. Overall, the sex ratio was well balanced. Different ethnicities were included. Although the included age range covered adolescents, adults, and older adults, only 1 RCT explicitly also included children. Therefore, the suitability and effects of yoga in children with asthma could not be evaluated. The results of the present review thus seem to be applicable to most adult patients with asthma in clinical practice but not for children with asthma.

Overall, ROB of the included trials was unclear or high. Most importantly, few RCTs reported adequate allocation concealment. Because inadequate allocation concealment has been empirically demonstrated to be the most important source of bias in RCTs,[42] this strongly limits the interpretability of results. In sensitivity analyses, no effect was robust against all potential sources of bias. Moreover, there were hints on potential publication bias. The internal validity of the results is thus limited.

Strengths and Weaknesses

To the best of our knowledge, this is the first meta-analysis available on yoga for asthma. Strengths of this review include the use of subgroup analyses to assess the effects of different forms of yoga and in different participant groups, the assessment of applicability of the results,[43] the low heterogeneity of the data, and the comprehensive literature search without language restrictions. The primary limitation of this review is the low methodologic quality of the included RCTs, limiting the interpretability of the results. Because few RCTs reported longer-term effects, the results of this review are only applicable to the short term. Yoga is a heterogeneous intervention by definition.[3] Although subgroup analyses allowed a clearer interpretation of which forms of yoga interventions are effective in asthma patients, it remains unclear whether, for example, interventions such as the use of the PCLE can be regarded as an equivalent alternative for traditional yogic breathing exercises.[6]

Implications for Further Research

Future RCTs should ensure rigorous methods, mainly adequate sample size based on a priori power calculation, adequate randomization, allocation concealment, intention-to-treat analysis, and blinding of at least outcome assessors. Authors of prospect research should improve the reporting of yoga trials and follow commonly accepted guidelines (eg, Consolidated Standards of Reporting Trials, CONSORT).[44]

Future RCTs should try to differentiate between specific and nonspecific effects of yoga interventions. Because most sham-controlled RCTs in this review used the PCLE that is not a traditional yoga intervention but a medical device that simply mimics yogic breathing,[22] it seems important to compare other more traditional yoga interventions to credible sham procedures. However, these procedures still need to be developed and tested for suitability.

Implications for Clinical Practice

Yoga, in particular yoga forms that include breathing exercises, seem to be more effective than usual care for alleviating asthma. Nonyogic breathing exercises seem to be an effective intervention at least for improving patient-reported outcomes in asthma patients,[45] and evidence regarding the psychological interventions is

inconclusive.[46] Thus, the equivalent effects of yoga and (other) breathing interventions and the superiority beyond psychological interventions could also be carefully interpreted as a hint on effectiveness of yoga. However, because no effects beyond sham interventions were found, the positive effects of yoga in patients with asthma could be interpreted on a basis of nonspecific or context-dependent effects of yoga rather than specific effects of the intervention. Moreover, the interpretability of the results is limited by the high ROB. Therefore, yoga cannot be considered a routine intervention for asthma patients at this point. Because it seems to be a relatively safe intervention in this patient population, complex yoga or yoga breathing interventions can be considered ancillary interventions or alternatives to other breathing exercises for asthma patients interested in complementary interventions.

Supplementary Data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.anai.2014.03.014.

References

[1] National Asthma Education and Prevention Program (NAEPP). *Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma*. Bethesdsa, MD: National Heart Lung and Blood Institute; 2007.

[2] Tantisira KG, Colvin R, Tonascia J, Strunk RC, Weiss ST, Fuhlbrigge AL. Airway responsiveness in mild to moderate childhood asthma: sex influences on the natural history. *Am J Respir Crit Care Med*. 2008;178:325–331.

[3] Feuerstein G. *The Yoga Tradition*. Prescott, AZ: Hohm Press; 1998.

[4] Iyengar BKS. *Light on Yoga*. New York, NY: Schocken Books; 1966.

[5] Birdee GS, Legedza AT, Saper RB, Bertisch SM, Eisenberg DM, Phillips RS. Characteristics of yoga users: results of a national survey. *J Gen Intern Med*. 2008;23:1653–1658.

[6] Posadzki P, Ernst E. Yoga for asthma? a systematic review of randomized clinical trials. *J Asthma*. 2011;48:632–639.

[7] Sharma M, Haider T, Bose PP. Yoga as an alternative and complementary treatment for asthma: a systematic review. *J Evid Based Complement Alternat Med*. 2012;17:212–217.

[8] Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ*. 2009; 339:b2535.

[9] Higgins JPT, Green S. *Cochrane Handbook for Systematic Reviews of Interventions*. West Sussex, England: John Wiley & Sons Ltd; 2008.

[10] Busse WW, Morgan WJ, Taggart V, Togias A. Asthma outcomes workshop: overview. *J Allergy Clin Immunol*. 2012;129:S1–S8.

[11] Cloutier MM, Schatz M, Castro M, et al. Asthma outcomes: composite scores of asthma control. *J Allergy Clin Immunol*. 2012;129:S24–S33.

[12] Krishnan JA, Lemanske RF Jr, Canino GJ, et al. Asthma outcomes: symptoms. *J Allergy Clin Immunol*. 2012;129:S124–S135.

[13] Wilson SR, Rand CS, Cabana MD, et al. Asthma outcomes: quality of life. *J Allergy Clin Immunol*. 2012;129:S88–S123.

[14] Tepper RS, Wise RS, Covar R, et al. Asthma outcomes: pulmonary physiology. *J Allergy Clin Immunol*. 2012;129:S65–X87.

[15] Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. Hillsdale, NJ: Lawrence Erlbaum Associates; 1988.

[16] Cooper HM, Hedges LV, Valentine JC. *The Handbook of Research Synthesis and Meta-analysis*. 2nd ed. New York, NY: Russell Sage Foundation; 2009.

[17] Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ*. 2003;327:557–560.

[18] Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ*. 1997;315:629–634.

[19] Bhikshapathi DVRN, Jayanthi C, Kishan V, Krishna DR, Muzeeb S. Influence of yogasanas on the physiology, therapy and theophylline pharmacokinetics in bronchial asthma patients. *Acta Pharm Sci*. 2007;49:187–194.

[20] Kligler B, Homel P, Blank AE, Kenney J, Levenson H, Merrell W. Randomized trial of the effect of an integrative medicine approach to the management of asthma in adults on disease-related quality of life and pulmonary function. *Altern Ther Health Med*. 2011;17:10–15.

[21] Bidwell AJ, Yazel B, Davin D, Fairchild TJ, Kanaley JA. Yoga training improves quality of life in women with asthma. *J Altern Complement Med*. 2012;18: 749–755.

[22] Cooper S, Oborne J, Newton S, et al. Effect of two breathing exercises (Buteyko and pranayama) in asthma: a randomised controlled trial. *Thorax*. 2003;58: 674–679.

[23] Fluge T, Richter J, Fabel H, Zysno E, Weller E, Wagner TO. Long-term effects of breathing exercises and yoga in patients with bronchial asthma [in German]. *Pneumologie*. 1994;48:484–490.

[24] Manocha R, Marks GB, Kenchington P, Peters D, Salome CM. Sahaja yoga in the management of moderate to severe asthma: a randomised controlled trial. *Thorax*. 2002;57:110–115.

[25] Mekonnen D, Mossie A. Clinical effects of yoga on asthmatic patients: a preliminary clinical trial. *Ethiop J Health Sci*. 2010;20:107–112.

[26] Nagarathna R, Nagendra HR. Yoga for bronchial asthma: a controlled study. *Br Med J (Clin Res Ed)*. 1985;291:1077–1079.

[27] Prem V, Sahoo RC, Adhikari P. Comparison of the effects of Buteyko and pranayama breathing techniques on quality of life in patients with asthma: a randomized controlled trial. *Clin Rehabil*. 2013;27:133–141.

[28] Sabina AB, Williams AL, Wall HK, Bansal S, Chupp G, Katz DL. Yoga intervention for adults with mild-to-moderate asthma: a pilot study. *Ann Allergy Asthma Immunol*. 2005;94:543–548.

[29] Saxena T, Saxena M. The effect of various breathing exercises (pranayama) in patients with bronchial asthma of mild to moderate severity. *Int J Yoga*. 2009; 2:22–25.

[30] Singh S, Soni R, Singh KP, Tandon OP. Effect of yoga practices on pulmonary function tests including transfer factor of lung for carbon monoxide (TLCO) in asthma patients. *Indian J Physiol Pharmacol*. 2012;56:63–68.

[31] Singh V, Wisniewski A, Britton J, Tattersfield A. Effect of yoga breathing exercises (pranayama) on airway reactivity in subjects with asthma. *Lancet*. 1990;335:1381–1383.

[32] Sodhi C, Singh S, Bery A. Assessment of the quality of life in patients with bronchial asthma, before and after yoga: a randomised trial. *Iran J Allergy Asthma Immunol*. 2014;13:55–60.

[33] Sodhi C, Singh S, Dandona PK. A study of the effect of yoga training on pulmonary functions in patients with bronchial asthma. *Indian J Physiol Pharmacol*. 2009;53:169–174.

[34] Vedanthan PK, Kesavalu LN, Murthy KC, et al. Clinical study of yoga techniques in university students with asthma: a controlled study. *Allergy Asthma Proc*. 1998;19:3–9.

[35] Vempati R, Bijlani RL, Deepak KK. The efficacy of a comprehensive lifestyle modification programme based on yoga in the management of bronchial asthma: a randomized controlled trial. *BMC Pulm Med*. 2009;9:37.

[36] Cramer H, Lauche R, Langhorst J, Dobos G, Paul A. Quality of life and mental health in patients with chronic diseases who regularly practice yoga and those who do not: a case-control study. *Evid Based Complement Alternat Med*. 2013;2013:702914.

[37] Cramer H, Lauche R, Langhorst J, Paul A, Michalsen A, Dobos G. Predictors of yoga use among internal medicine patients. *BMC Complement Altern Med*. 2013;13:172.

[38] Cramer H, Lange S, Klose P, Paul A, Dobos G. Yoga for breast cancer patients and survivors: a systematic review and meta-analysis. *BMC Cancer*. 2012;12:412.

[39] Cramer H, Lauche R, Haller H, Dobos G. A systematic review and meta-analysis of yoga for low back pain. *Clin J Pain*. 2013;29:450–460.

[40] Cramer H, Lauche R, Langhorst J, Dobos G. Effectiveness of yoga for menopausal symptoms: a systematic review and meta-analysis of randomized controlled trials. *Evid Based Complement Alternat Med*. 2012;2012:863905.

[41] Cramer H, Krucoff C, Dobos G. Adverse events associated with yoga: a systematic review of published case reports and case series. *PLoS One*. 2013; 8(10):e75515.

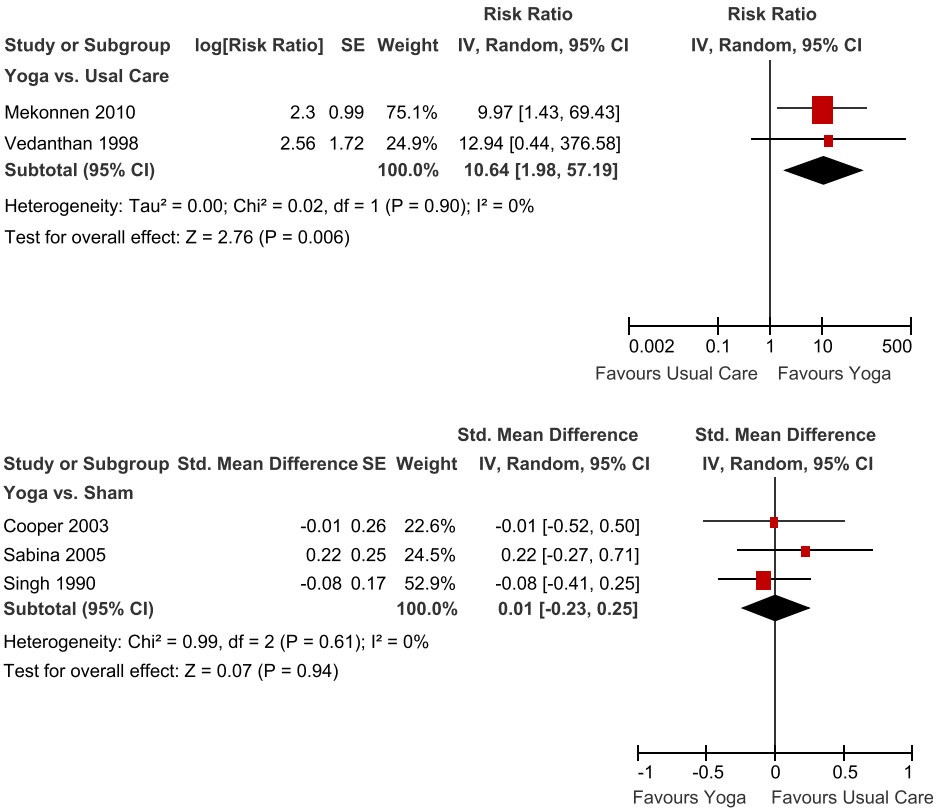
[42] Schulz KF, Chalmers I, Hayes RJ, Altman DG. Empirical evidence of bias: dimensions of methodological quality associated with estimates of treatment effects in controlled trials. *JAMA*. 1995;273:408–412.

[43] Gartlehner G. Assessment of adverse effects and applicability: two areas not (yet) covered adequately in Cochrane reports. *Z Evid Fortbild Qual Gesundhwes*. 2008;102:497–502.

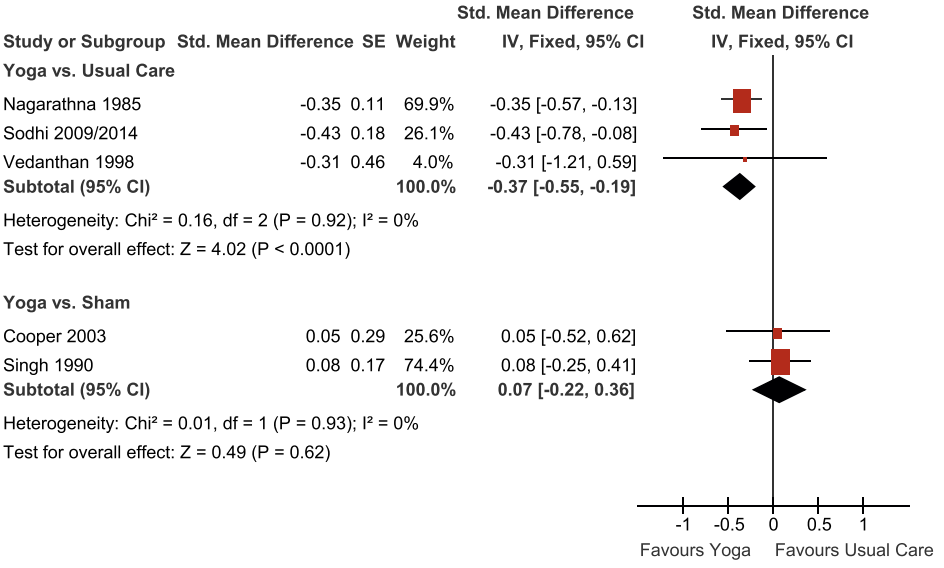
[44] Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: updated guidelines for reporting parallel group randomized trials. *Ann Intern Med*. 2010; 152:726–732.

[45] Freitas DA, Holloway EA, Bruno SS, Chaves GS, Fregonezi GA, Mendonca KP. Breathing exercises for adults with asthma. *Cochrane Database Syst Rev*. 2013; 10:CD001277.

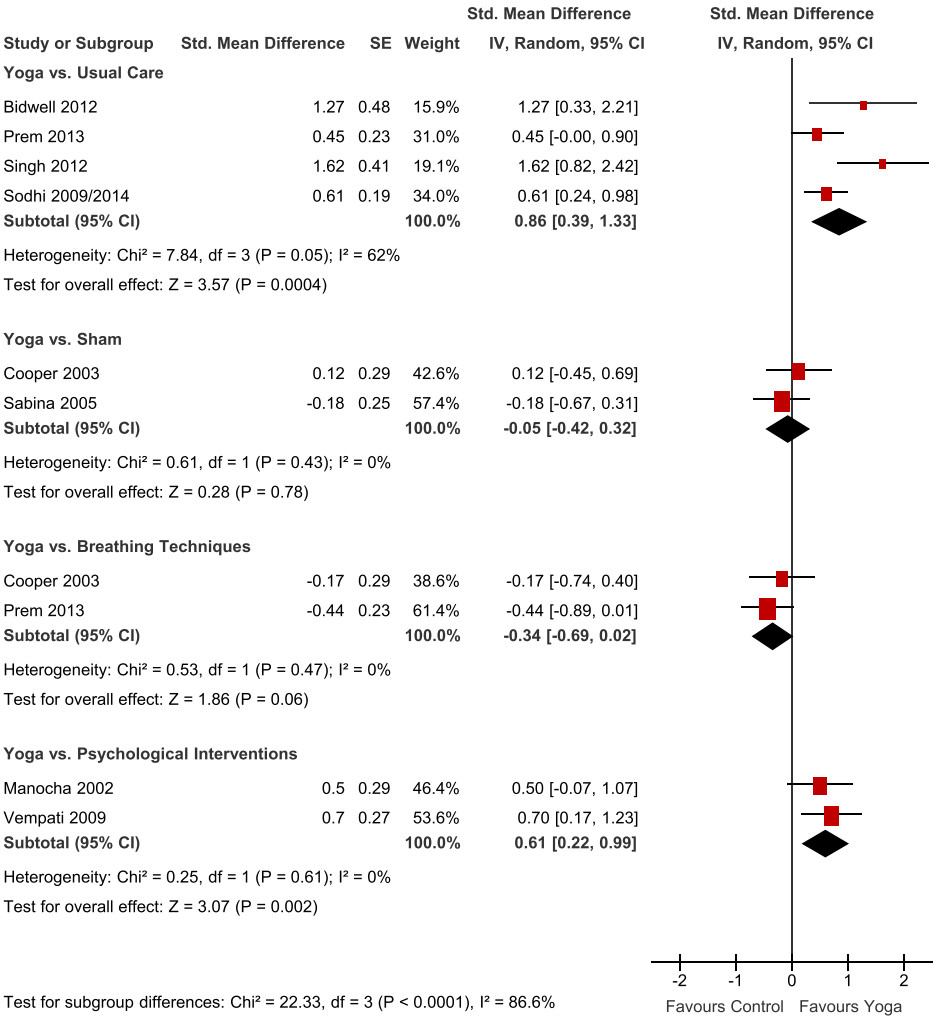
[46] Yorke J, Fleming SL, Shuldham CM. Psychological interventions for adults with asthma. *Cochrane Database Syst Rev*. 2006;(1):CD002982.



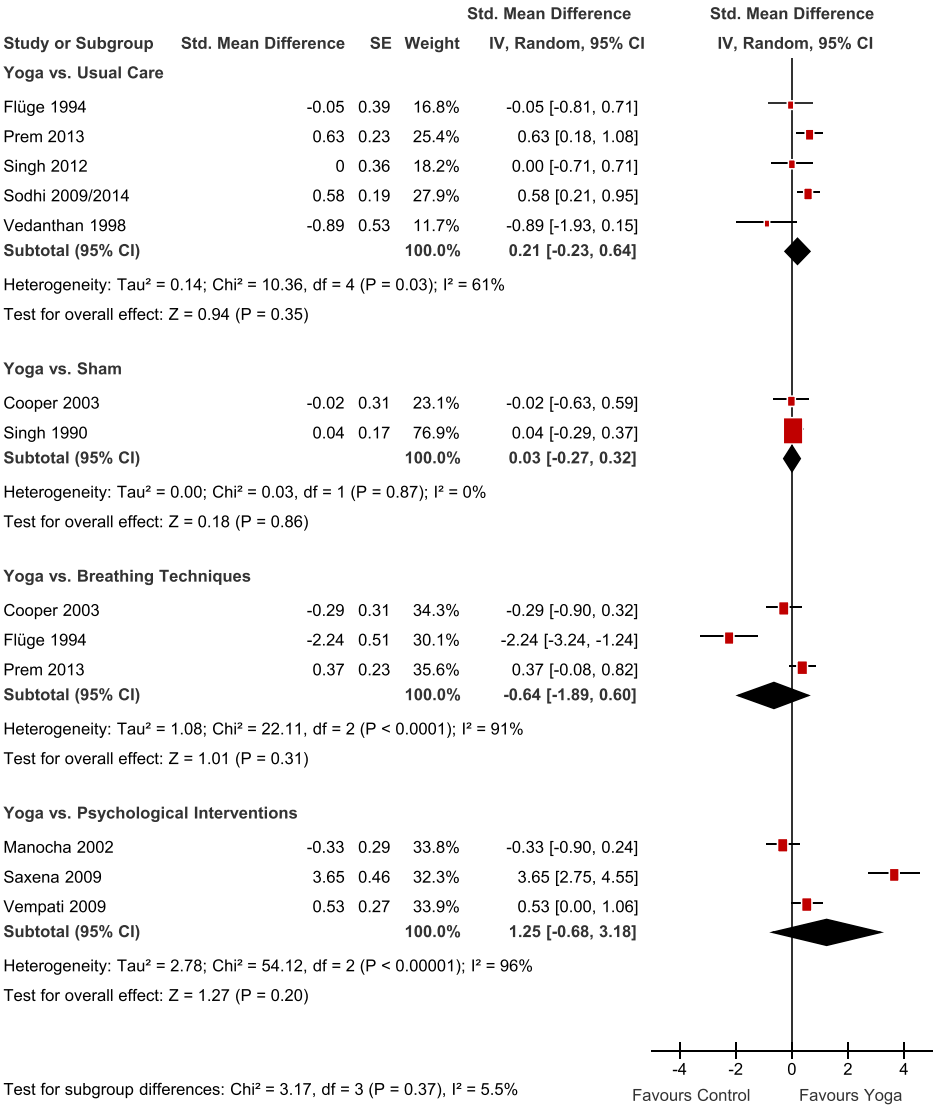
eFigure 1. Effects of yoga on asthma control (medication use).



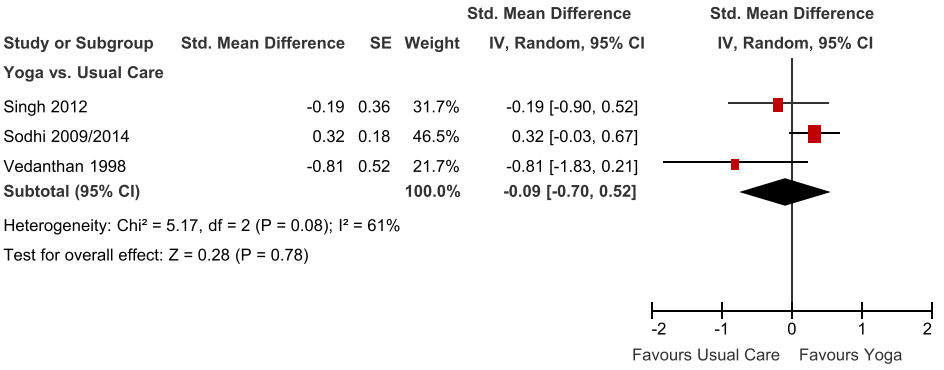
eFigure 2. Effects of yoga on asthma symptoms.



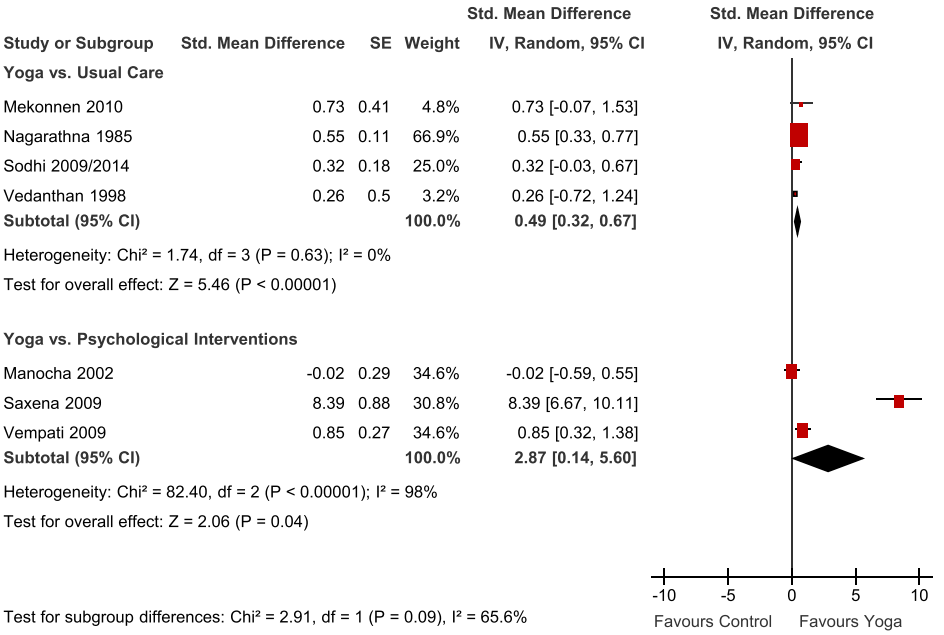
eFigure 3. Effects of yoga on health-related quality of life.



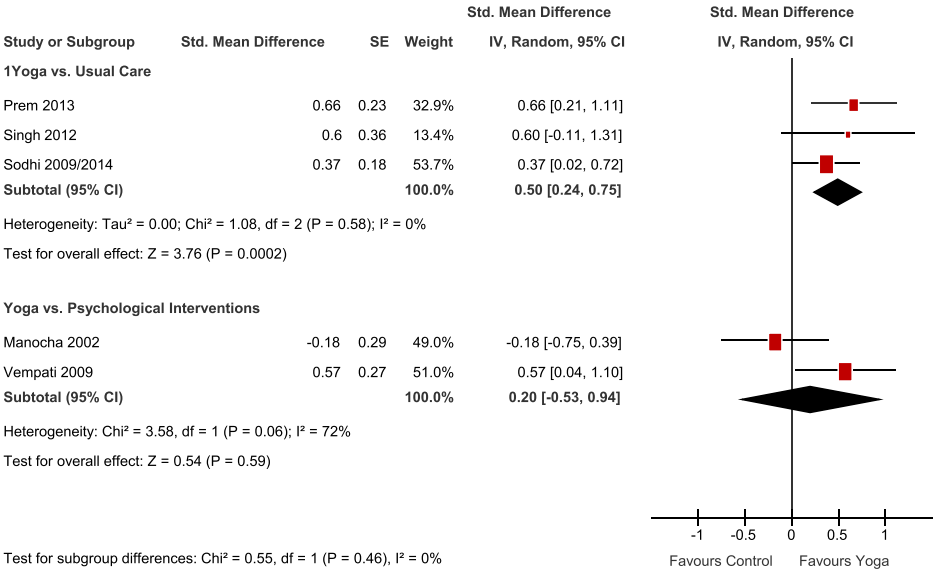
eFigure 4. Effects of yoga on forced expiratory volume in 1 secon.



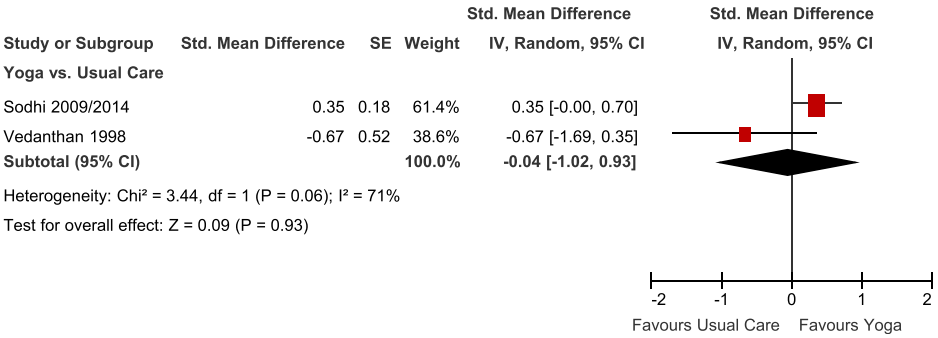
eFigure 5. Effects of yoga on forced vital capacity.



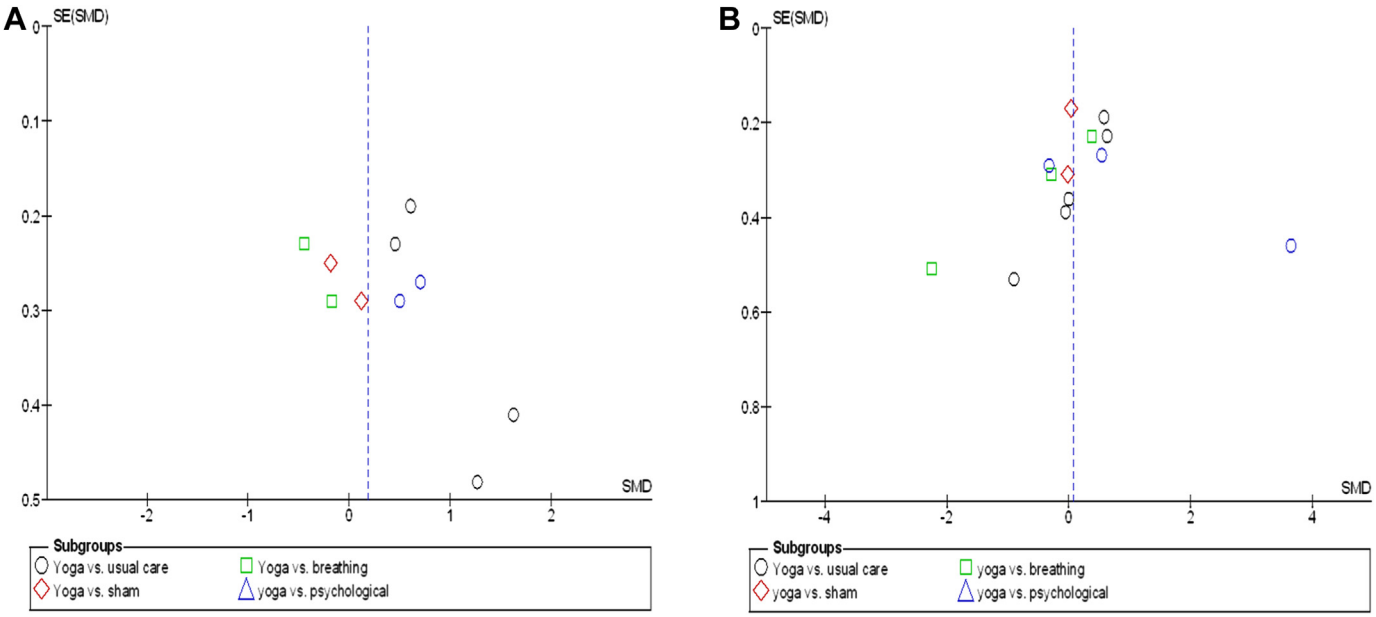
eFigure 6. Effects of yoga on peak expiratory flow rate.



eFigure 7. Effects of yoga on ratio of forced expiratory volume in 1 second to forced vital capacity.



eFigure 8. Effects of yoga on forced expiratory flow between 25% and 75%.



eFigure 9. Funnel plots for outcomes: quality of life *(A)* and forced expiratory volume in 1 second *(B)*.