Review Article

Effectiveness of yogic exercise on respiratory health indices: A systematic review and meta-analysis of intervention studies

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Abstract

Respiratory health is a vital component of overall well-being, with various interventions being explored to enhance pulmonary function. This systematic review and meta-analysis aimed to comprehensively evaluate the impact of yogic exercise on respiratory health indices, focusing on Forced Vital Capacity (FVC), a key measure of lung function. A rigorous search identified 53 relevant intervention studies, which were subjected to a thorough assessment and quantitative synthesis. The findings of this meta-analysis revealed a significant and positive effect of yogic intervention on Forced Vital Capacity (FVC). The collective evidence from the included studies demonstrated consistent improvements in FVC following yogic exercise regimens. The magnitude of the observed effect underscores the potential of yogic practices as a beneficial strategy for enhancing respiratory health. The systematic review also explored potential sources of heterogeneity, considered study quality, and assessed publication bias. Sensitivity analyses reaffirmed the robustness of the observed effect on FVC, highlighting the reliability of the results. The implications of these findings are promising, suggesting that the incorporation of yogic exercise into respiratory health interventions could hold substantial clinical and public health value. Further research is warranted to elucidate the underlying mechanisms through which yogic practices exert their positive effects on respiratory health. Additionally, investigations into the optimal types, durations, and frequencies of yogic interventions are essential for refining recommendations in both preventive and therapeutic contexts. In conclusion, this systematic review and meta-analysis provide compelling evidence of the effectiveness of yogic exercise in improving Forced Vital Capacity (FVC), a critical indicator of respiratory health. These findings contribute to a growing body of literature supporting the potential of holistic and non-pharmacological approaches to enhance pulmonary function and overall well-being.

Key Words: Yoga Intervention, Asthma, Respiratory Health, Meta-analysis

Introductions

Asthma is a chronic inflammatory airway disorder characterized by hypersensitivity to various stimuli and widespread episodic airway obstruction (National Heart and Blood Institute, 2007). 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 (Tantisira et al., 2008). 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 (Feuerstein, 1998). 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

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put varying focus on physical and mental practices (Feuerstein, 1998). Although yoga is frequently used by patients with asthma,(Birdee et al., 2008) prior systematic reviews have not supported its efficacy in alleviating asthma (Posadzki & Ernst, 2011; M. Sharma et al., 2012). 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, this review aims 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(Moher et al., 2009) and recommendations of the Cochrane Collaboration(Higgins et al., 2019) were used to lend a framework for the reporting structure of this review.

Eligibility Criteria

Studies contain yogic interventions i.e., pranyama, posture (asanas), meditation through randomized control trials, and clinical trials were eligible. No language restrictions were applied. Participants included both gender and different age groups with mild to moderate asthma as well as healthy individuals. No restrictions were made regarding gender, physical fitness, and sedentary behavior, social or economical status. Intervention included (1) yoga breathing interventions including various types of pranayama, (based on traditional yoga practice) (2) interventional included physical posture (asanas), meditation and/or life style advise. Studies were eligible with variation in yoga tradition, length or frequency of the yoga session, or duration of the program. Studies that allowed individual co-intervention were eligible. Studies that compared yoga with usual care or any active control intervention were eligible as control. One group pretest-posttest studies were also eligible.

To be eligible for inclusion, the studies have to assess at least one primary outcome: (1) In studies with asthmatic patients, frequency of medication use, or asthma attacks, respiratory indices were assessed by validated instruments (2) pulmonary functions assessed by validated measure such as spirometry. (3) Studies reported complete outcomes i.e., mean, standard deviation, number of participants, participant's characteristics, details of yoga intervention, ethical approvals, random sequence generation and clearly depicts experimental designs of an intervention. Secondary outcomes included safety of the intervention assessed as number of patients with adverse events.

Search Methods

Five electronic databases were searched from their inception through July 17, 2022: MEDLINE/PubMed, Scopus, the Cochrane Central Register of Controlled Trials, Google Scholar, and IndMED. The literature search was performed around search terms for yoga, pranayama and asthma and adapted for each database as required. The complete search startegey for MEDLINE is given in Table 1. Some other data sources such as ResearchGate (researchgate.net) and Academia (academia.org) 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 (L.S. and R.P.A.). 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.P.S.) until consensus was reached. If necessary, additional information was obtained from the authors of the primary study.

Data Extraction and Management

Two reviewers (L.S. and R.P.A.) independently extracted data on participants (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, mean, standard deviation,), 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.P.S.) and consensus achieved by discussion.

Statistical Analysis

The summary of the effect size and effect size of each study was calculated using raw mean difference (D). When the outcomes are reported on a meaningful scale and all studies in the analysis use the same scale, the meat-analysis could be performed directly on the raw differences in means (Borenstein et al., 2021). The effect size, a value which reflects the magnitude of the treatment effect the strength of a relationship between two variables is the unit of currency in a meta-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, raw mean differences (D) with 95% confidence intervals (CIs) were calculated as the difference in means between groups divided by the pooled SD (Cohen, 2013; Higgins et al., 2019).

Equation 1 $$D = \frac{\overline{X}_1 - \overline{X}_2}{SD_{Pooled}}$$

Where, D = raw mean difference, n1 and n2 are the sample size in two groups, S1 and S2 are the standard deviation in two groups.

Equation 1.1 $$SD_{Pooled} = \sqrt{\frac{(n_1-1)S_1^2+(n_2-1)S_2^2}{n_1+n_2-2}}$$

A positive (D) was defined to indicate beneficial effects of yoga compared with the control intervention for all outcomes except for asthma symptoms where a negative (D) was defined to indicate beneficial effects (i.e., decreased symptoms). Cohen's categories were used to evaluate the magnitude of the overall effect size as follows: (D) of 0.2 to 0.5, small; (D) of 0.5 to 0.8, medium; and (D) greater than 0.8, large effect sizes (Cohen, 2013).

Assessment of Heterogeneity

Heterogeneity depicts the variance in true effect sizes. The magnitude of heterogeneity was analyzed using the I2 statistics and categorized as follows: I2 of 0% to 24%, low; I2 of 25% to 49%, moderate; I2 of 50% to 74%, substantial; and I2 of 75% to 100%, considerable heterogeneity (Higgins et al., 2003, 2019). The I2 test was used to assess whether differences in results are compatible with chance alone or what proportion of the observed variance reflect real difference in effect size. Higgins et al.(Higgins et al., 2003) (2003) proposed using the statistics I2, to reflect this proportion, that could serve as a kind of signal-to-noise ratio. It is computed as:

$Equation$ 1.2 $$I^2 = \left(\frac{Q - df}{Q}\right) \times 100\%$$

$$Equation\ 1.3 \qquad Q = \sum_{i=1}^{k} w_i (Y_i - M)^2$$

Where, w_i is the study weight, Y_i is the study effects size and M is the summary effect and k is the number of studies

Given the low power of this test when only a few studies or studies with small sample sizes are included in a meta-analysis, P ≤ .10 was regarded to indicate significant heterogeneity (Higgins et al., 2019).

Subgroup and Sensitivity Analysis

Subgroup analyses were conducted for participant age group (adults or adolescents vs children) and type of yoga intervention (meditation vs pranayama vs postures, asanas), participants characteristics (asthma patients vs healthy individual) and gender of participants (male and female). 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.

Risk of Bias Across Studies

Several lines of evidence show that studies that report relatively high effect sizes are more likely to be published that studies that report lower effect sizes. Since published studies are more likely to find their way into a meta-analysis, and bias in the literature is likely to be reflected in the meta-analysis as well. This issue is generally known as publication bias.

Risk of bias (ROB) was assessed by funnel plot. Funnel plot is a mechanism which display the relationship between study size and effects size. The funnel plot was plotted with effects size on the X axis and the sample size of variance on the Y axis. Large studies appear towards the top of the graph and generally cluster around the mean effect size. Smaller studies appear towards the bottom of the graph, and tend to be spread across broad range of values (Borenstein et al., 2021). If at least 10 studies were included in a meta-analysis funnel plot were generated using Review Manager Software (version 5.4; 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 (Egger et al., 1997).

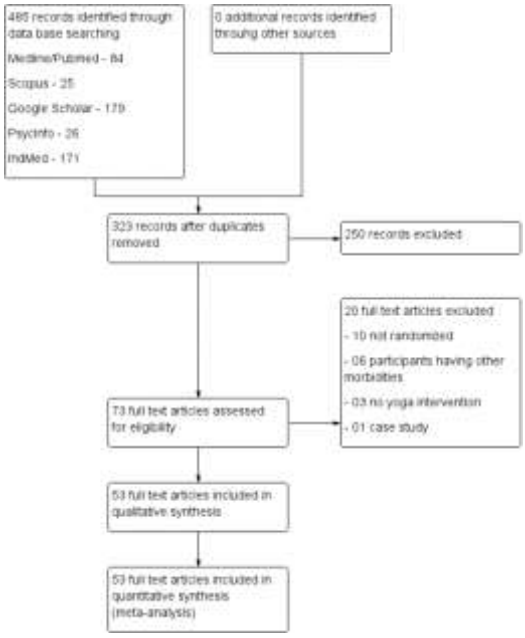

Figure 1 Flow chart of the results of the Literature search

Table 1 Characteristics of the included studies

Sr. No	Study	Subjects Characteristics				Intervention Details			Outcomes of the Studies						MD*	ES*
		Age	Gender	Subjects*	Disease	F*	Duration* (Minutes)	Length* (Days)	Yoga			Control				
									Mean	SD	N	Mean	SD	N		
1	Hovsepian et al (1990)(Hovsepian et al., 2013)	19.02	F	H	-	2	60	90	2.9	0.4	30	2.8	0.4	30	0.1	0.25
2	Singh V et al (1997)(V. Singh et al., 1990)	19-54	M	P	Asthma	2	15	14	2.45	0.78	9	3.22	0.79	9	0.77	0.98
3	Joshi et al (2001)(Joshi et al., 1992)	18.5	M	H	-	2	20	42	3.2	0.27	23	3.16	0.28	23	0.04	0.15
4	Raju et al (2004)(Raju et al., 1997)	34.71	M	H	-	7	90	30	3.56	0.58	35	3.41	0.51	35	0.15	0.27
5	Yadav R K (2010)(R. K. Yadav & Das, 2001)	22.7	F	H	-	7	60	84	2.541	0.269	60	2.019	0.289	60	0.522	1.87
6	Harinath et al (2011)(Harinath et al., 2004)	25-35	M	H	-	6	60	90	4.8	0.12	15	3.6	0.11	15	1.2	10.42
7	Swami et al (2011)(Swami et al., 2010)	35.65	F	P	Hypothyroid	7	45	180	2.39	0.43	20	2.26	0.38	20	0.13	0.32
8	Sivakumar et al (2012)(Sivakumar et al., 2011)	23.6	M/F	H	-			10	3.66	0.85	12	3.64	0.82	12	0.02	0.02
9	Panwar et al (2012)(Panwar et al., 2012)	21.47	M/F	H	-	7	30	90	3.73	0.18	75	3.48	0.73	75	0.25	0.47
10	Ruprai et al (2012)(Ruprai et al., 2012)	37.5	M	P	Bronchial Asthma	7	60	84	3.64	0.52	40	2.92	0.52	40	0.72	1.38
11	Santaella et al (2012)(Santaella et al., 2011)	68.6	M/F	H	-	2	30	120	3.3	0.8	15	3.1	0.6	14	0.2	0.28
12	Kondam et al (2012)(Kondam et al., 2012)	18-25	M/F	H	-	6	30	42	3.94	0.26	35	3.36	0.28	35	0.58	2.15
13	Halder et al (2013)(Halder et al., 2012)	21-33	M	H	-	5	90	90	4.5	0.41	60	4.4	0.42	60	0.1	0.24
14	Chakraborty et al (2013)(Chakraborty et al., 2013)	50-70	M/F	H	-	7	30	42	2.1	0.29	40	2.085	0.288	40	0.015	0.05
15	Kadu et al (2013)(Kadu & Deshpande V. K, 2013)	42.97	M	H	-	7	60	180	2.92	0.19	45	2.94	0.22	45	0.02	0.10
16	Singh S et al (2013) (S. Singh et al., 2012)	18-60	M/F	P	Asthma	5		60	3.43	0.93	30	3.23	0.93	30	0.2	0.22
17	Satpathy et al (2013)(Satpathy et al., 2013)	50	M	P	COPD	7	15	42	4.33	0.05	37	4.23	0.05	37	0.1	2.00
18	Pandit et al (2013)(Pandit & Vaidya, 2013)	30-40	M	P	Bronchial Asthma	7	60	180	2.74	0.36	30	2.51	0.23	30	0.23	0.76
19	Zaicenkoviene et al (2013)(Zaičenkovienė et al., 2013)	28.9	F	H	-	-		180	3.7	0.49	22	3.68	0.48	22	0.02	0.04
20	Mooventhan et al (2014)(Mooventhan & Khode, 2014)	18-27	M/F	H	-	6	10	14	2.77	0.66	41	2.72	0.63	41	0.05	0.08

[F = Frequency of yogic sessions per week, Duration = Duration of each session in minutes, Length = Days of total yogic intervention, Subjects = Health condition of selected subjects (P: Patients, H: Healthy), SD = Standard deviation, MD = Mean Difference, ES = Effect Size]
COPD = Chronic Obstructive Pulmonary Disease,

Table 1 Continue

		Subjects Characteristics				Intervention Details			Outcomes of the Studies							
Sr. No	**Study**	**Age**	**Gender**	**Subjects***	**Disease**	**F***	**Duration* (Minutes)**	**Length* (Days)**	**Yoga**			**Control**			**MD***	**ES***
									Mean	**SD**	**N**	**Mean**	**SD**	**N**		
21	Kondam et al (2014)(Kondam et al., 1970a)	18-25	M/F	H	-	7	60	180	3.1	0.29	20	2.31	0.44	20	0.79	2.12
22	D'Souza et al (2014)(D'Souza & Avadhany, 2014)	7.9	M/F	H	-	7	45	90	1.284	0.242	91	1.096	0.205	91	0.188	0.84
23	Dinesh et al (2015)(Dinesh et al., 2015)	18.58	M/F	H	-	7	30	84	2.51	0.69	39	2.13	0.48	30	0.38	0.62
24	Gupta M et al (2015)(Gupta et al., 2014)		M/F	H	-				3.94	0.63	30	3.24	0.54	30	0.7	1.19
25	Hoang & Nguyen et al (2015)(HOANG & NGUYEN, 2015)	47.6	M	P	Bronchial Asthma	7	30	90	3.03	0.49	24	2.5	0.42	24	0.53	1.16
26	Karmur et al (2015)(Karmur, Joshi, Padalia, & Sarvaiya, 2015)	20-65	M/F	H	-	6	60	70	3.03	0.76	40	2.25	0.69	40	0.78	1.07
27	Yadav A et al (2015)(A. Yadav et al., 2015)	45-65	M/F	P	CAD	6	60	90	2.12	0.11	40	1.589	0.08	40	0.531	5.52
28	Beutler et al (2016)(Beutler et al., 2016)	36	F	H	-	7	30		4.6	0.6	9	4.3	0.3	6	0.3	0.59
29	Chauhan et al (2016)(Chauhan et al., 2015)	17-25	F	H	-	5	60	42	2.75	0.36	45	2.5	0.42	45	0.25	0.64
30	Jiwtode et al (2016)(Jiwtode & Mahajan, 2016)	33.45	M/F	H	-	5	45	56	3.78	0.49	90	3.43	0.52	90	0.35	0.69
31	Raghavendra et al (2016)	31.8	M/F	P	Bronchial Asthma			10	2.7	0.57	30	2.62	0.68	30	0.08	0.13
32	Singh S et al (2016) (S. Singh & Tripathi, 2017)	40-50	M	P	COPD	7		42	2.04	0.16	15	1.87	0.15	15	0.17	1.10
33	Sharma et al (2017)(D. Sharma, 2017)	19-25	M	H	-	7	30	49	4.9	0.37	20	4.73	0.4	20	0.17	0.44
34	Agnihotri et al (2017)(Agnihotri et al., 2016)	12_60	M/F	P	Asthma	5	30	180	85.83	8.07	121	80.9	5.48	121	4.93	0.71
36	Hakked et al (2017)(Hakked et al., 2017)	13-20	M/F	H	-	5	90	30	3.14	1.03	14	2.91	0.42	14	0.23	0.29
37	Singh J et al (2017)(J. Singh & Das, 2017)	18-22	M	H	-	6	50	42	5.06	0.27	30	4.87	0.31	30	0.19	0.65
38	Dar et al (2018)(Dar, 2017)	18-20	M	h	-	6	45	42	3.18	0.37	20	2.82	0.47	20	0.36	0.85
39	Akhani et al (2019)(Akhani et al., 2019)	18.4	F	H	-	6	95	28	3.25	0.85	72	3.13	0.63	72	0.12	0.16
40	Budhi et al (2019)(Budhi et al., 2019)	18-30	M	H	-	6	15	30	3.48	1.22	15	2.52	0.61	15	0.96	1.00

[F = Frequency of yogic sessions per week, Duration = Duration of each session in minutes, Length = Days of total yogic intervention, Subjects = Health condition of selected subjects (P : Patients, H: Healthy), SD = Standard deviation, MD = Mean Difference, ES = Effect Size]
COPD = Chronic Obstructive Pulmonary Disease, CAD = Coronary Artery Disease

Table 1 Continue

Sr. No	Study	Subjects Characteristics				Intervention Details			Outcomes of the Studies						MD*	ES*
		Age	Gender	Subjects*	Disease	F*	Duration* (Minutes)	Length* (Days)	Yoga			Control				
									Mean	SD	N	Mean	SD	N		
41	Artchoudane et al (2019)(Artchoudane et al., 2018)	53.4	M/F	P	COPD*			28	2.21	0.5	32	1.99	0.64	32	0.22	0.38
42	Kumar S et al (2019)(Kumar, 2019)	22	M/F	H	-	7	90	28	3.91	0.99	30	3.63	0.97	30	0.28	0.29
43	Turan et al (2020)(Turan & Tan, 2020)	40.28	M/F	P	Asthma	2	60	42	3.82	0.92	56	3.11	0.89	56	0.71	0.78
44	Edrogan et al (2020)(Erdoğan Yüce & Taşcı, 2020)	42.1	F	P	Asthma	7	20	30	3.24	0.9	25	2.85	0.94	25	0.39	0.42
45	Hemachandrika et al (2020)(Hemachandrika et al., 2019)	17-22	M/F	H	-	7	60	28	3.2	0.66	52	3.15	0.67	52	0.05	0.08
46	Dhargave et al (2021)(Dhargave et al., 2021)	7.9	M	P	DMD*	2	45	270	1.1	0.3	43	0.9	0.2	45	0.2	0.79
47	Khurde et al (2021)(Khurde et al., 2021)	39.05	M/F	H	-	6	60	180	3.44	0.66	200	3.06	0.77	200	0.38	0.53
48	Jahan et al (2021)(Jahan et al., 2021)	18.6	F	H	-	7	10	28	2.702	0.26	25	2.387	0.25	25	0.315	1.24
49	Gunjiganvi et al (2021)(Gunjiganvi et al., 2021)	42.6	M	P	Blunt Chest Trauma	7	60	28	58.5	11.68	42	38.1	8.9	42	20.4	1.96
50	Balaguru et al (2022)(Balaguru et al., 2022)	22.97	M/F	H	-	5	30	84	2.99	0.52	30	2.88	0.56	30	0.11	0.20
51	Jana et al (2021)(Jana, 2021)	30-45	F	H	-	5	45	126	2.51	0.33	34	2.06	0.23	34	0.45	1.58
52	Joice et al (2021)(Joice, 2021)	45-55	F	P	Postmenopausal	5	30	84	2.24	0.77	30	2.12	0.56	30	0.12	0.18
53	Chochalingam et al (2022)(Chochalingam et al., n.d.)	19-23	F	H	-			84	3.22	0.38	20	2.19	0.19	20	1.03	3.43
54	Sangeethalaxmi et al (2022) (Sangeethalaxmi & Hankey, 2022)	18-30	M/F	P	Bronchial Asthma	7	30	90	2.28	0.29	60	1.45	0.12	60	0.83	3.74

[F = Frequency of yogic sessions per week, Duration = Duration of each session in minutes, Length = Days of total yogic intervention, Subjects = Health condition of selected subjects (P: Patients, H: Healthy), SD = Standard deviation, MD = Mean Difference, ES = Effect Size]

COPD = Chronic Obstructive Pulmonary Disease, CAD = Coronary Artery Disease, DMD =Duchenne Muscular Dystroph

RESULTS

Literature Search

The literate search explored a total of 323 nonduplicate records of which 73 full-text articles were assessed for eligibility (Figure 1). 20 articles were excluded due to following reasons: they were not randomized, participants having other morbidities, no yoga intervention, and case study. 53 full-text articles with a total of 4225 participants (2018 in yoga and 2107 in control) were included in the quantitative analysis and meta-analysis.

Study Characteristics

Characteristics of the included studies were presented in Table 1 respectively. 12 interventions included female participants(Akhani et al., 2019; Beutler et al., 2016; Chauhan et al., 2015; Chochalingam et al., n.d.; Erdoğan Yüce & Taşcı, 2020; Hovsepian et al., 2013; Jahan et al., 2021; Jana, 2021; Joice, 2021; Swami et al., 2010; R. K. Yadav & Das, 2001; Zaičenkovienė et al., 2013). 17 interventions included only male participants(Budhi et al., 2019; Dar, 2017; Dhargave et al., 2021; Gunjiganvi et al., 2021; Halder et al., 2012; Harinath et al., 2004; HOANG & NGUYEN, 2015; Joshi et al., 1992; Kadu & Deshpande V. K, 2013; Pandit & Vaidya, 2013; Raju et al., 1997; Ruprai et al., 2012; Satpathy et al., 2013; D. Sharma, 2017; J. Singh & Das, 2017; S. Singh & Tripathi, 2017; V. Singh et al., 1990). 24 interventions included mixed-gender participants(Agnihotri et al., 2016; Artchoudane et al., 2018; Balaguru et al., 2022; Chakraborty et al., 2013; de Souza-Pajuelo et al., 2021; Dinesh et al., 2015; Gupta et al., 2014; Hakked et al., 2017; Hemachandrika et al., 2019; Jiwtode & Mahajan, 2016; Karmur, Joshi, Padalia, Sarvaiya, et al., 2015; Khurde et al., 2021; Kondam et al., 1970a, 2012; Kumar, 2019; Mooventhan & Khode, 2014; Panwar et al., 2012; Raghavendra et al., 2016; Sangeethalaxmi & Hankey, 2022; Santaella et al., 2011; S. Singh et al., 2012; Sivakumar et al., 2011; Turan & Tan, 2020; A. Yadav et al., 2015). In the context of the health history of the participants, 18 studies included patients as subjects in their intervention. Out of the eighteen studies 10 interventions included 'bronchial asthmatic' patients as subjects(Agnihotri et al., 2016; Erdoğan Yüce & Taşcı, 2020; HOANG & NGUYEN, 2015; Pandit & Vaidya, 2013; Raghavendra et al., 2016; Ruprai et al., 2012; Sangeethalaxmi & Hankey, 2022; S. Singh et al., 2012; V. Singh et al., 1990; Turan & Tan, 2020). 3 interventions included the subjects having COPD (chronic obstructive pulmonary disease)(Artchoudane et al., 2018; Satpathy et al., 2013; S. Singh & Tripathi, 2017). One intervention included hypothyroid patients(Swami et al., 2010). One intervention included patients with CAD (coronary artery disease)(A. Yadav et al., 2015). One intervention included the patients of DMD (Duchenne Muscular Dystrophy)(Dhargave et al., 2021). One intervention was based on 'blunt chest trauma' patients(Gunjiganvi et al., 2021), while one intervention has included to investigate the effects of yogic practice on respiratory functions of postmenopausal women(Joice, 2021). The patients included in the interventions have mild to moderate asthma or other disease of moderate severity. Rest of the studies having healthy participants in their interventions and further categorized into subgroups as per gender and age group of the participants.

Two interventions included 270 children having the age of 7 to 9 years (de Souza-Pajuelo et al., 2021; Dhargave et al., 2021). eleven interventions included 927 adolescences aged ranged between 10 to 23 years(Akhani et al., 2019; Artchoudane et al., 2018; Dar, 2017; Dinesh et al., 2015; Hemachandrika et al., 2019; Hovsepian et al., 2013; Joshi et al., 1992; Kondam et al., 1970a; Kumar, 2019; Panwar et al., 2012; R. K. Yadav & Das, 2001) and Ten interventions used 683 adults having ages ranged 24< years(Chakraborty et al., 2013; Erdoğan Yüce & Taşcı, 2020; HOANG & NGUYEN, 2015; Joice, 2021; Kadu & Deshpande V. K, 2013; Santaella et al., 2011; Satpathy et al., 2013; J. Singh & Das, 2017; Turan & Tan, 2020; A. Yadav et al., 2015). Thirteen studies with 900 subjects mainly focused on meditation as a yogic

intervention to study the influences on respiratory indices(Balaguru et al., 2022; Beutler et al., 2016; de Souza-Pajuelo et al., 2021; Dhargave et al., 2021; Hakked et al., 2017; Hovsepian et al., 2013; Joshi et al., 1992; Kadu & Deshpande V. K, 2013; Mooventhan & Khode, 2014; Panwar et al., 2012; Santaella et al., 2011; S. Singh & Tripathi, 2017; Swami et al., 2010). The different types of meditation techniques i.e., spiritual meditation, mindfulness meditation, mantra meditation, focused meditation etc. were performed during yogic interventions by the participants. Twelve studies included 778 participants and used pranayama as main yogic intervention (Budhi et al., 2019; Chochalingam et al., n.d.; Gupta et al., 2014; HOANG & NGUYEN, 2015; Karmur, Joshi, Padalia, Sarvaiya, et al., 2015; Kondam et al., 1970a, 1970b; Ruprai et al., 2012; Sangeethalaxmi & Hankey, 2022; V. Singh et al., 1990; Turan & Tan, 2020; A. Yadav et al., 2015)

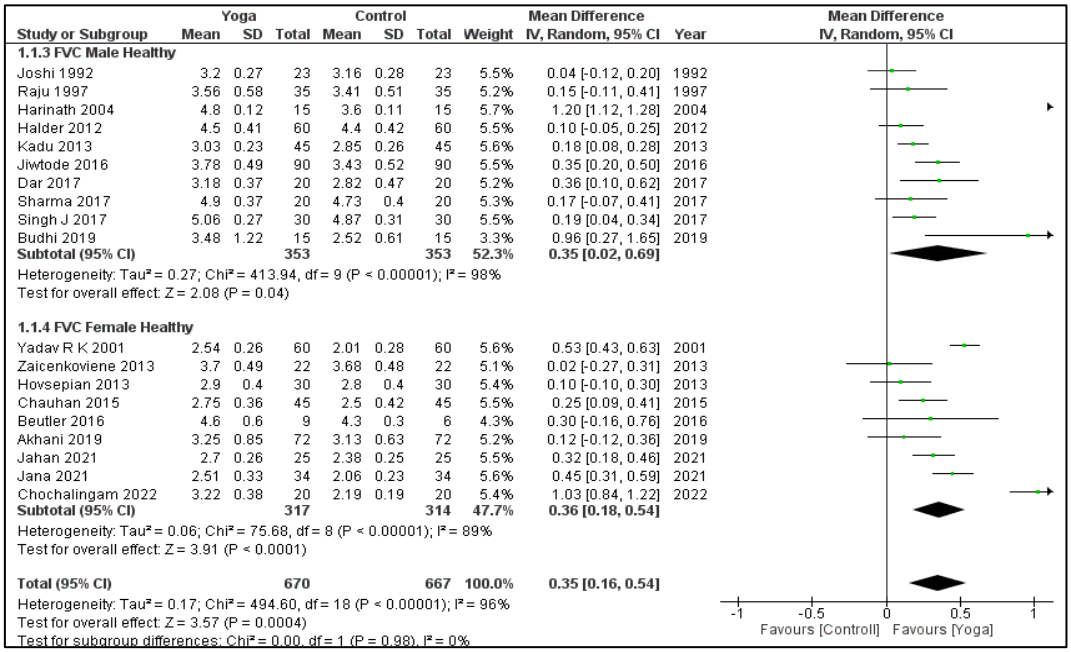

Figure 2 Effects of yoga on forced vital capacity in healthy participants

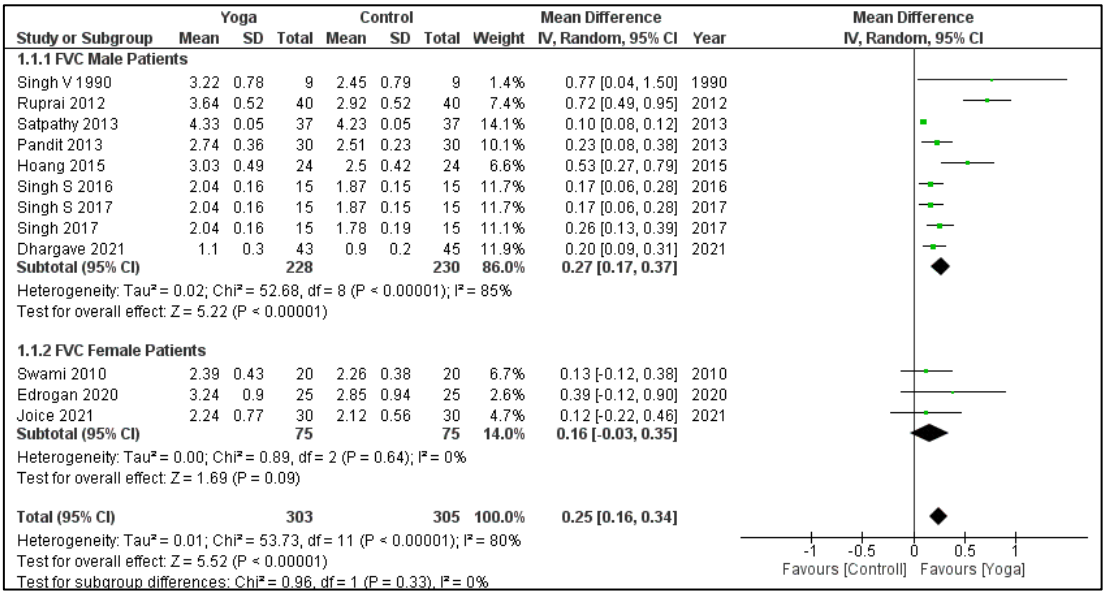

Figure 3 Effect of yoga on forced vital capacity of asthmatic patients

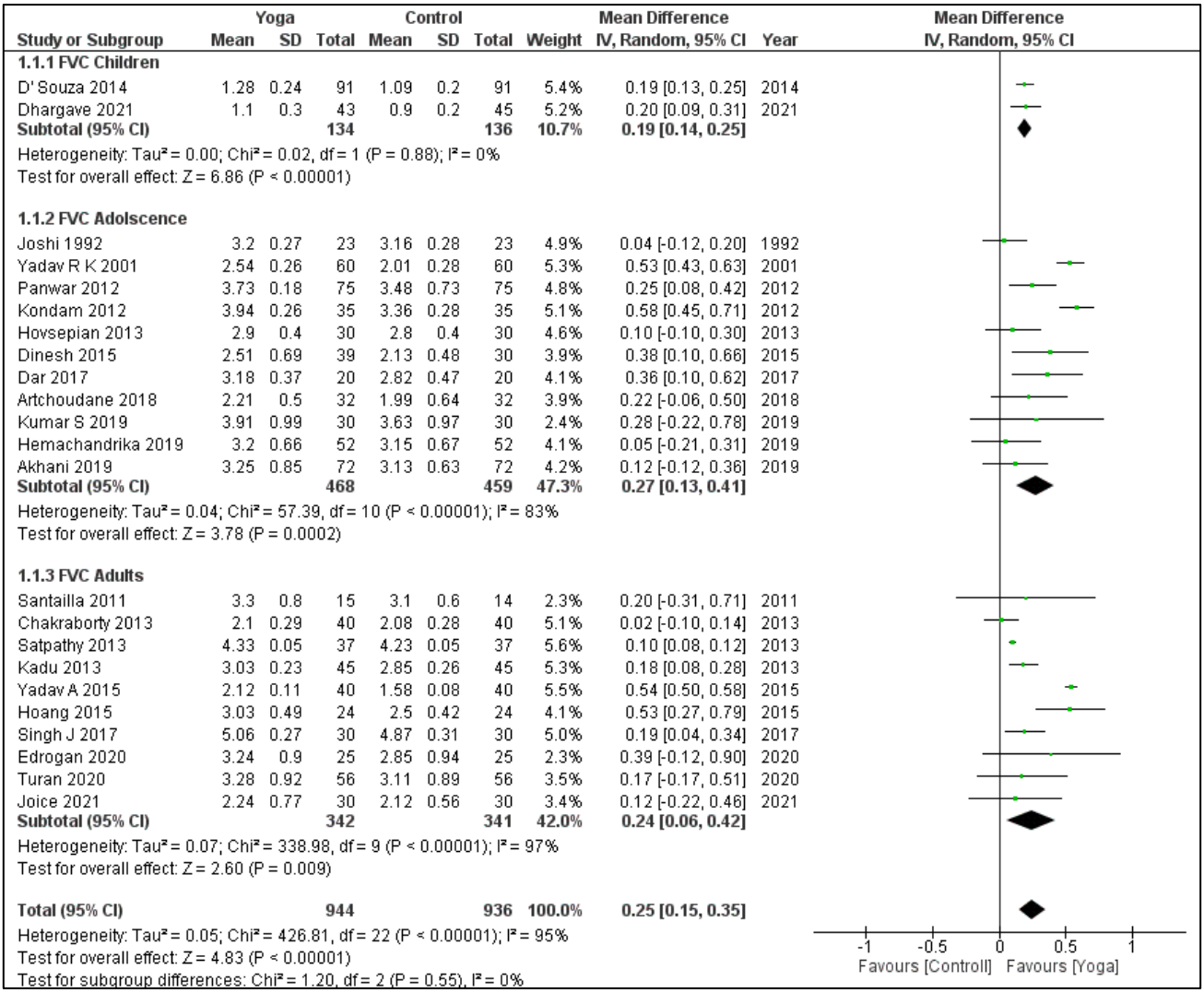

Figure 4 Effect of yoga on the forced vital capacity of the participants of different age group

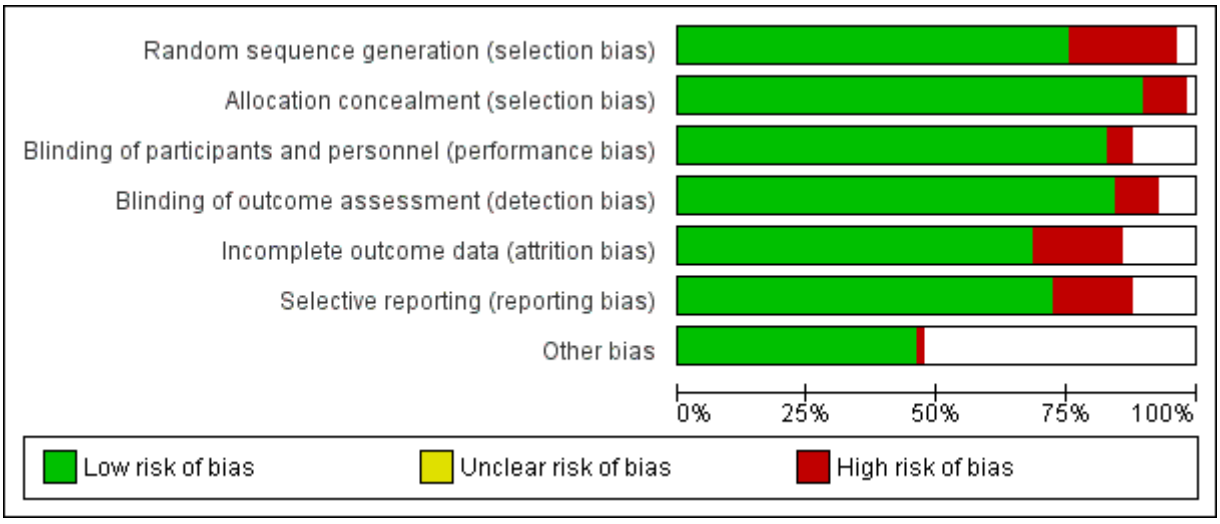

Figure 5 Risk of bias graph: review authors' judgments about each risk of bias item presented as percentages across all included studies

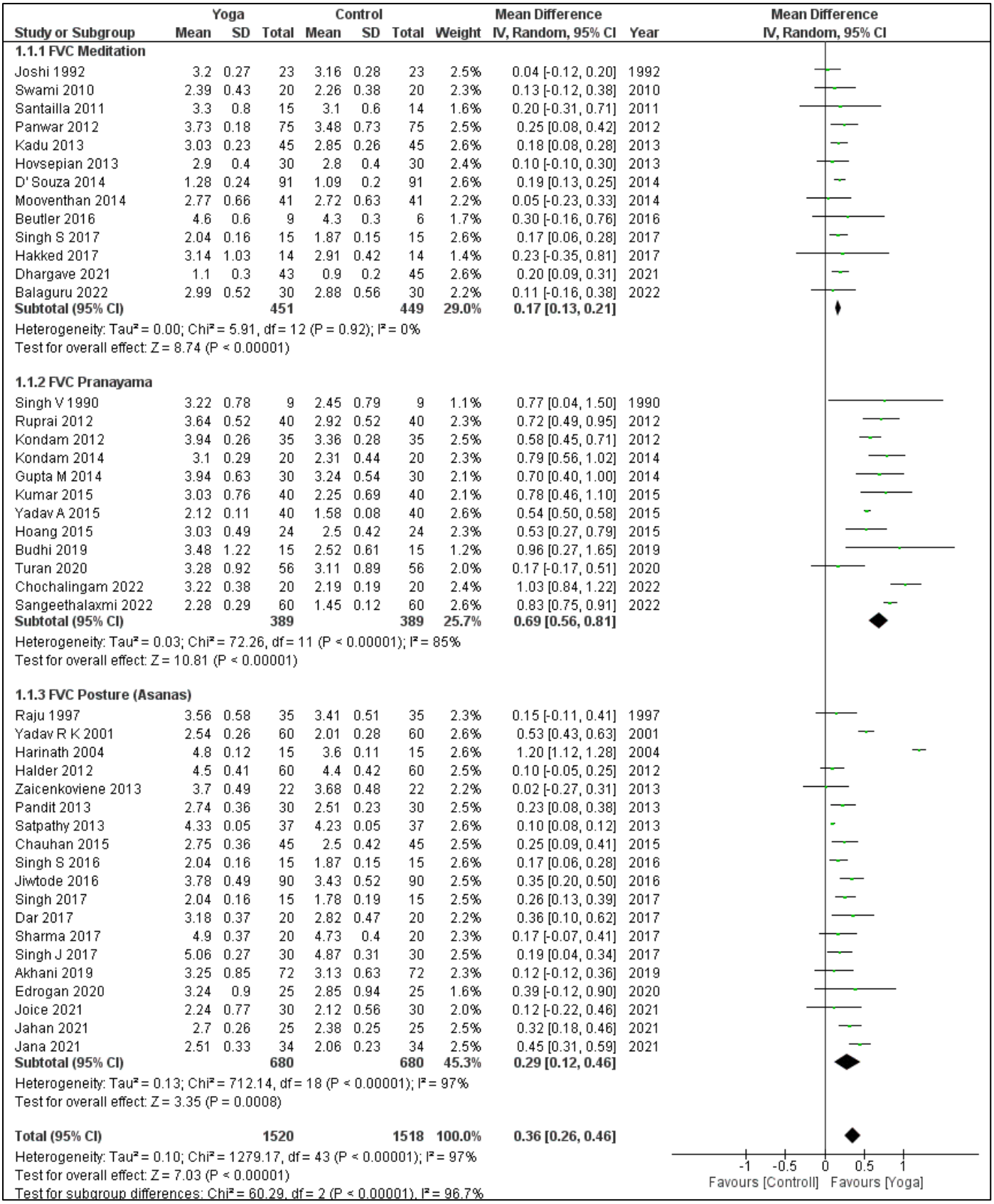

Figure 6 Effect of yoga on the forced vital capacity of the participants having different yogic intervention

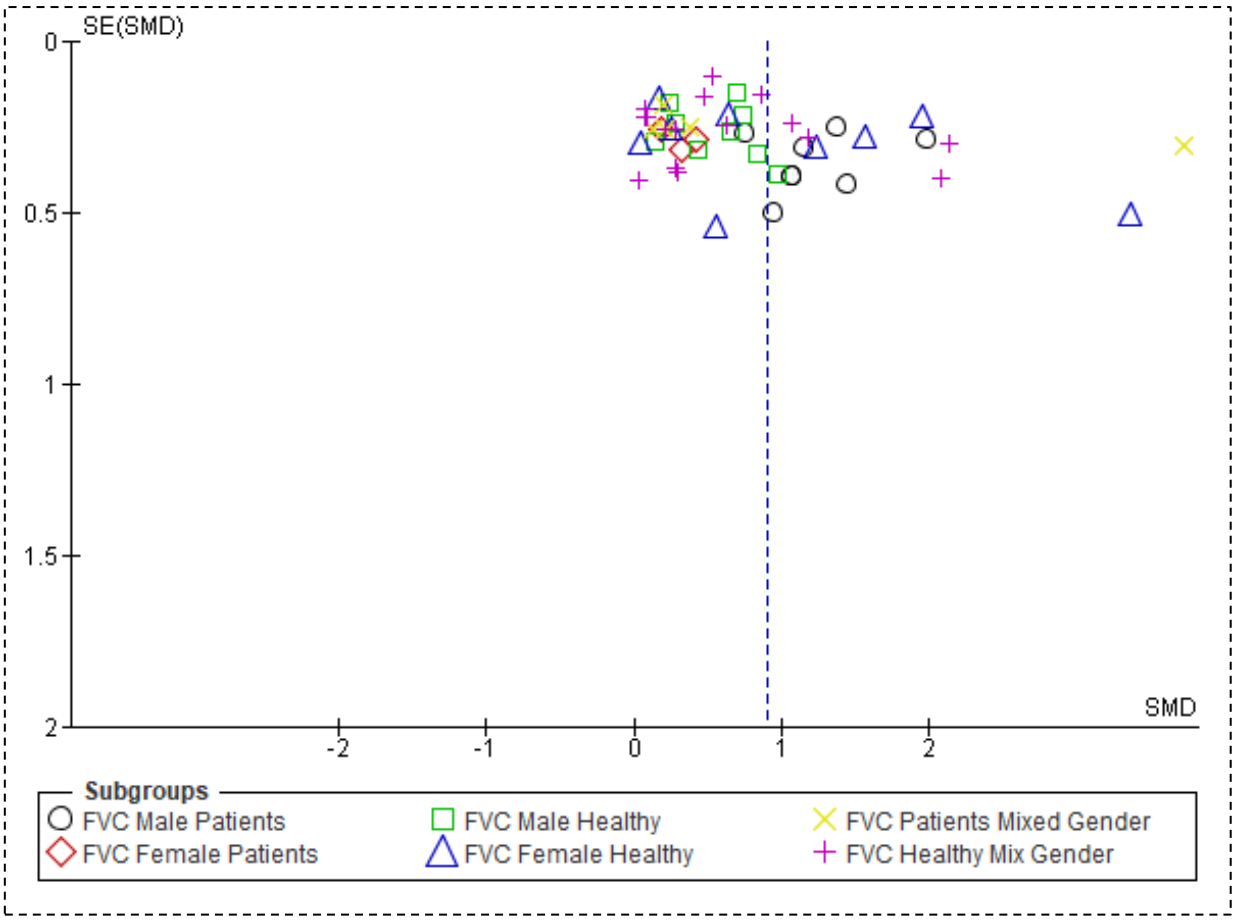

Figure 7. *Funnel Plot.*

Discussion

The present study performed a comprehensive approach including 53 yogic interventions with various subgroup analysis. The forced vital capacity (FVC) has been considered as dependent variable which is a essential domain of respiratory volumes.

First, the studies containing healthy individuals were analyzed through sub-group analysis methods for both groups. The effect size of yogic interventions on healthy male subjects (Figure 2) was 0.35 (0.02, 0.69) respectively. As per the degree of effects size, it indicated small degree of effects of yogic intervention on respiratory indices. The effects size was ranged from small to moderate among the studies. No larger effect size (More than 0.8) were observed across the studies including healthy male subjects. However, forced vital capacity (FVC) is a latent measure of respiratory health. A small increase in FVC indicate significant changes in respiratory health. Similar outcomes were taking into consideration among female counterparts. The effects size showing in Figure 2 was 0.36 (0.18, 0.54). The test of overall effects (z) in both sub-groups shown significant differences across the studies. Therefore, high amount of heterogeneity was observed among the studies. The overall effect size of sub-groups analysis was 0.35 (0.16, 0.54). The p value of test for sub-groups difference was 0.98, it indicated that both the groups i.e., males and females reported similar effects of yogic interventions on respiratory indices of a healthy individual. Gender has no variation regarding the effects of yogic interventions. The yogic interventions may be designed irrespective of gender-based differences.

Second, the studies including asthmatic patients of both genders were analyzed separately (Figure 3). The effect size of studies including male patients was 0.27 (0.17, 0.37), while, the effect size for female patients was 0.16 (-0.03, 0.35). Very small

effects were observed among the studies of asthmatic patients. The medicine used by the patients to control the asthmatic symptoms during the interventions was unknown. Although, the effects were also negligible. Especially, in the case of female patients, no significant increase was reported in their FVC after yogic intervention. Some studies reported significant improvement in asthmatic patients after different yogic intervention. There are several factors that effects the outcomes studies i.e., severity of the asthma, age of the patients, medicine used, presence of other diseases and environment related issues. Such factors, should be controlled during the intervention to know the true effects of various yogic practices. On the basis of the present outcomes, the yoga is not an effective mean for asthmatic patients to improve their respiratory health. Although, various research gaps were also discussed in this research. Therefore, more studies with controlled situations were need to study the true effects of yogic interventions in asthmatic patients.

Third and very important aspect was age of the participants (Figure 4). The sub-group analysis was performed among children, adolescent, and adult subjects. Two studies including 270 (Control + Yoga) children reported a very low degree of summary effect [0.19 (0.14, 0.25)]. The studies including adolescent subjects reported slightly higher summary effects 0.27 (0.13, 0.41), which also indicated a low degree of effects. The summary effects of adults was 0.24 (0.06, 0.42). The z test for overall effects ($z = 4.83$, $P < 0.00001$) was significant. It means a significant variation exists among the studies outcomes, while, the subgroup difference was not significant ($Chi2 = 1.20$, $P = 0.55$). These outcomes reported similar effects of yogic intervention on respiratory health indices irrespective of chronological age.

Finally, the selected studies were categorized according to the main yogic exercise performed and a sub-group analysis was performed among the following strata, i.e., ‘meditation’, ‘pranayama’, and ‘asanas’ as well. The meditations group has the lowest summary effects [0.17 (0.13, 0.21), followed by posture (Asanas) which reported slightly higher summary effects [0.29 (0.12, 0.46)]. The studies that used ‘Pranayama’ as a yogic intervention showed a moderate degree of summary effect [0.69 (0.56, 0.81)]. The test for sub-group difference ($Chi2 = 60.29$, $P<0.00001$) was also significant at 0.05 level. It means the pranayama is the best mean of yogic practice to increase respiratory health in healthy individuals in comparison to other yogic exercise like meditation and postural exercises etc.

In summary, it has been observed in earlier studies that yoga has a significant impact on various respiratory volumes and health indices, but the degree of effects was not reported clearly. The present review identified the gap and examine the degree of different yogic interventions on possible sub-groups. Most of the included studies have significant mean differences but the degree of effects was limited to a small effect size. Only the pranayama group showed a moderate effect size. None of the sub-groups shows a large degree of effect.

Limitations of the study

All studies contain some degree of limitations. Based on the methodological quality and obtained data of the present study some limitations have been taking into consideration that might affects the outcomes of the present research work.

The severity of the asthma and current medicine used by the patients was not reported in the studies. This information would allow the researcher to categorize the subjects accordingly and more refined outcomes may be retained. The physical activity profile i.e., sedentary, moderate, or vigorous, and work occupation of the subjects were also missing from the studies. The age of the subjects in experimental and control groups should be reported separately and the groups should consist of the same age or with little variations. The group contained higher variation in age of the subjects affects the outcomes and reliability of the study.

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