Systematic review of the effectiveness of breathing retraining in asthma management

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EXPERT REVIEWS

Systematic review of the effectiveness of breathing retraining in asthma management

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In asthma management, complementary and alternative medicine is enjoying a growing popularity worldwide. This review synthesizes the literature on complementary and alternative medicine techniques that utilize breathing retraining as their primary component and compares evidence from controlled trials with before-and-after trials. Medline, PubMed, Cumulative Index to Nursing and Allied Health Literature and the Cochrane Library electronic databases were searched. Reference lists of all publications were manually checked to identify studies not found through electronic searching. The selection criteria were met by 41 articles. Most randomized controlled trials (RCTs) of the Buteyko breathing technique demonstrated a significant decrease in β_2-agonist use while several found improvement in quality of life or decrease in inhaled corticosteroid use. Although few in number, RCTs of respiratory muscle training found a significant reduction in bronchodilator medication use. Where meta-analyses could be done, they provided evidence of benefit from yoga, Buteyko breathing technique and physiotherapist-led breathing training in improving asthma-related quality of life. However, considerable heterogeneity was noted in some RCTs of yoga. It is reasonable for clinicians to offer qualified support to patients with asthma undertaking these breathing retraining techniques.

Keywords: asthma • Buteyko breathing technique • complementary medicine • respiratory muscle retraining • systematic review

Complementary and alternative medicine (CAM) has been defined as "a broad domain of healing resources that encompasses all health systems, modalities and practices and their accompanying theories and beliefs, other than those intrinsic to the politically dominant health system of a particular society or culture in a given historical period" [1]. CAM is popular in the general community for the self-management of asthma. Between 20–30% of adults and 50–60% of children have been identified in more rigorously designed studies as having used CAM for asthma yet approximately half of CAM users do not inform their general practitioner of their CAM use [2]. Breathing retraining, a popular form of CAM, is the subject of this review.

Prominent among breathing retraining therapies is the Buteyko breathing technique (BBT), based on the work of Konstantin Buteyko [3]. Buteyko theorized that hyperventilation was the pathological basis of many diseases including asthma, suggesting that hypocapnia consequent to hyperventilation initiates bronchospasm, and patented a formula based on breath-hold time which, he claimed, predicted end-tidal CO_2 [201]. BBT utilizes shallow, controlled breathing and respiratory pauses in an attempt to increase alveolar and arterial CO_2 tension, which BBT proponents suggest may reverse bronchospasm.

Other breathing retraining techniques forming part of CAM include **yoga, biofeedback** and respiratory muscle training. Yoga techniques include deep-breathing exercises (pranayama), postures (asanas), mucus expectoration (kriyas), meditation, prayer and often dietary changes to reduce asthma symptoms. Biofeedback aims to reduce symptoms through gain of voluntary control over autonomic processes. Direct biofeedback training consists of

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Table 1. Randomized controlled trials of breathing modification techniques.

Study† (year)	Sample	Design	Intervention	Withdrawals	Follow-up	Difference between groups (intervention vs control)	Ref.
Bowler *et al.* (1998)	39 community volunteers with asthma	RCT True randomization Double blind	1-week training with Buteyko representative versus relaxation and asthma education	2 (1 intervention, 1 control)	12 weeks	↓ MV: 3.6 l/min ($p = 0.004$) ↓ β_2-agonist: 847 µg/day ($p = 0.002$) ↑ AQOL score (p trend = 0.09) No between-group difference in PEF or FEV_1 No change in $ETCO_2$ in either group	[12]
Opat *et al.* (2000)	36 community volunteers with asthma	RCT Sample size estimate True randomization	4 weeks BBT training video versus nature video	8	4 weeks	↑ AQOL: -1.29 for total score ($p = 0.043$) ↓ β_2-agonist: 210 µg /day ($p = 0.008$)	[20]
Thomas *et al.* (2003)	33 volunteers with asthma/ dysfunctional breathing	RCT Sample size estimate True randomization	2 weeks retraining with physiotherapist versus nurse-led asthma education	5 (1 intervention, 4 control [3 at 6 months])	1 and 6 months	At 1 month: ↑ AQLQ total score‡ At 6 months: ↑AQLQ activities score‡ At 6 months: ↓ Nijmegen score‡	[22]
Cooper *et al.* (2003)	89 community volunteers with asthma	RCT Sample size estimate True randomization Double blind	2 weeks BBT with certified practitioner veruss PCLE or placebo	20 (7 intervention, 6 PCLE, 7 placebo)	6 months	↓ symptom scores by two points ($p = 0.003$) ↓ β_2-agonist: two puffs/day ($p = 0.005$) No between-group difference in FEV_1, ICS use, asthma exacerbations or AQLQ scores	[15]
McHugh *et al.* (2003)	38 community volunteers with asthma	RCT Sample size estimate True randomization Double blind	1-week BBT with Buteyko representative versus asthma education	4	6 weeks, 3 months, 6 months	↓ β_2-agonist 6 weeks; 38% between-group difference§ 3 months: 35% between-group difference§ ↓ ICS 6 weeks: 24% between-group difference§ 3 months: 34% between-group difference§ 6 months: 51% between-group difference§ No difference in lung function	[16]
Slader *et al.* (2006)	57 community volunteers with asthma	RCT Sample size estimate True randomization Double blind	28 weeks BBT taught by video versus 28 weeks non-specific upper body exercises taught by video	7 (3 intervention, 4 control)	12 and 28 weeks	↑ β_2-agonist-free days at 12 weeks in both groups compared with baseline ($p < 0.001$) No between-group difference in β_2-agonist-free days at 12 or 28 weeks ↓ ICS use (50%) in each group at 13 weeks compared with baseline ($p < 0.0001$) No lung function or $ETCO_2$ change	[17]

†Studies listed in order of year of publication.
‡All p-values <0.02.
§All p-values <0.04.
↑: Increase in ↓: Decrease in; ACT: Airway control test; AQLQ: Asthma Related Quality-of-Life Questionnaire; AQOL: Asthma-related quality of life; BBT: Buteyko breathing technique; BT: Breathing training; CCMAS: Chinese Children's Manifest Anxiety Scale; $ETCO_2$: End tidal carbon dioxide; FEV_1: Forced expiratory volume in 1 s; GASCC: General Anxiety Scale for Chinese Children; HAD: Hospital Anxiety and Depression Questionnaire; ICS: Inhaled corticosteroid; MAQOLQ: Mini Asthma Quality-of-Life questionnaire (Juniper); MV: Minute volume; NQ: Nijmegen questionnaire; PCLE: Pink City Lung Exerciser; PEF: Peak expiratory flow; PEFR: Peak expiratory flow rate; RCT: Randomized controlled trial; SF-36v2 PC: Short Form-36 version 2 Health Survey physical component; SGRQ: St George Respiratory Questionnaire.

Table 1. Randomized controlled trials of breathing modification techniques (cont.).

Study† (year)	Sample	Design	Intervention	Withdrawals	Follow-up	Difference between groups (intervention vs control)	Ref.
Holloway *et al.* (2007)	85 subjects with mild or well-controlled asthma recruited from semirural general practice	RCT Sample size estimate True randomization	Five 1-h sessions physiotherapy (Papworth method) plus usual treatment versus usual treatment	13 (7 intervention, 6 control)	6 and 12 months	↓ SGRQ symptom score at 6 and 12 months: between-group difference 8.6 points ($p = 0.007$) ↓ HAD anxiety score at 6 and 12 months: between-group difference 1.5 points ($p = 0.006$) ↓ HAD depression score at 12 months: between-group difference 0.5 points ($p = 0.03$) ↓ NQ total score at 6 and 12 months: between-group difference 2.3 points ($p = 0.015$) No between-group difference in lung function at either follow-up	[19]
Meuret *et al.* (2007)	12 adults with asthma recruited by advertisement	RCT Not clear whether truly randomized	Capnometry-assisted breathing retraining plus usual treatment versus usual treatment	None	8 weeks in intervention group (n = 8)	In intervention group: ↓ ACQ score ($p < 0.05$) ↓ Steen asthma symptom score ($p < 0.01$) ↓ PEF variability ($p < 0.05$) No change in FEV_1	[13]
Cowie *et al.* (2008)	129 subjects from university-based asthma program	RCT Sample size estimate True randomization	Five sessions of BBT from accredited practitioner versus five sessions of BT from physiotherapist	11 (9 intervention, 2 control)	3 and 6 months	At 6 months: ↑ in asthma control (79 vs 72% controlled) but no between-group difference ($p = 0.4$) ↑ MAQOLQ scores same in both groups (0.96 vs 0.95) ↓ ICS use: 317 vs 56 µg/day ($p = 0.02$)	[21]
Thomas *et al.* (2009)	183 general practice asthma patients with moderate ↓ AQLQ score	RCT True randomization	Physiotherapist-supervised BT versus nurse-led asthma education	14 BT and 8 control following randomization. Further 7 BT and 2 control did not attend 1-month follow-up	1 and 6 months	↑ AQLQ total score: between-group difference 0.38 units at 6 months. ↓ NQ score, ↓ HAD anxiety and depression scores at 6 months (All between-group difference $p \leq 0.03$) No between-group difference in FEV_1, MV or $ETCO_2$ at 1-month follow-up	[14]

†Studies listed in order of year of publication.
‡All p-values <0.02.
§All p-values <0.04.
↑: Increase in ↓: Decrease in; ACT: Airway control test; AQLQ: Asthma Related Quality-of-Life Questionnaire; AQOL: Asthma-related quality of life; BBT: Buteyko breathing technique; BT: Breathing training; CCMAS: Chinese Children's Manifest Anxiety Scale; $ETCO_2$: End tidal carbon dioxide; FEV_1: Forced expiratory volume in 1 s; GASCC: General Anxiety Scale for Chinese Children; HAD: Hospital Anxiety and Depression Questionnaire; ICS: Inhaled corticosteroid; MAQOLQ: Mini Asthma Quality-of-Life questionnaire (Juniper); MV: Minute volume; NQ: Nijmegen questionnaire; PCLE: Pink City Lung Exerciser; PEF: Peak expiratory flow; PEFR: Peak expiratory flow rate; RCT: Randomized controlled trial; SF-36v2 PC: Short Form-36 version 2 Health Survey physical component; SGRQ: St George Respiratory Questionnaire.

Table 1. Randomized controlled trials of breathing modification techniques (cont.).

Study‡ (year)	Sample	Design	Intervention	Withdrawals	Follow-up	Difference between groups (intervention vs control)	Ref.
Chiang *et al.* 2009	48 children with moderate/severe asthma from a hospital clinic	RCT Sample size estimate True randomization Not clear whether double blind	Breathing/relaxation training plus self-management plan versus self-management plan	11 (4 experimental and 7 control) from original cohort (n = 59) did not complete the study	12 weeks	In both groups: ↑ PEFR, ↓ medication use, ↓ asthma symptoms but no between-group differences In experimental group only: ↓ CCMAS score ↓ GASCC score ↓ overall asthma medication use	[24]
Grammatopoulou *et al.* (2011)	40 hospital clinic adults with mild/moderate asthma	RCT Sample size estimate True randomization	Physiotherapist-led BT plus usual treatment versus usual treatment	None	6 months testing at 0, 1, 3 and 6 months	↑ $ETCO_2$ at 1, 3 and 6 months ↓ respiratory rate at 1, 3 and 6 months ↑ ACT at 1 and 3 months ↑ SF-36v2 PC score at 1 and 3 months No between-group difference FEV_1% predicted at any time	[18]

‡Studies listed in order of year of publication.
†All p-values <0.02.
§All p-values <0.04.
↑: Increase in; ↓: Decrease in; ACT: Airway control test; AQLQ: Asthma Related Quality-of-Life Questionnaire; AQOL: Asthma-related quality of life; BBT: Buteyko breathing technique; BT: Breathing training; CCMAS: Chinese Children's Manifest Anxiety Scale; $ETCO_2$: End tidal carbon dioxide; FEV_1: Forced expiratory volume in 1 s; GASCC: General Anxiety Scale for Chinese Children; HAD: Hospital Anxiety and Depression Questionnaire; ICS: Inhaled corticosteroid; MAQOLQ: Mini Asthma Quality-of-Life questionnaire (Juniper); MV: Minute volume; NQ: Nijmegen questionnaire; PCLE: Pink City Lung Exerciser; PEF: Peak expiratory flow; PEFR: Peak expiratory flow rate; RCT: Randomized controlled trial; SF-36v2 PC: Short Form-36 version 2 Health Survey physical component; SGRQ: St George Respiratory Questionnaire.

'rewards' (visual or auditory signals) if the subject maintains a measured respiratory parameter within predetermined limits. Respiratory muscle training aims to strengthen muscles to meet the increased work of breathing in asthma.

A Cochrane review updated in 2004 analyzed evidence for some of these techniques [4]. The review included only randomized controlled trials (RCTs) and only those with methods not using a device. Seven studies were included, with the review authors stating that the evidence was insufficient to allow any conclusions. Another review of six RCTs (three of which were also in the Cochrane Review) could not draw a firm conclusion [5]. Both reviews suggested further investigation was warranted.

While an RCT is the 'gold standard' for estimating benefits and risks of interventions, such studies are difficult to implement in CAM because of problems finding convincing placebos and hence difficulty maintaining blinding. Another problem is funding for CAM research as, unlike pharmacotherapy, there is no industry supporter. Thus it is important to examine all available trials, including those that are uncontrolled, as these might provide additional evidence concerning CAM. Recent reviews suggested that nonrandomized trials can either over- or under-estimate treatment effect [6] but usually provide useful information [7].

Supporters of CAM point out that for asthma management, these techniques are less costly and have fewer unwanted side-effects than pharmaceutical products. In this review, we aim to identify evidence from controlled and uncontrolled trials as to the benefits and risks of one form of CAM, breathing retraining techniques, in asthma management.

Research design & methods

Study design

A systematic literature search was conducted to identify all trials published from 1954 to July 12th 2011 in peer-reviewed journals on breathing retraining techniques in asthma management.

Search strategy

Medline, PubMed, Embase, Cumulative Index to Nursing and Allied Health Literature and the Cochrane Library electronic databases were searched using the keywords "asthma" and "complementary medicine" or "breathing exercises" or "breathing therapy" or "breathing retraining" or "buteyko" or "yoga" or "biofeedback" or "relaxation" both as free text and Medical Subject Headings (MESH) terms. Reference lists were manually checked to identify studies not found through electronic searching.

Inclusion criteria

All peer-reviewed journal articles related to the use of breathing techniques as a treatment for asthma were examined. Asthma had to be either diagnosed by a clinician or fulfill the criteria of the American Thoracic Society [8], British Thoracic Society [9] or those of Crofton and Douglas [10]. Breathing modification had to be the primary component of the intervention and the technique used had to be described in detail. Studies in chronic asthma and acute exercised-induced asthma were included. Studies were included if they reported spirometry, respiratory resistance, provocation

Table 2. Randomized controlled trials of yoga techniques.

Study (year)	Sample	Design	Intervention	Withdrawals/ drop outs	Follow-up	Difference between groups (intervention vs control)	Ref.
Nagarathna *et al.* (1985)	106 asthma patients from yoga clinic	RCT (matched pairs) Not clear whether truly randomized	2 weeks 2.5 h/day integrated yoga plus usual management versus usual management	25 withdrawals (group numbers not stated)	54 months	↓ attacks per week ↓ bronchodilator medication per week ↑ PEF All between-group comparisons: $p < 0.01$	[28]
Singh *et al.* (1990)	22 adults	RCT (case-crossover) Not clear whether truly randomized or double-blind	2 weeks PCLE (I:E 1:2) 2 weeks PCLE placebo device	4	2 weeks 4 weeks	↑ histamine PD_{20}: 0.96 mg ($p = 0.013$) No significant change in lung function	[29]
Ceugniet *et al.* (1994)	27 males with severe asthma age <19 years	RCT Not clear whether truly randomized	Exercise training – three groups: I:E 1:1 versus I:E 1:3 versus no instructions	3 from 'no instructions' group	Immediate	No between-group difference in FEV_1/FVC Trend for lesser fall in FEV_1 with exercise in I:E 1:1 and 1:3 groups ($p = 0.041$)	[26]
Ceugniet *et al.* (1996)	16 asthma patients age <19 years	RCT Not clear whether truly randomized	Nine sessions of exercise training with I:E 2:1 breathing (group 1) versus no breathing instructions (group 2)	None	Immediate	↓ respiratory rate ($p = 0.0002$) ↑ tidal volume ($p = 0.0009$) ↑ tidal volume/FVC by 25% ↓ dead space/tidal volume by 12% ↓ SaO_2 by 4% ($p = 0.018$)	[27]
Vedanthan *et al.* (1998)	17 adult asthma clinic outpatients	RCT True randomization	16 weeks 45 min three times a week integrated yoga versus usual management	None	Results reported at weeks 4 and 6 of study PEFR reported for 7 yoga and 7 controls only	No between-group difference in medication use, spirometry, morning and evening PEFR at weeks 4 and 6 of the study	[32]
Manocha *et al.* (2002)	59 adults symptomatic on moderate/ high dose ICS	RCT True randomization Double-blind	Weekly for 4 months 2 h Sahaja yoga versus 2 h relaxation, discussion, CB exercises	12 (9 intervention, 3 control)	4 months 6 months	↓ methacholine PD_{20}: 1.5 doubling doses greater ($p = 0.047$). ↑ in AQLQ and POMS ($p = 0.05$) No between-group difference in any parameter.	[33]
Sabina *et al.* (2005)	62 adults with mild/ moderate asthma	RCT Sample size estimate True randomization Double-blind	4 weeks 180 min/week integrated Iyengar yoga versus stretching exercises	17	8 weeks 12 weeks 16 weeks	At 16 weeks follow-up, significant improvement in AQOL, rescue inhaler use, spirometry in both groups but no between-group differences	[34]
Sodhi *et al.* (2009)	120 adults (hospital clinic and yoga camps)	RCT Not clear whether truly randomized	45 min yoga training/ week for 8 weeks plus usual care versus usual care only	None	4 weeks 8 weeks	↑ all lung function parameters at 4 and 8 weeks in intervention group ($p < 0.01$) compared with baseline. No between-group comparisons done	[30]
Vempati *et al.* (2009)	60 adults in Integral Health Clinic	RCT Not clear whether truly randomized	40 h yoga teaching, diet, lectures, regular phone follow-up and usual care versus usual care	3 (1 intervention, 2 control), results for 29 in yoga group, 28 in control group	8 weeks	↑ lung function only in yoga group (PEFR better in yoga group at baseline; $p = 0.03$) ↓ EIB No change in serum ECP ↑ total AQOL score (both groups)	[31]

↑: Increase in ↓: Decrease in; AQLQ: Asthma Related Quality-of-L ife Questionnaire; AQOL: Asthma related quality of life; CB: Cognitive behavior; ECP: Eosinophilic cationic protein; EIB: Exercise-induced bronchoconstriction; FEV_1: Forced expiratory volume in 1 s; FEV_1/FVC: Forced expiratory volume/forced vital capacity (%); FVC: Forced vital capacity; ICS: Inhaled corticosteroid; I:E: Inspiratory:expiratory ratio; PCLE: Pink City Lung Exerciser; PD_{20}: Provocation dose needed to cause a 20% fall in forced expiratory volume in 1 s; PEF: Peak expiratory flow; PEFR: Peak expiratory flow rates; POMS: Profile of mood states; RCT: Randomized controlled trials.

Table 3. Randomized controlled trials of respiratory muscle training.

Study (year)	Sample	Design	Intervention	Withdrawals/ drop outs	Follow-up	Difference between groups (intervention vs control)	Ref.
Girodo *et al.* (1992)	67 community volunteers	RCT True randomization	16 weeks deep diaphragmatic breathing versus physical exercise	25 from the original 92	26 weeks	↓ medication at 16 weeks: 50% ↓ severity ↑ diaphragmatic breathing: 262%	[40]
Weiner *et al.* (1992)	30 asthma clinic outpatients	RCT Double-blind	6 months threshold inspiratory muscle trainer with increasing resistance versus sham	0	6 months	↑ PI_{max} at RV: 24.1 cmH_2O ↓ PM_{peak}/PI_{max}: 6.7% ↓ night time asthma ↓ daytime asthma ↓ morning tightness ↓ cough All compared with baseline in intervention group ($p < 0.05$) No change in controls	[41]
Weiner *et al.* (2000)	82 respiratory clinic outpatients	RCT Not clear whether truly randomized Double-blind	4 months as above	1 (intervention)	4 months	↑ PI_{max} at RV: 15.2 cmH_2O ↓ Borg score with increasing pressures ↓ β_2-agonist /week: two puffs All compared with baseline in intervention group ($p < 0.05$) No change in controls	[42]
Weiner *et al.* (2002)	22 female clinic outpatients	RCT Double-blind Not clear whether truly randomized	20 weeks as above	3 (1 intervention, 2 controls)	20 weeks	PI_{max} at RV: 30 cmH_2O ↓ β_2-agonist /day: 0.9 puffs ↓ Borg score with increasing pressures All compared with baseline in intervention group ($p < 0.05$) No change in controls	[43]

↑: Increase in; ↓: Decrease in; PI_{max}: Maximal inspiratory mouth pressure; PM_{peak}: Peak pressure; RCT: Randomized control trial; RV: Residual volume.

tests, quality-of-life indices, medication use or asthma symptoms as outcomes.

Exclusion criteria

Studies were excluded if they did not report original data, were not related to breathing retraining or the patient population was not asthmatic (i.e., hyperventilation syndrome, panic disorder or chronic obstructive pulmonary disease), where chronic obstructive pulmonary disease was a comorbid condition and study outcomes were either not measured or not reported.

Data extraction

Titles and abstracts were reviewed by two authors (J Burgess and B Ekanayake) to assess potential eligibility. For studies where eligibility could not be determined from the abstract, the full text was reviewed. For those papers that met the inclusion criteria, design characteristics including participant recruitment, blinding, sample size, power calculations, duration of training period, run-in and follow-up (where applicable), and participant characteristics including age, gender, treatment location (hospital/outpatient) and baseline parameters were extracted from the full text. Allocation was considered to be truly randomized if it employed a method that used chance to assign participants to comparison groups in a trial, for example, by using a random numbers table or a computer-generated random sequence [101]. Baseline measures of the objective and subjective assessment of asthma severity were also extracted. These included spirometry values, peak expiratory flow rates, respiratory resistance, symptoms, quality-of-life and health care utilization. Type and duration of the intervention and where applicable, control therapy, were noted. Primary and secondary outcomes and adverse events were noted together with tests of statistical significance. Where the RCTs listed in Tables 1–4 presented data in a format that did not allow inclusion in a meta-analysis, an attempt was made to contact the corresponding author. Where the data could be obtained in a suitable format, the studies were included in a meta-analysis.

Data synthesis

Continuous outcomes were expressed as weighted mean differences (95% CI) or as standardized mean differences (95% CI) if

Table 4. Randomized controlled trials of biofeedback training.

Study (year)	Sample	Design	Intervention	Withdrawals/ drop outs	Follow-up	Difference between groups (intervention vs control)	Ref.
Kahn *et al.* (1973)	20 children attending allergy clinic	RCT Not clear whether truly randomized	Five sessions/month of biofeedback conditioning to ↑ FEV_1 versus weekly FEV_1 monitoring	None	9 months	↓ ED visits 3.9/year ($p < 0.05$) ↓ medication 6.2/year ($p < 0.01$) ↓ asthma attacks 33.1/year ($p < 0.05$)	[46]
Kahn *et al.* (1977)	80 8–15 year olds attending allergy clinic	RCT Not clear whether truly randomized	Five to eight sessions visual feedback of FEV_1 versus weekly monitoring ten sessions of induced obstruction	4	12 months	↓ asthma severity ↓ attack number	[45]
Janson-Bjerklie *et al.* (1982)	16 asthma subjects	RCT Double blind Not clear whether truly randomized	Five sessions of contingent feedback versus noncontingent (random) feedback	1 from control group	2 weeks	↓ mean TRR by 40% at 2 weeks ($p = 0.049$)	[44]
Mussell *et al.* (1988)	16 asthmatic adults	RCT Double blind Not clear whether truly randomized	Five sessions of induced bronchospasm, then TNBF, noncontingent TNBF, bronchodilator inhaler, placebo inhaler response versus no intervention	None	None	↑ nonsignificant improvement in rate of recovery from bronchospasm with TNBF compared with no intervention	[50]
Lehrer *et al.* (1997)	17 asthmatic adults	RCT Not clear whether truly randomized	Six sessions RSA feedback versus thoracic EMG and incentive spirometry versus self-relaxation	None	6 weeks	With RSA: ↓ Ri 23% ↑ PEF by 203 ml ($p < 0.003$) ↓ $ETCO_2$ by 0.91% ($p = 0.15$) ↓ RR ($p < 0.0003$) ↑ respiration depth ($p < 0.006$)	[47]
Lehrer *et al.* (2004)	94 volunteer adult asthma subjects	RCT Not clear whether truly randomized	1) HRV biofeedback and BT 2) HRV biofeedback only 3) Placebo EEG biofeedback 4) Waiting list	18 (6 from group 1 5 from group 2 5 from group 3 2 from group 4)	10 weeks	↓ controller medication use in groups 1 and 2 ($p < 0.0001$) and group 3 ($p < 0.02$) ↓ airway resistance in group 1 ($p < 0.0007$) and group 2 ($p < 0.002$) FEV_1 unchanged any group	[49]
Lehrer *et al.* (2006)	45 volunteer adult asthma subjects	RCT Not clear whether truly randomized	1) HRV biofeedback and BT: age ≥40 compared with age <40 2) HRV biofeedback only: age ≥40 compared with age <40	9 (4 from group 1 5 from group 2)	10 weeks	↓ controller medication use in both groups ($p < 0.001$) No within-group difference by age. ↓ Airway resistance in group 2 with no difference by age	[48]

↑: Increase in; ↓: Decrease in; BT: Breathing training; ED: Emergency department; EMG: Electromyography;$ETCO_2$: End tidal carbon dioxide; FEV_1: Forced expiratory volume in 1 s; HRV: Heart rate variability; PEF: Peak expiratory flow; RCT: Randomized controlled trial; Ri: Respiratory impedance; RR: Respiratory rate; RSA: Respiratory sinus arrhythmia; TNBF: Trachea noise biofeedback; TRR: Total respiratory resistance.

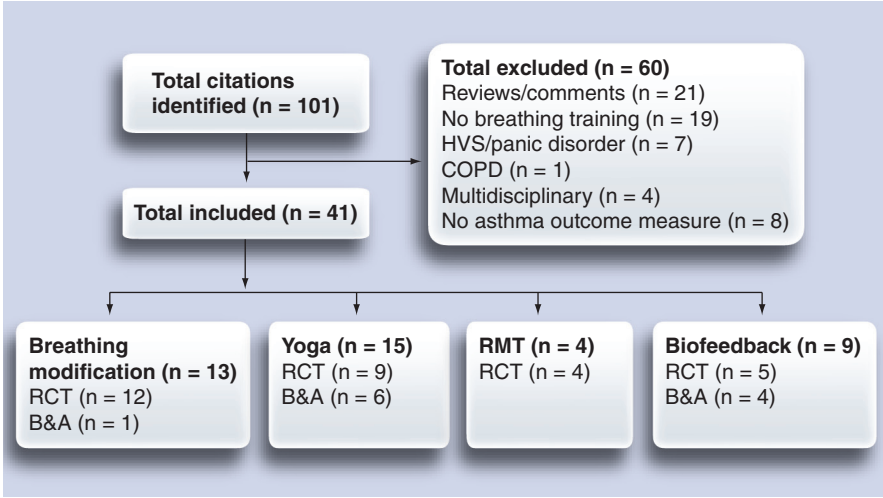

Figure 1. Summary of citations included in review.
B&A: Before-and-after trial; COPD: Chronic obstructive pulmonary disease; HVS: Hyperventilation syndrome; RCT: Randomized controlled trial; RMT: Respiratory muscle training.

different methods of measuring outcomes were used. A fixed-effects model was the default method of meta-analysis but a random-effects model was used when heterogeneity was judged important ($I^2 \geq 25\%$) [11]. Where heterogeneity was judged extreme ($I^2 \geq 80\%$), a pooled estimate and forest plot were not presented. All meta-analyses were done using Stata Statistical Software: Release 10.1 (Stata Corporation, College Station, TX, USA).

Results

Search results

The initial search strategy identified 101 original articles of which 60 were excluded for various reasons, leaving 41 articles that were analyzed (Figure 1).

Breathing modification techniques

A total of 12 RCTs examined the effect of breathing modification techniques compared with control interventions. Six RCTs employed the BBT and six employed respiratory physiotherapy aimed at eliminating over-breathing and developing slow, controlled breathing (Table 1). Participants were recruited from the community via advertisements (n = 7), through a hospital- or university-based asthma clinic (n = 2) or through their general practitioner (n = 4). All subjects were free from cardiorespiratory comorbidities. All but three studies [12–14] reported and met sample-size estimates designed to detect a significant change in the outcome measure. Double blinding was effected in four studies [12,15–17] and true randomization in all but one [13]. Active intervention varied from 1 week of training with a therapist to 28 weeks of watching an instruction video daily. A defined control intervention was present in all but three studies [13,18,19] and follow-up periods ranged from 4 to 28 weeks (Table 1). Four out of six RCTs of BBT found a significant decrease in β_2-agonist use in the BBT group compared with controls [12,15,16,20], while another found a decrease in β_2-agonist and inhaled corticosteroid (ICS) use in both BBT and control groups with no between-group difference [17]. Two BBT trials observed a significant decrease in ICS use over 6 months [16,21], while seven studies (four BBT and three physiotherapy) found improvement in one or more quality-of-life parameters or anxiety/depression scores [12,14,18–22]. No breathing modification trial showed an improvement in lung function in the intervention group compared with controls.

Bowler *et al.* examined BBT taught by an accredited BBT representative versus relaxation and asthma education in 39 asthma subjects and found a significant decrease in minute volume in the BBT group, in keeping with BBT theory, as well as a decrease in daily β_2-agonist use and a trend towards improved quality of life in the BBT group [12]. No change was found in lung function or in end-tidal CO_2 in either group. However, follow-up time was quite short and the authors conceded the possibility of bias as some of the BBT participants received unplanned telephone contact/support from the BBT therapist that could have influenced quality-of-life self-assessment and β_2-agonist use.

Opat *et al.* compared the effect of BBT taught by video with a 'placebo' video in adults with moderate asthma and found that BBT was associated with a significant improvement in AQOL score and a significant reduction in β_2-agonist use, but no significant change in peak expiratory flow rate [20].

Thomas *et al.* examined breathing retraining by a respiratory physiotherapist employing techniques common to standard physiotherapy and BBT compared with nurse-led asthma education [22]. The participants were a subgroup of asthmatic patients with dysfunctional breathing as measured by the Nijmegen questionnaire [23]. The study found that AQOL improved significantly in the breathing retraining group and that two patients would need to be treated to produce clinically relevant improvement

Table 5. Nonrandomized controlled trials of breathing modification techniques.

Study (year)	Sample	Design	Intervention	Withdrawals	Follow-up	Magnitude of difference	Ref.
McHugh *et al.* (2006)	8 children with asthma	Before-and-after trial	BBT instruction by an accredited BBT representative	None	3 months	↓ β_2-agonist use by 66% ↓ ICS use by 41% ↓ symptom score by 12%	[25]

↓: Decrease in; BBT: Buteyko Breathing Technique; ICS: Inhaled corticosteroid.

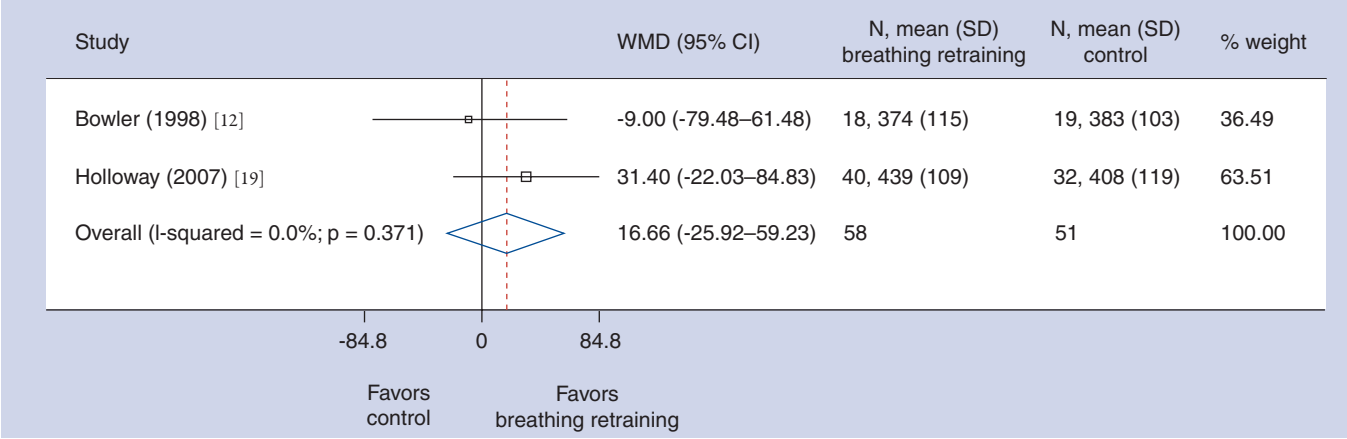

Figure 2. Weighted mean difference in peak expiratory flow (l/min) from breathing retraining randomized controlled trials.
SD: Standard deviation; WMD: Weighted mean difference.

in asthma-related quality-of-life questionnaire (AQLQ) for one patient in 1 month (number needed to treat: 1.96; 95% CI: not reported). There was some evidence that beneficial effects declined with time if breathing techniques were not maintained. After the end of 6 months treatment, the number needed to treat had increased from two to four. A limitation of this study was that lung function was not measured.

Cooper *et al.* compared BBT taught by a certified BBT practitioner with controled breathing (to mimic 'pranayama' yoga) using the 'Pink City Lung Exerciser' (PCLE) and a 'placebo' PCLE [15]. The study found significant improvement in asthma symptoms and bronchodilator use in the BBT group compared with both the PCLE and placebo groups, but no between-group difference in forced expiratory volume in 1 s (FEV_1) or provocation dose needed to cause a 20% fall in FEV_1 (PD_{20}) for methacholine or ICS use.

McHugh *et al.* examined BBT taught by an accredited representative versus asthma education and relaxation in 38 subjects with asthma [16]. The groups were individually matched for asthma severity and were followed up over 6 months. Instructor contact with the participants during follow-up was planned *a priori* and was the same in each group. While there was no change in lung function between groups, there was a significant reduction in ICS and β_2-agonist use in the BBT group. However, the participants in the BBT arm might have become aware of allocation as the use of the term 'Buteyko' was not prohibited during instruction, possibly resulting in incomplete participant blinding.

Slader *et al.*'s video-based trial used hypoventilation, nasal breathing and breath holding at functional residual capacity mimicking BBT as the active intervention and a combination of nonspecific upper body exercises as the control intervention. The study found no significant change in FEV_1, FVC or airway hyper-responsiveness (AHR) in either active or control group but significant and comparable reduction in bronchodilator and ICS use and improvement in AQLQ in both groups [17]. The conclusion was that breathing techniques may be useful in the management of patients with mild asthma symptoms who use a

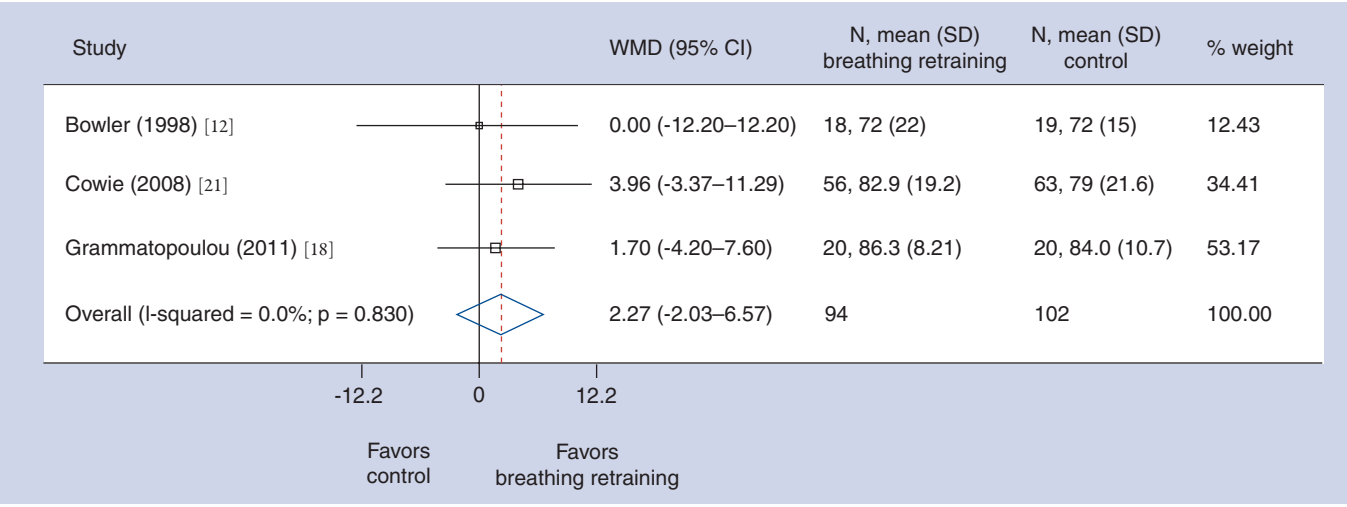

Figure 3. Weighted mean difference in forced expiratory volume in 1 s (% predicted) from breathing retraining randomized controlled trials.
SD: Standard deviation; WMD: Weighted mean difference.

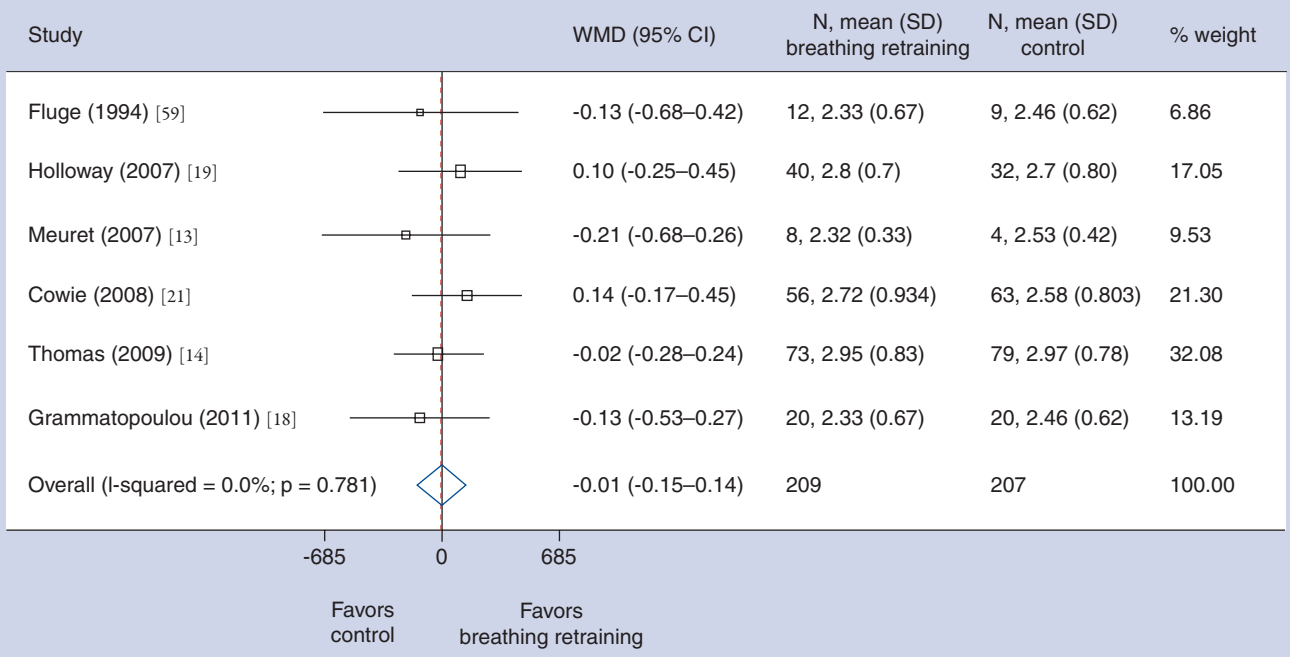

Figure 4. Weighted mean difference in forced expiratory volume in 1 s (l) from breathing retraining randomized controlled trials.
SD: Standard deviation; WMD: Weighted mean difference.

reliever frequently, but there is no evidence to favor shallow nasal breathing over nonspecific upper body exercises.

Cowie *et al.* compared BBT taught by an accredited practitioner with breathing exercises taught by a physiotherapist and found significant and comparable improvement in asthma control and quality-of-life scores in both groups but no difference in FEV_1% predicted between the groups [21]. The improvement in medication use and AQLQ score in both arms in these two studies suggested a common mechanism or that improvement was due to nonspecific effects.

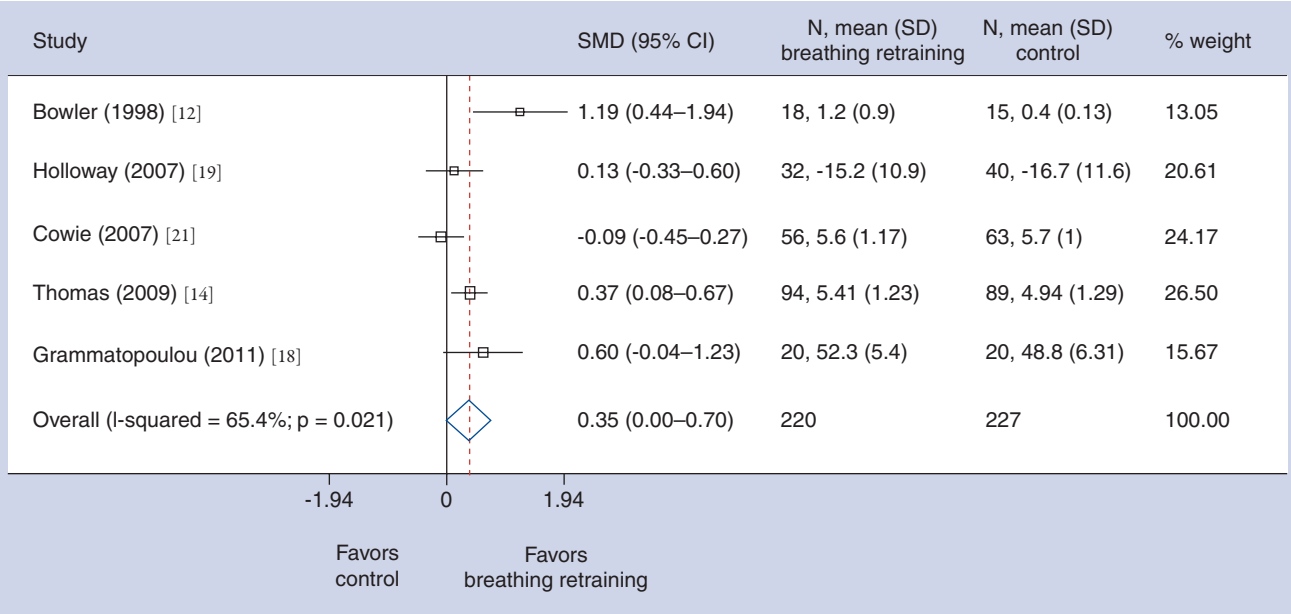

Figure 5. Standardized mean difference in asthma-related quality-of-life score from breathing retraining randomized controlled trials. Asthma-related quality-of-life scores from the Holloway study (lower score is better) were attributed negative values to be consistent with other studies (higher score is better). Weights are from random effects analysis.
SD: Standard deviation; SMD: Standardized mean difference.

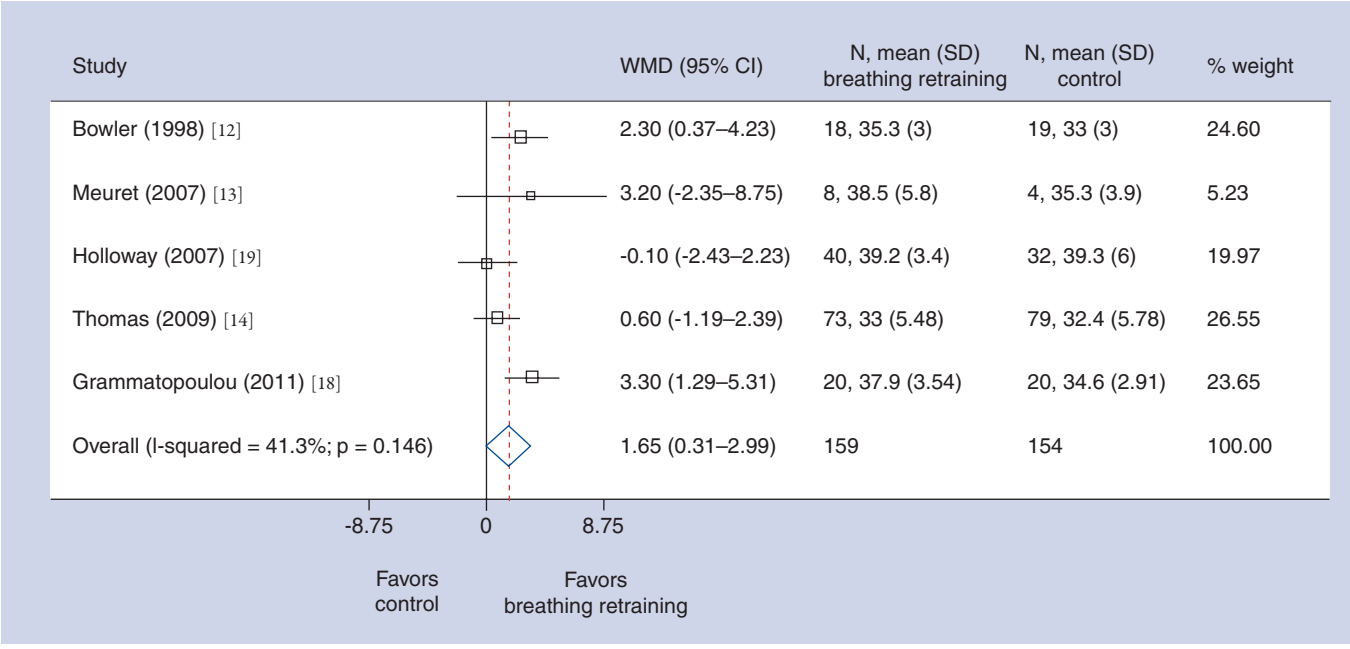

Figure 6. Weighted mean difference in end tidal CO_2 (mmHg) from breathing retraining randomized controlled trials. Weights are from random effects analysis.
SD: Standard deviation; WMD: Weighted mean difference.

Holloway *et al.* examined a physiotherapist-taught breathing technique (Papworth method) plus usual care versus usual care only in a cohort with mild or well-controlled asthma from a semirural general practice [19]. At both 6- and 12-month follow-up, there was significant improvement in St George Respiratory Questionnaire symptom score, hospital anxiety and depression (HAD) questionnaire anxiety and depression scores and Nijmegen questionnaire score but no between-group difference in lung function. The study was limited by the absence of a control intervention. Thomas *et al.* also examined physiotherapist-led breathing training versus nurse-led asthma education in a larger cohort of subjects with reduced asthma-related quality-of-life (AQOL) recruited from general practice [14]. At 6-month follow-up, significant improvements in AQLQ score, Nijmegen questionnaire score and HAD questionnaire anxiety and depression scores in the breathing training group compared with the control group were

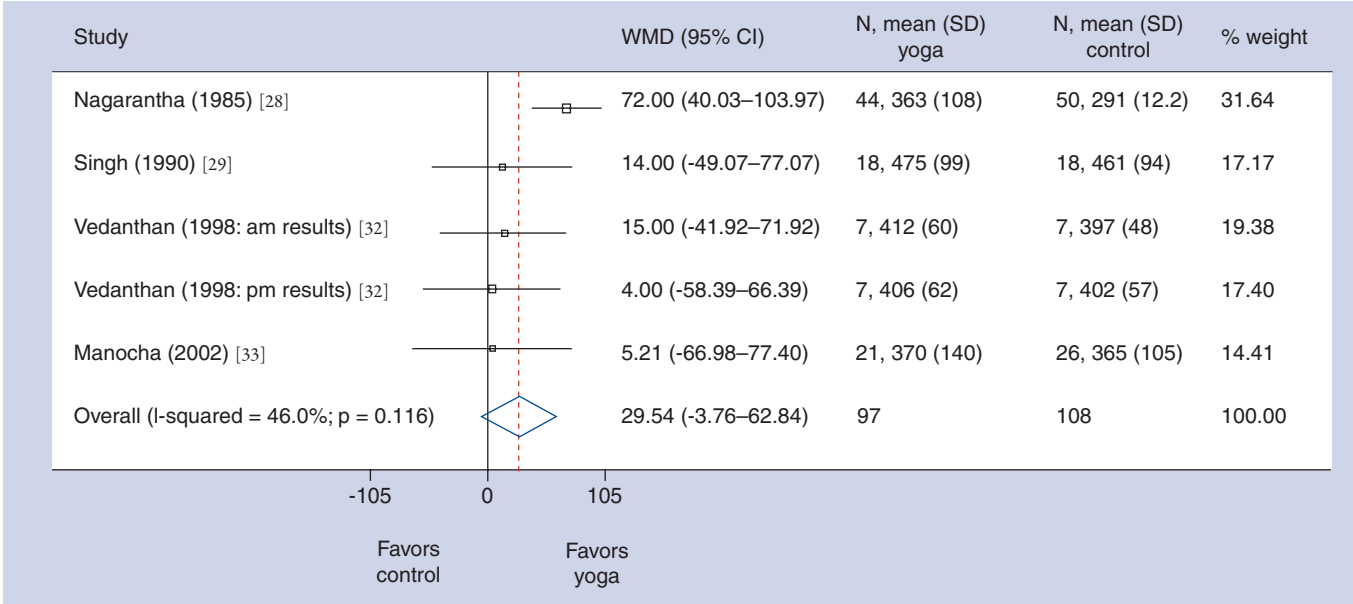

Figure 7. Weighted mean difference in peak expiratory flow (l/min) from yoga randomized controlled trials. Weights are from random effects analysis.
SD: Standard deviation; WMD: Weighted mean difference.

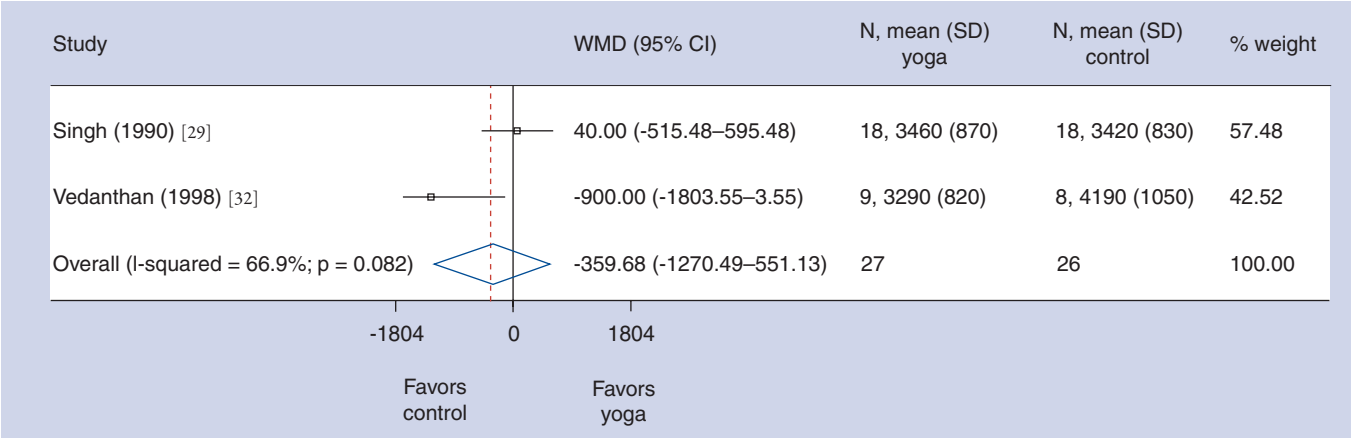

Figure 8. Weighted mean difference in forced expiratory volume in 1 s (ml) from yoga randomized controlled trials.
Weights are from random effects analysis.
SD: Standard deviation; WMD: Weighted mean difference.

found. However, there was no improvement in lung function in either group. More recently, Grammatopoulou *et al.* examined the effect of physiotherapist-led breathing training plus usual treatment in 40 adults with mild/moderate asthma recruited from a hospital asthma clinic [18]. They found significant improvement in airway control test (ACT) score, Short Form-36 version 2 Health Survey (SF-36v2) physical component score, increased end tidal CO_2 and reduced respiratory rate in the intervention group compared with controls who continued with usual treatment only. While there was no between-group change in lung function, there was a significant improvement in FEV_1% predicted within the intervention group at 3 months follow-up compared with baseline.

Meunert *et al.* conducted a pilot study in 12 asthma subjects recruited by advertisement [13]. The intervention was initial education in breathing patterns in asthma followed by capnometry-assisted breathing training and home breathing exercises over a 4-week period, plus usual treatment (n = 8). The control group (n = 4) continued with usual treatment for the 4-week period and were then offered the intervention, taken up by only two participants. At 8-week follow-up normocapnia (end-tidal pCO_2 40 mmHg), an improvement in asthma control, asthma symptoms and a reduction in PEF variability with no change in FEV_1 were found in the intervention group. Follow-up was not done in the control group. The small number in the study together with the absence of useful data from the control group limits the usefulness of the findings.

Chiang *et al.* examined the effect of breathing/relaxation instruction in addition to a clinic-planned asthma self-management program compared with self-management only in 48 Taiwanese children with moderate to severe asthma recruited from an asthma clinic [24]. PEF, asthma symptoms and medication use improved in both groups with no between-group differences. There was a significant reduction in anxiety scores in the experimental group only. The adequacy of blinding in the study was in doubt in that the breathing/relaxation instruction was given by a 'researcher'.

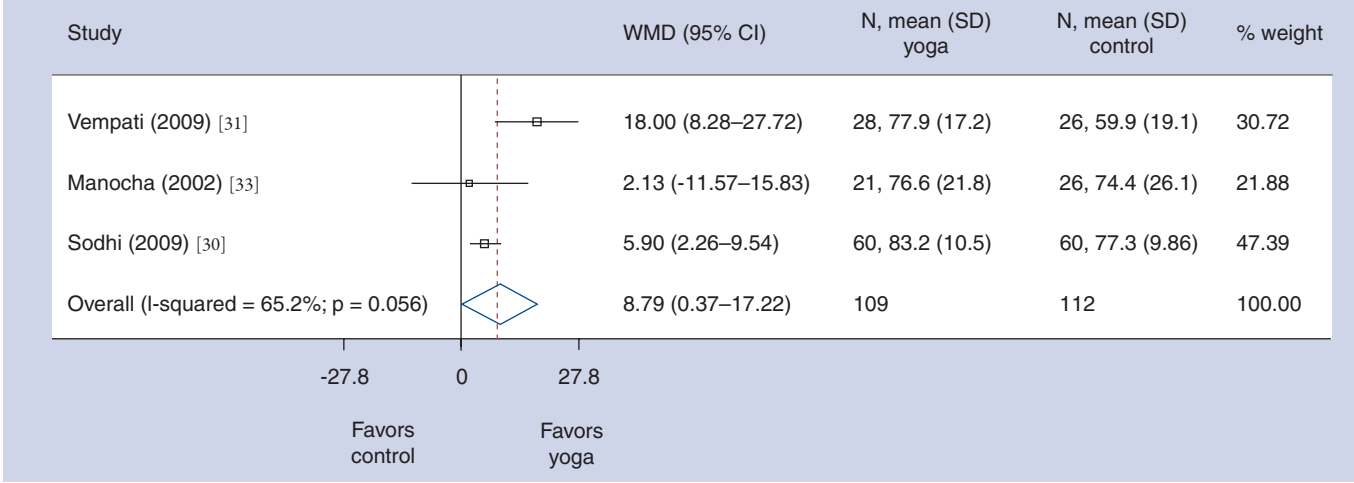

Figure 9. Weighted mean difference in forced expiratory volume in 1 s (% predicted) from yoga randomized controlled trials.
Weights are from random effects analysis.
SD: Standard deviation; WMD: Weighted mean difference.

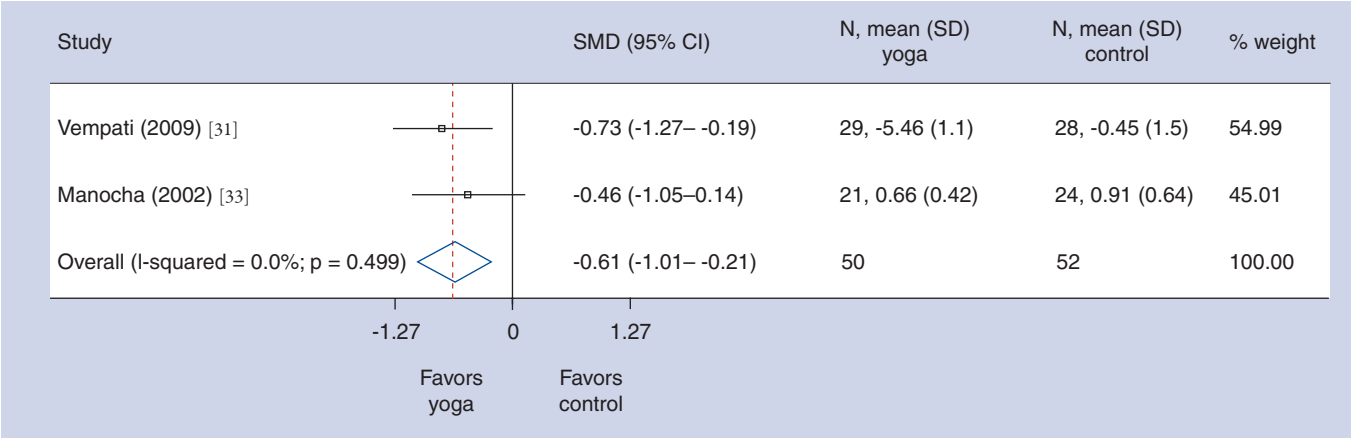

Figure 10. Standardized mean difference in asthma-related quality-of-life score from yoga randomized controlled trials.
Asthma-related quality-of-life score from Vempati study (lower score is better) were attributed negative values to be consistent with Manocha study (higher score is better).
SD: Standard deviation; SMD: Standardized mean difference.

McHugh *et al.* examined breathing retraining using BBT on eight asthmatic children using a before-and-after (B&A) design (Table 5) [25]. At 3-month follow-up, the main findings were a decrease in β_2-agonist and ICS use, a reduction in missed school days and oral steroid courses and an improved asthma symptom score compared with baseline. However, confidence intervals and tests of significance were not reported and lung function was not examined. The authors conceded that self-selection of the participants and the small number in the study precluded meaningful interpretation of the results.

It was not possible to include data from all studies in a meta-analysis of breathing retraining owing to differences in outcome reporting. However, where such analyses could be done, no effect of breathing retraining on lung function could be demonstrated (Figures 2–4) but a favorable effect of breathing retraining on AQOL and on end-tidal CO_2 was shown (Figures 5 & 6).

Yoga

Randomized controlled trial studies

A total of 14 studies examined yoga in asthma management and nine used an RCT design (Table 2). In six out of the nine studies [26–31] it was not clear whether true randomization had been carried out and in seven studies [26–32] double blinding was either not clear or not done. Follow-up times in these studies varied from immediate to 54 months and study numbers ranged from 16–120. Two studies found a significant between-group difference in lung function or AQOL [27,31].

The longest study in terms of follow-up [28], found significant benefit from integrated yoga exercises as well as usual treatment with increased PEFR, decreased medication use and a decrease in attack severity. However, the study participants were from a yoga clinic, with the associated risk of selection bias, and while both active and control groups continued with usual prescribed bronchodilator medication, the control group did not receive a 'placebo' intervention. There was a high attrition rate (47%) as only 'frequent' practitioners (>16 days per month) in the intervention arm were included in the final analysis, which was not intention-to-treat.

Singh *et al.* utilized pranayama by enforcing the 1:2 inspiratory:expiratory ratio with the PCLE device (a disk with a one-way valve that imposes a 1:2 ratio) compared with an otherwise identical (non-pranayama) device in a case-crossover study of 22 adults with mild asthma [29]. There was a significant increase in the doubling dose for PD_{20} for histamine with the active compared with the control device but no significant difference in lung function parameters between the devices.

Although their research question addressed exercise training rather than yoga in asthma management, Ceugniet *et al.* incorporated a pranayama technique into their study of exercise training in children with severe asthma [26]. They reported a trend towards better FEV_1 but no significant effect on FEV_1/FVC ratio following exercise training with pranayama. No change was found in lung function in the control group following similar exercise training without pranayama. In a later study on a similar participant group, the same authors [27] found that the same intervention significantly reduced respiratory frequency, dead space/tidal volume ratio and increased tidal volume in the group using exercise with pranayama. However, postexercise oxygen saturation in the intervention group was reduced from pretest values by a clinically important amount, whereas it did not change in the control group.

Vedanthan *et al.* found that 16 weeks of integrated yoga compared with usual treatment had no effect on lung function as measured at 4 and 6 weeks after study commencement [32]. Manocha *et al.* examined Sahaja yoga compared with relaxation, discussion and cognitive behavior training [33]. They found an improvement in AHR, AQOL mood subscale and the profile of mood states score at the end of the 4-month study period in the intervention group only but no significant between-group differences in any measure 2 months later. Sabina *et al.* trialed 16 weeks of integrated yoga versus stretching exercises and found no between-group difference in FEV_1, rescue inhaler use and AQOL at 16 weeks [34].

Table 6. Nonrandomized controlled trials of yoga techniques.

Study (year)	Sample	Design	Intervention	Withdrawals/ drop outs	Follow-up	Magnitude of difference	Ref.
Nagendra *et al.* (1986)	570 yoga school participants	Before-and-after trial	2 weeks of 2.5 h/day or 4 weeks of 1.5 h/day of asanas, pranayamas, lectures	None	3–54 months	↓ attacks/week: 2.6; ↓ severity: 0.45 ↓ bronchodilator doses/week: 5.81 ↓ cortisone doses/year: 87.45 ↑ PEFR: 53.9 l/min	[38]
Jain *et al.* (1991)	46 asthmatic children, recruitment unknown	Before-and-after trial	40 weeks of inpatient yoga training. 2.5 h/day of kriyas, asanas and pranayamas	20 lost to follow-up	2 years	↑ FEV_1: 11.8% predicted; ↑PEFR: 8.3 l/min ↓ exercise lability index: 11.3% ↑ resting PaO_2: 7.1 mmHg ↑ postexercise PaO_2: 6.4 mmHg ↓ postexercise $PaCO_2$: 2 mmHg	[35]
Jain *et al.* (1993)	42 adult respiratory outpatients	Before-and-after trial	40 days inpatient yoga training then monthly outpatient visits for 1 year	11 lost to follow-up	1 year	↑ FEV_1: 7.9% predicted ↑ MVV: 14.9 l/min; ↑ MMFR: 26.5 l/min ↑ 12-min walk distance: 19.1m ↑ physical fitness index: 4.7 ↑ exercise lability index: 4.3%	[36]
Khanam *et al.* (1996)	9 respiratory outpatients	Before-and-after trial	7 days of yoga camp 2 h/day of asanas, pranayamas, lectures	None	None	↑ breath holding time: 10 s ↑ peak inspiratory flow rate: 2 l/min ↑ chest expansion: 3.56 cm/min	[37]
Sathyprabha *et al.* (2001)	37 adults, recruitment unknown	Before-and-after trial	21 days inpatient yoga therapy, diet and 'nature cure treatment'	None	None	↑ VC: 1.06l; ↑FVC: 1.1l ↑ FEV_1: 1.4l ↑ FEV_1/FVC: 14.02% ↑ MVV: 18.2 l/min	[39]

↑: Increase in; ↓: Decrease in; FEV_1: Forced expiratory volume in 1 s; MMFR: Maximal mid-expiratory flow rate; MVV: Maximum voluntary ventilation; PEFR: Peak expiratory flow rate; VC: Vital capacity.

Sodhi *et al.* examined yoga breathing exercises in addition to usual treatment versus usual treatment only in a cohort of asthma subjects recruited from a hospital clinic and yoga camps [30]. They reported significant improvement in all lung function parameters compared with baseline in the intervention group but no between-group comparisons were carried out.

Vempati *et al.* randomized 60 participants from a hospital-based 'Integral Health Clinic' to either an intensive yoga instruction program or to usual care and found significant improvement in lung function and exercise-induced bronchoconstriction in the intervention group compared with the control group and improvement in AQOL in both groups [31]. However, the study population was biased towards yoga devotees, therapist-related effects were uneven between the groups and the follow-up period was short.

The meta-analyses of RCTs of yoga on lung function showed no effect on PEF or absolute values of FEV_1 (Figures 7 & 8). However, there was a favorable effect of yoga on FEV_1% predicted (Figure 9) and a favorable effect of yoga on AQOL (Figure 10).

Nonrandomized controlled trial studies

Five such studies were found (Table 6) and all used the B&A method [35–39]. Two studies had substantial loss to follow-up [35,36]. Study numbers ranged from 9 to 570 and follow-up times from immediate to 54 months with all studies reporting improvement in lung function, AQOL or AHR for the intervention compared to the control group.

Respiratory muscle training

A total of four RCTs [40–43] investigated the effect of respiratory muscle training on asthma (Table 3). Participant numbers ranged from 22 to 92 with follow-up times varying between 4 and 6 months; all studies employed muscle strengthening techniques. All studies found significant improvement in lung function, β_2-agonist use or symptoms in the active intervention group compared with controls.

Girodo *et al.* employed a then novel method of deep diaphragmatic breathing training that did not involve the use of a corset. Over a 16-week training period, this technique lessened attack intensity and decreased total medication use by 50%,

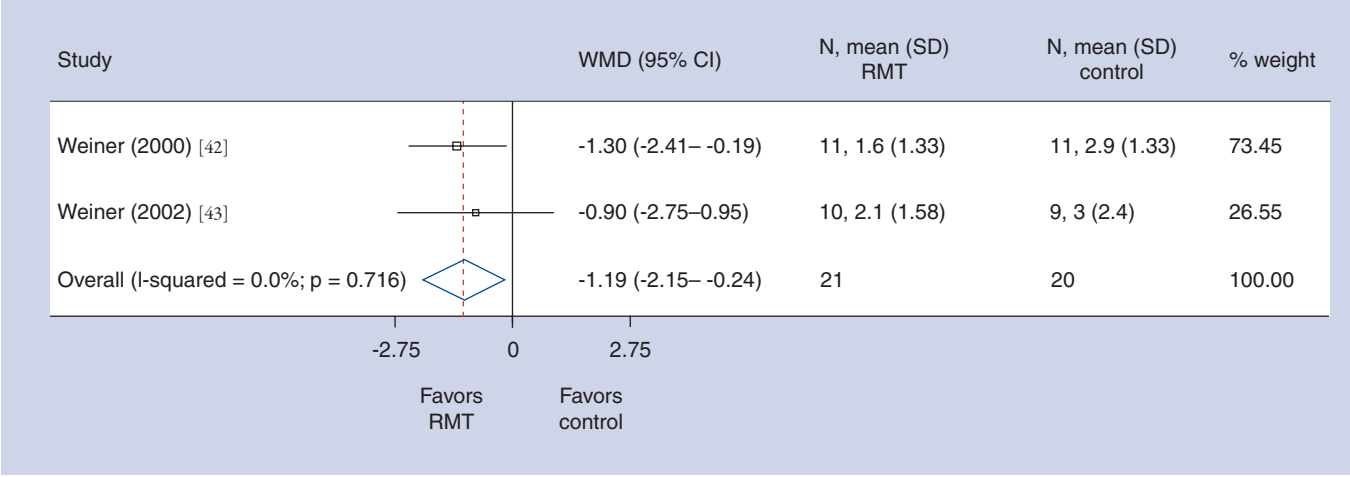

Figure 11. Weighted mean difference in β_2-agonist use from respiratory muscle training randomized controlled trials.
RMT: Respiratory muscle training; SD: Standard deviation; WMD: Weighted mean difference.

although for many participants, persistence with the exercise program was short-lived [40].

Weiner *et al.,* in three separate RCTs, found that specific inspiratory muscle training using either an externally weighted device or a purpose-designed threshold inspiratory muscle trainer (HealthScan; NJ, USA) compared with 'sham' muscle training significantly increased inspiratory muscle strength as measured by maximal inspiratory mouth pressure at residual volume (PI_{max} at residual volume). With 4–6 months training, subjects with the active intervention improved FEV_1, FVC, symptoms and Borg dyspnea score and decreased bronchodilator use. The most recent of these studies that compared female to male asthmatics [43] found that using the same training method to allow females to attain a PI_{max} equal to that of males resulted in a significant and highly correlated decrease in both dyspnea score and medication use in the active intervention group only.

A meta-analysis (Figure 11) showed a favorable effect of respiratory muscle training on β_2-agonist use.

Biofeedback training

A total of seven RCTs [44–50] and five B&A studies [51–55] were identified (Tables 4 & 7). Six RCTs [44–49] and two B&A studies [52,53] found significant improvement in lung function, medication use or asthma symptoms. Participant numbers were generally small and follow-up times were short.

Kahn *et al.* trained 20 children with asthma attending an allergy clinic to induce bronchoconstriction using inhalation, suggestion or medication methods previously known to induce bronchoconstriction [46]. Bronchodilatation via FEV_1 biofeedback reinforcement was then taught weekly to the intervention group (n = 10). Compared to ten controls who received weekly FEV_1 measurement but no biofeedback reinforcement, the intervention group experienced significant reductions in medication use, number of emergency room visits and asthma attacks over the 1-year follow-up period. Lung function was not reported. However, when Khan *et al.* repeated the study in 80 similar children over a 12-month period, these findings could not be replicated [45]. A limitation in these studies was the use of a forced expiratory maneuver as the biofeedback instrument. Any improvement could not necessarily be attributed to genuine operant conditioning as the maneuver is partly dependent on motivation and effort, which might vary between individuals.

Mussell *et al.* in a study of trachea–bronchial noise reduction as the biofeedback instrument to reverse induced bronchospasm, found that trachea–bronchial noise reduction as the biofeedback instrument was modestly and nonsignificantly more effective than no intervention [50]. Janson-Bjerklie *et al.* trialed contingent biofeedback versus random feedback and found that total respiratory resistance (TRR) across five training sessions was greater in their intervention group than the control group [44]. Lehrer *et al.* found that respiratory sinus arrhythmia as a feedback tool compared with electromyography biofeedback plus incentive inspirometry or self-relaxation reduced respiratory impedance by 23% in a small group of adults with asthma but the authors did not report results of any statistical tests [47]. Two later studies by Lehrer *et al.* found that heart rate variability biofeedback plus breathing training or heart rate variability biofeedback alone significantly reduced controller medication use and improved airway resistance, independent of increasing age in asthmatic adults but produced no change in lung function [48,49].

One uncontrolled study [52] showed a significant improvement in mid-expiratory flow rate and TRR compared with baseline using an auditory signal reflecting TRR as the biofeedback tool while another [53] found improvement in FEV_1 and FEF_{50} in 17 out of 20 asthmatic children taught to use respiratory sinus arrhythmia feedback to prolong expiration. On the other hand, Erskine-Millis *et al.* found no benefit for TRR from either short-term or more intensive biofeedback training compared with baseline and even a deterioration in FEV_1 after more intensive training. It was concluded that no benefit was to be had from biofeedback training in adults with moderate/severe chronic asthma [51].

Steptoe *et al.* showed that nonasthmatic subjects were able to decrease airways resistance significantly and consistently over biofeedback training sessions, but asthmatic subjects' airways

Table 7. Nonrandomized controlled trials of biofeedback training.

Study (year)	Sample	Design	Intervention	Withdrawals/ drop outs	Follow-up	Magnitude of difference	Ref.
Feldman (1976)	4 inpatient children with severe asthma	Before-and-after trial	Biofeedback training with an auditory signal reflecting TRR as feedback tool	None	None	↑ MMEF: 7.8% ($p < 0.05$) ↓ TRR: 64.5% ($p < 0.01$)	[52]
Steptoe *et al.* (1981)	8 asthmatic hospital staff 16 nonasthmatic students	Before-and-after trial (planned but not completed as a controlled study)	Four session of four trials of feedback using visual and auditory signals to reflect TRR	None	None	No consistent change in TRR in asthmatic group members	[55]
Erskine-Millis *et al.* (1987)	Study 1: 9 adults Study 2: 10 adults (asthma with an emotional trigger)	Before-and-after trial	Study 1: 4 weeks biofeedback training using visual display to indicate TRR Study 2: one prolonged session of biofeedback training (1 h with rests) using visual display to indicate TRR	None	S1: 4 weeks S2: none	Study 1: no change in TTR Study 2: no change in TTR ↓ FEV_1 (by 21%; $p < 0.01$)	[51]
Mass *et al.* (1993)	15 outpatients with asthma	Before-and-after trial	Three sessions over 4 weeks of feedback training requiring participant to maintain respiratory resistance within a target range using a visual analog	1	4 weeks	No change in FEV_1,, breathlessness, physical activity or reliever medication use	[54]
Lehrer *et al.* (2000)	20 children with clinical diagnosis of asthma	Before-and-after trial	Daily sessions of RSA biofeedback to induce prolonged expiration 5 days/week for 13–15 sessions	None	3 weeks	↑ FEV_1 and ↑ FEF_{50} at study end in 17 out of 20 children	[53]

↑: Increase in; ↓: Decrease in; FEV_1: Forced expiratory volume in 1 s; FEF_{50}: Forced expiratory flow at 50% of forced vital capacity; MMEF: Maximal mid-expiratory flow; RSA: Respiratory sinus arrhythmia; TRR: Total respiratory resistance.

resistance was more variable, with only a trend towards a decrease ($p = 0.059$) [55]. Finally, Mass *et al.* found no change in lung function, dyspnea score or reliever medication use over a 4-week trial period of biofeedback to reduce respiratory resistance in a cohort of 15 asthmatics [54].

Discussion

The BBT has been the most widely publicized among the CAM techniques used in asthma management. Individual studies using BBT consistently demonstrated a reduction in asthma medication use, and together with respiratory physiotherapy studies, often showed an improvement in AQOL and the subjective experience of asthma symptoms. However, there was no significant improvement in lung function in any of the BBT studies to account for the positive results. This was supported by the results of meta-analyses, which failed to show an effect of these techniques using pooled estimates. While it is possible that the deep inspiration required for lung function testing might induce bronchoconstriction [56] and override any beneficial effect from BBT, it is also possible that the studies were inadequately powered to detect changes in lung function parameters. Larger studies might reveal an effect. A meta-analysis of the studies that explored the postulated underlying mechanism proposed in BBT showed a significant increase in end-tidal CO_2 in the active intervention arm.

Critics of BBT argue that medication reduction could be due to the therapist's influence and it is difficult to evaluate that possibility. On the other hand, there was no evidence of a detrimental effect on asthma control with reduction in medication usage and to some extent, there might have been an improvement in symptoms. Longer follow-up is needed to show that improvement in asthma control as measured by medication usage is sustained for a duration that is clinically meaningful, and that BBT has no adverse effects. Despite the lack of evidence for physiological change to account for the observed benefits, a decrease in medication use could be useful considering the possible systemic effects of ICS use [57,58].

Respiratory muscle training studies were few in number but three out of four such studies found positive results in terms of

improved lung function and quality of life, and a meta-analysis showed a significant reduction in medication use, warranting further examination of this technique.

Methods in yoga were highly heterogeneous, ranging from comprehensive inpatient programs to short-term outpatient training. Comparing RCTs to non-RCTs, we found that non-RCTs involving yoga training tended to yield higher therapeutic effects than RCTs. Studies that isolated a component of yoga found some benefit, whereas the only RCT of integrated yoga that yielded significant improvement was limited by a high and selective drop-out rate. Nonetheless, a meta-analysis showed a favorable effect of yoga on AQOL and a similar, although limited, effect was seen on one measure of lung function. We attempted to perform sensitivity analyses by incorporating non-RCTs of yoga in some of the meta-analyses. However this was not possible owing to unavailability of data from non-RCTs in a form suitable for inclusion in a meta-analysis.

Biofeedback training was limited by heterogeneity in methodology and often limited by small sample sizes. The need for specialized equipment in patient training limits the more general use of this technique among asthma patients.

Nearly all systematic reviews are restricted to RCTs and the inclusion of B&A trials in this review is novel. In a B&A trial, it is difficult to link improvements in outcome measures to the intervention as the outcome may have multiple determinants and it is difficult to know what proportion of a given outcome is determined by the intervention and what is due to patient-related factors. With that limitation, it is notable that the B&A trials of yoga techniques tended to show improvement in outcomes such as medication use and lung function parameters, which were sometimes statistically significant. It would be of interest to see the results of an adequately powered, well-designed RCT of a clearly defined yoga intervention in asthma management.

Owing to differences in study design, sample size, participant retention and adequacy of follow-up it was difficult to draw firm conclusions about the benefits of these treatments.

Conclusion

The BBT and similar breathing retraining techniques, yoga and respiratory muscle training all showed some benefit as alternative treatments for asthma. However, there were too few well-designed studies with adequate power and length of follow-up to allow definite conclusions to be drawn. On the existing evidence, and provided that prescribed medications were continued, it would be reasonable for clinicians to offer qualified support to asthma patients intending to undertake such techniques under the supervision of a qualified instructor.

Given the rising popularity of complementary and alternative medicine in asthma, further studies of breathing retraining are warranted so that clinicians and patients alike can make informed treatment decisions.

Expert commentary

Asthma management can be difficult. As is often the case in chronic disease for which a cure cannot always be offered, patients with asthma will turn to CAMs in an attempt to self-help. The literature on CAMs in asthma management is not extensive and that which exists may report findings that are not always based on robust study design. However, clinicians would do well not to prejudge complementary methods but evaluate the empirical evidence for the benefits and risks of these methods, and if such evidence is lacking, take the lead in implementing adequately powered trials that employ the scientific method that might provide the evidence.

There is evidence indicating possible benefit from several techniques, the BBT, yoga and respiratory muscle retraining. All are readily available, not difficult to learn and may be cost-effective. These techniques will not replace asthma medication or a carefully designed asthma plan, but their use should not be dismissed out of hand. Further well-designed trials of these techniques are needed to properly evaluate their place in asthma management.

Five-year view

Patient-driven asthma self-help will not lessen in the near future and clinicians should take the lead in setting up scientific trials of self-help methods, particularly breathing retraining. Consequently, we anticipate that the body of evidence for breathing retraining in asthma management will grow over the next few years and result in the establishment of clear guidelines as to whether and when such techniques should be employed.

Key issues

- Despite their popularity among asthma patients, breathing retraining techniques are controversially regarded by clinicians.
- The Buteyko breathing technique (BBT), physiotherapist-led breathing retraining, respiratory muscle retraining, yoga and biofeedback have been trialed in asthma management.
- In pooled estimates, asthma-related quality of life was significantly improved by BBT or physiotherapist-led breathing retraining and by yoga. No evidence was found for improvement in lung function from BBT or physiotherapist-led breathing retraining. However, there is limited evidence for improvement in lung function from yoga and for the reduction in β_2-agonist use from respiratory muscle retraining.
- On current evidence, it is reasonable for clinicians to offer qualified support to patients intending to use BBT, physiotherapist-led breathing retraining, yoga or respiratory muscle retraining, provided there is supervision by a qualified instructor, usual prescribed medication is continued and limitations of the interventions are understood.
- Biofeedback is unlikely to be of practical use in asthma management.
- Further well-designed, adequately powered randomized controlled trials of breathing retraining techniques in asthma management are warranted.

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