

Physical training for asthma (Review)

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ABSTRACT

Background

Physical training programmes have been designed for asthmatic subjects with the aim of improving physical fitness, neuromuscular coordination and self-confidence. Habitual physical activity increases physical fitness and lowers ventilation during mild and moderate exercise thereby reducing the likelihood of provoking exercise induced asthma. Exercise training may also reduce the perception of breathlessness through a number of mechanisms including strengthening respiratory muscles. Subjectively, many asthmatics report that they are symptomatically better when fit, but results from trials have varied and have been difficult to compare because of different designs and training protocols.

Objectives

The purpose of this review was to assess evidence for the efficacy and effectiveness of physical training in asthma.

Search strategy

We searched the Cochrane Airways Group Specialised Register, SportDiscus and the Science Citation Index up to May 2005.

Selection criteria

Randomised trials in asthmatic subjects undertaking physical training. Subjects had to be eight years and older. Physical training had to be undertaken for at least 20 to 30 minutes, two to three times a week, over a minimum of four weeks.

Data collection and analysis

Eligibility for inclusion and quality of trials were assessed independently by two reviewers.

Main results

Thirteen studies (455 participants) were included in this review. Physical training had no effect on resting lung function or the number of days of wheeze. The results of this review have shown that lung function and wheeze is not worsened by physical training in patients with asthma. Physical training improved cardiopulmonary fitness as measured by an increase in maximum oxygen uptake of 5.4 ml/kg/min (95% confidence interval 4.2 to 6.6) and maximum expiratory ventilation 6.0 L/min (95% confidence interval 1.5 to 10.4). There were no data concerning quality of life measurements.

Authors' conclusions

In people with asthma, physical training can improve cardiopulmonary fitness without changing lung function. It is not known whether improved fitness is translated into improved quality of life. It is comforting to know that physical training does not have an adverse effect on lung function and wheeze in patients with asthma. Therefore, there is no reason why patients with asthma should not participate in regular physical activity.

PLAIN LANGUAGE SUMMARY

Asthmatic subjects often have worsening symptoms when they exercise (exercise induced asthma). This can prevent them playing sports or attempting to keep fit. Physical training programs have been designed to improve physical fitness, muscle coordination and

confidence. The review of trials found that exercise training had no effect on resting lung function or the number of days of wheeze. However, the review found physical training does improve cardiopulmonary fitness. More research is needed.

BACKGROUND

Subjects with asthma have a unique response to physical activity which has clinically important consequences for both their asthma and their general health. On the one hand, exercise can provoke an increase in airways resistance in most asthmatics leading to exercise-induced asthma (EIA). On the other hand, regular physical activity and participation in sports are considered to be important components in the overall management of asthma, especially in children and adolescents (Orenstein 1996). This aspect of the link between asthma and exercise has not been as critically investigated as have the mechanisms of EIA.

Exercise-induced asthma can be prevented or reduced by pre-treatment with a number of anti-asthma medications including beta agonists, cromones and leukotriene antagonists. The effect of nedocromil sodium in preventing EIA has been reported in a Cochrane Airways Group review (Spooner 1999). Nevertheless, the fear of inducing an episode of breathlessness inhibits many asthmatics from taking part in physical activities. A low level of habitual physical activity in turn leads to low level of physical fitness. Thus a number of studies (Clark 1988 and Garfinkel 1992), but not all (Santuz 1997), have reported asthmatics to have lower cardiorespiratory fitness than their peers.

Physical training programmes have been designed for asthmatic subjects with the aim of improving physical fitness, neuromuscular coordination and self-confidence, but the reported results have varied and have been difficult to compare because of different study designs and training protocols. Subjectively, many asthmatics report that they are symptomatically better when fit, but the physiological basis of this perception has not been systematically investigated. Habitual physical activity increases physical fitness and lowers the minute ventilation of mild and moderate exercise thereby reducing the likelihood of provoking EIA. Exercise training may also reduce the perception of breathlessness through a number of mechanisms including strengthening respiratory muscles.

OBJECTIVES

This review was undertaken to gain better understanding of the effect of physical training on an asthmatic subject's respiratory and general health from all relevant clinical trials, and where possible, by undertaking a meta-analysis of the data from these trials.

CRITERIA FOR CONSIDERING STUDIES FOR THIS REVIEW

Types of studies

Randomised controlled trials of asthmatic subjects undertaking physical training.

Types of participants

Subjects aged eight years and older with asthma diagnosed by a physician and/or by the use of objective criteria (e.g. bronchodilator reversibility), subjects with any degree of asthma severity could be included. Studies reporting results on patients with COPD were excluded; but data from studies of mixed populations were included when separate data was available for the asthmatic patients.

Types of intervention

Physical training (whole body aerobic exercise lasting 20 to 30 minutes undertaken two to three times a week) with a minimum duration of four weeks.

Types of outcome measures

Bronchodilator usage
Episodes of wheeze
Symptoms (recorded in daily diary cards)
Exercise endurance
Work capacity
Walking distance
Quality of life with subjective symptom measures
Physiological measurements (i.e. PEFR, FEV₁, FVC, VO₂max, VEmax, HRmax, MVV)

SEARCH METHODS FOR IDENTIFICATION OF STUDIES

See: Cochrane Airways Group methods used in reviews.

The Cochrane Airways Group Specialised Register and the Cochrane Central Register of Controlled Trials (CENTRAL) were searched for studies using the terms:

“work capacity” OR (physical* and activit*) OR train* OR rehabilitat* OR fitness* or exercis*

Additional searches were carried out on MEDLINE (1966-May 2005), EMBASE (1980-May 2005), SportDiscus (1949-May 2005) and also on the Current Contents Index (1995-May 2005) as well as Science Citation Index (1995-May 2005). The

reference lists of all primary studies were reviewed to identify trials not captured by electronic and manual searches. Citations were reviewed without language restriction. When more data was required for the systematic review the authors of the study were contacted requesting the additional information or clarification.

METHODS OF THE REVIEW

All titles and abstracts identified by the search that appeared relevant were selected for full text review by two reviewers independently. Of these 49 publications were identified as potentially relevant studies. The full text of each paper was obtained and translated where necessary. Two reviewers agreed that 13 of these studies were suitable for inclusion and the remaining 36 studies were excluded.

DESCRIPTION OF STUDIES

All studies were randomised controlled trials of asthmatic subjects undertaking physical training. Physical exercise training (whole body aerobic exercise lasting 20 to 30 minutes undertaken 2 to 3 times a week) with a minimum duration of four weeks.

METHODOLOGICAL QUALITY

STUDY SELECTION AND QUALITY ASSESSMENT

Two reviewers assessed the trials for inclusion by only looking at the methods section of each paper while remaining unaware of the study's results, conclusion and authors. Furthermore each reviewer independently applied written inclusion/exclusion criteria to the methods section of each study to determine the adequacy of patient randomisation, blinding, baseline comparability, outcome measures, and the handling of withdrawals/dropouts. The extent of the reviewers agreement was documented.

All trials that appeared potentially relevant were assessed, and if suitable were included in the review. Data for the trial was extracted by two reviewers.

The methodological quality of the included trials was assessed with particular emphasis on the allocation concealment, which was ranked using the Cochrane approach:

Grade A: Adequate concealment

Grade B: Uncertain

Grade C: Clearly inadequate concealment

Grade D: Not used (no attempt at concealment)

In all cases disagreements about the inclusion or exclusion of a study was resolved with discussion. A third reviewer would have been consulted if disagreement persisted, however this was not required.

Selected studies which were subsequently excluded on methodological grounds are identified and the reason for exclusion provided in the table of 'Characteristics of excluded studies'.

SUBGROUP ANALYSIS

There was an insufficient number of studies to justify subgroup analysis.

RESULTS

Search for studies

The electronic search yielded 948 (637 studies up till 2002 & 311 from 2002-May 2005 in an update search) potential studies: 25 references were found in EMBASE, 82 in MEDLINE, 76 in SPORTSDISCUS and 765 from the Airways Group register and CENTRAL. An additional 28 references were added from bibliographic searching of relevant articles and a further study (Neder 1999) was added as a result of personal communication. Of a total of 977 abstracts, 49 were identified as dealing with physical training.

For this update five new studies were added (Council 2003 with 16 participants; Huang 1989 with 90 participants; Matsumoto 1999 with 16 participants; van Veldhoven 2001 with 47 participants; Weisgerber 2003 with eight participants).

Two reviewers agreed that 13 of these studies were potentially suitable for inclusion and the remaining 36 excluded for reasons explained in 'Characteristics of Excluded Studies'.

The majority of the trials did not describe the method of randomisation and did not make any references to masking (blinding). We wrote to 12 authors of the 13 included studies for further information and received four replies. The low response rate was not surprising; the oldest included trial was published in 1972, and the oldest trial considered for inclusion was published in 1964.

The results for each outcome measured are reported as overall effects of exercise versus control. Figures in parenthesis indicates the number of studies that contributed towards that particular outcome measure.

PEFR (L/min): {four studies}

There was no significant effect of physical training on PEFR, mean difference (MD) -5 L/min, 95% CI -28 to 17.

FEV₁ (L): {five studies}

Physical training had no significant effect on FEV₁, MD 0.01 L (95% CI -0.14 to 0.16).

FVC (L): {four studies}

There was no significant effect of physical training on FVC, MD 0.09 L (95%CI -0.12 to 0.30).

Episodes of Wheeze (days): {one study}

Training did not have any significant effect on the number of episodes with wheeze.

VE_{max} (L/min): {four studies}

Physical training significantly improved VEmax by 6 L/min, (95%CI 1.57 to 10.43). Tests for heterogeneity were not significant.

VO₂max (ml/kg/min): {seven studies}

This review showed that physical training caused an increase in VO₂max of 5.4 ml/kg/min, (95% CI = 4.24 to 6.61). This finding was based on pooled data from seven studies. Tests for heterogeneity were not significant.

Work Capacity (W): {three studies}

Physical training increased work capacity by 14.95 W, (95%CI 11.52 to 18.38). However, this pooled mean overall result contained significant heterogeneity. All three studies were of similar quality therefore a sensitivity analysis based on quality would be inappropriate. Looking at the studies more closely the only major difference between the three studies is that in the Ahmaidi 1980 trial all participants had a run-in period prior to study entry. It is possible that this may have contributed towards the heterogeneity observed. Therefore, work capacity was re-analysed without the Ahmaidi 1980 trial and the heterogeneity was absent from the pooled result which still showed an improvement in work capacity with physical training by 6.27 W, (95%CI 1.85 to 10.70).

No usable data were available from any of the studies on the following outcomes: maximum ventilatory ventilation (MVV), bronchodilator usage, symptom diary, exercise endurance, walking distance or quality of life measures.

HR_{max} (bpm): {five studies}

Five studies reported HR_{max} as an outcome measure with the overall effect being an increase in HR_{max} of 7.70 bpm, (95%CI 5.57 to 9.83). However, this overall mean effect contained significant heterogeneity. The elimination of Counil 2003 study removed the heterogeneity. There was still a significant increase in overall mean HR_{max} with four of the studies, 3.17 bpm, (95%CI = 0.65 to 5.70).

Subgroup analyses

Subgroup analyses (see Methods) could not be performed because of the small study numbers and the missing data.

DISCUSSION

A comprehensive search strategy was developed for this review and every effort was made to identify all relevant studies. Whilst several attempts were made to identify unpublished work, it is conceivable that some studies could have been missed. However, the main problem was the small number of RCTs that evaluated the effects of physical training on asthmatic subjects, coupled with the small number of subjects studied.

There was no evidence of an effect on resting lung function. This lack of improvement in pulmonary function confirms findings

from previous uncontrolled studies (Arborelius 1984; Nickerson 1983; and Haas 1987). However, all the studies in this review were conducted over a short period (three to four months). Although physical training decreased the number of days of wheeze by 7.5 days, this result was not statistically significant.

There were positive benefits with exercise training. Analysis of the following outcomes discussed individually showed statistically significant results:

VO₂max - ml/kg/min (seven studies)

This is a measure of the maximum oxygen uptake that can be achieved by a subject. There was a significant increase in VO₂max in the training group (P<0.00001). Four of the seven studies showed a significant increase in VO₂max. Training studies in healthy subjects have shown that VO₂max may increase by up to 20% (Brooks 1996), the extent being dependent upon initial fitness level, type of training and age. Asthmatics respond to physical training in a similar manner and degree to non asthmatics (Robinson 1992).

VEmax - L/min (four studies)

Physical training significantly improved VEmax by 6 L/min. This is in line with the increases in VO₂max and as increases in ventilation would be expected to improve maximum oxygen uptake.

Work Capacity - W (two studies)

Physical training increased work capacity by 6.27 W, which follows from increases in ventilation and oxygen uptake.

HR_{max} - bpm (four studies):

This outcome measures the maximum heart rate in subjects during exercise training. In all four studies, this was determined by continuous recording on an electrocardiogram. The maximum heart rate increased in the group that underwent physical training by 3.17 bpm, (P=0.01). A decrease in maximum HR is the typical response to training (Brooks 1996). The present finding may indicate that a maximum effort was not achieved in the baseline test or that non-cardiac factors limited exercise capacity initially. For example training may result in a decrease in the perception of breathlessness resulting in greater maximum exercise effort.

Whilst statistically significant effects of physical training have been reported, it must be remembered that these were derived from a small number of subjects. The included studies employed different outcome measures, which were often unstandardised, at different baseline measures, were for varying lengths of time. Missing data from most of the studies undermines the validity of the findings. These methodological limitations and restrictions make it difficult to draw conclusions which are generalisable to a wider population.

AUTHORS' CONCLUSIONS

Implications for practice

In people with asthma, physical training can improve cardiopulmonary fitness without changing lung function. This appeared to be a normal training effect and not due to an improvement in resting lung function. It is not known whether improved fitness is translated into improved quality of life. It is comforting to note that physical training does not have an adverse effect on lung function and wheeze in patients with asthma. Therefore, there is no reason why patients with asthma are not able to participate in regular physical activities. When training asthmatic subjects, it would be appropriate to give them guidance about the prevention and treatment of exercise-induced asthma.

Implications for research

There is a need for a properly designed and conducted randomised clinical trials to assess the efficacy and effectiveness of physical training in the management of bronchial asthma. In particular it is important to measure whether the improved exercise performance that follows physical training is translated into improved quality of life.

POTENTIAL CONFLICT OF INTEREST

There are no known conflicts of interest. No funding has been received for this review.

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*Indicates the major publication for the study

TABLES

Characteristics of included studies

Study	Ahmaidi 1980
Methods	Randomised controlled trial with a run-in period
Participants	48 asthmatic subjects aged 12 to 17 years performed both a maximal incremental exercise test on a cycle ergometer and 20-MST. Ten of the subjects were then randomly chosen and trained three times per week at their ventilatory threshold (Vth) intensity level for three months. Another group of ten asthmatic subjects served as control subjects. Training intensity was adjusted monthly. There were twenty asthmatic subjects (10 in the intervention group and 10 in the control group).
Interventions	The training group participated in 36 sessions (3 d/wk for 3 months) of running on an outdoor track. Each session lasted 1 hour during which the children ran for 10min, 3 times, at their own predetermined ventilatory threshold.
Outcomes	VO2max, Vth, HRmax, Wmax, maximum oxygen pulse.
Notes	Lung function testing was done for the whole sample (of all possible 48 subjects) after the run-in period and before training but not after training.
Allocation concealment	B – Unclear

Study	Cochrane 1990
Methods	Patients were randomly allocated to either the training or the control group. A six week run-in period preceded training.
Participants	36 adults (14 male, 22 female) aged 16–40 years, with chronic asthma of mild to moderate severity as defined by a requirement for regular prophylactic treatment and reproducible airways obstruction when treatment withdrawn.
Interventions	30 minute training sessions, 3 times a week for 3 months.
Outcomes	FEV1, VO2max, VEmax, maximum oxygen pulse, HRmax, RR, Vth and VE/VO2max
Notes	The mean number of training sessions undertaken by each patient was 36 (range was 19–42 sessions).

Characteristics of included studies (Continued)

Allocation concealment B – Unclear

Study	Counil 2003
Methods	Randomised controlled trial with no run in period.
Participants	16 male asthmatic children aged 10-16 years were randomly assigned to a control group (n=7) or a training group (n=9) however two of the training group did not complete the study & results are only presented for the 7 participants in the training group who did complete the study. Nine of the 14 children were taking inhaled steroids. All participants underwent pulmonary function tests and aerobic fitness testing at the start of the study and had acclimatised to altitude (1400m) for at least 1 month. The study took place in a small city in the Pyrenees Mountains.
Interventions	The training group exercised by continuous cycling 3 times weekly for 6 weeks, 45 minutes each session. The target heart rate was individualised and corresponded to the anaerobic threshold level. Training sessions were supervised.
Outcomes	PEFR, FEV1, FVC, FRC, VEmax, HRmax, VO2, Episodes of Wheeze (days), Work capacity W, FRC%, maximal aerobic power, ventilatory reserve, aerobic threshold
Notes	Testing was done blindly regarding the training groups.
Allocation concealment	B – Unclear

Study	Fitch 1986
Methods	Randomised controlled trial with no run-in period.
Participants	26 asthmatic volunteers aged between 10 and 14 years were selected to participate in the study. The 1962 American Thoracic Society definition of asthma was utilised. 10 of the children formed the training group while the other 16 formed the control group.
Interventions	Warm-ups (i.e. jogging, calisthenics), followed by running sports (i.e. soccer, netball, volleyball, interval and continuous sprints). Intensity was at 75% of target heart rate.
Outcomes	PEFR, HRmax and VO2max
Notes	Nil
Allocation concealment	B – Unclear

Study	Girodo 1992
Methods	Randomised controlled trial with a run-in period.
Participants	Media solicitations for asthmatics to volunteer for an experimental breathing study yielded 274 respondents. 150 eliminated, eventually 92 volunteers remained. Of these 67 were randomly allocated to one of three groups. Mean age varied from 28-33 years.
Interventions	No details provided in published paper, written to author for information. Intensity level not mentioned.
Outcomes	No details provided in published paper, written to author for information, no reply to date.
Notes	We ignored the deep diaphragmatic breathing data and only used the control and physical training data.
Allocation concealment	A – Adequate

Study	Huang 1989
Methods	Randomised controlled trial with no run in period.
Participants	45 asthmatic children aged 6-12 years were randomly assigned to a control group (n=45) matched for age, sex & severity of asthma to a training group (n=45). All participants underwent a pre-enrollment physical, evaluation of pulmonary function with a peak flow meter every three months, and monitoring of clinical progress.

Characteristics of included studies (Continued)

Interventions	Swimming training conducted 3 times a week for an hour each session over an 8 week period.
Outcomes	Clinical progress was assessed by school absenteeism, emergency room visits, hospitalizations, days requiring daily medications and days of wheezing during a period of 12 months after the swimming sessions.
Notes	A total of 63 children had participated in training sessions but the results presented only include the 45 children who had attended all the sessions.
Allocation concealment	B – Unclear

Study Matsumoto 1999

Methods	Randomised controlled trial with no run in period.
Participants	16 children with severe asthma diagnosed according to the ATS criteria aged 8-12 years were randomly assigned to a control group (n=8) or a training group (n=8). No participants were taking oral steroids and other medication was not modified during the study period. The aerobic capacity of each child was determined at the start of the study. An evaluation of exercise induced bronchoconstriction and a histamine challenge test were also conducted.
Interventions	A swimming ergometer was used to assess work rate and corresponding heart rate at 125% of the lactate threshold. The training intensity was set to 125% of the lactate threshold for each participant individually. Training took place for 6 weeks in a heated indoor pool for 2 periods of 15 minutes on 6 days each week. A 10 minute break was taken between the two 15 min training periods. Training intensity was increased as necessary to remain at 125% of the lactate threshold.
Outcomes	Aerobic capacity of the subjects in both training and control groups was assessed again after the training period. Histamine responsiveness was also reassessed. Outcomes include change in work load during cycle test, % fall in FEV1 during swimming & cycle tests, changes in concentrations of histamine required to provoke a fall in FEV1 of 20% or more.
Notes	The mean duration of swimming training was 31.4 days (SD 3.2) and the mean distance swum per day was 851.5m (SD 52.2). The mean total distance achieved during the entire training period was 26,675m (SD 2827.6).
Allocation concealment	B – Unclear

Study Sly 1972

Methods	Randomised controlled trial. No run-in period was used.
Participants	26 asthmatic children aged between 9-13 years selected for the study from patients attending the pediatric allergy clinics of Charity Hospital.
Interventions	Breathing control swimming, calisthenics, tumbling, parallel bars, rope climbing, abdominal strengthening, wall ladder, running. Three times a week for 2 hours per session, 39 sessions in total.
Outcomes	Wheezy days, FVC, FEV1 and PEFR.
Notes	Attendance at training sessions varied from 22-39 sessions with an average attendance of 33 sessions.
Allocation concealment	C – Inadequate

Study Swann 1983

Methods	Randomised controlled trial with a run-in period.
Participants	Children attending the asthma clinic with proven exercise-induced bronchospasm (>20% fall in PEFR after exercise). Children aged between 7-14 years in the control group and between 8-13 years in the exercise group.
Interventions	Warm-ups, squat thrusts, star jumps, sit-ups and press-ups. Exercise loads were increased at each session. Twice a week for 3 months.
Outcomes	Minimum PEFR

Characteristics of included studies (Continued)

Notes All children were given sodium cromoglycate by Spinhaler, 15 minutes before exercise. Wrote to author to find out the duration of the training, received no reply to date.

Allocation concealment B – Unclear

Study Varray 1991

Methods Randomised controlled trial with no run-in period. Authors update: randomisation was ensured by drawing lots.

Participants Atopic asthmatic children were divided into 2 groups, control subjects (7) and swimmers (7). All 14 subjects were known to have recurrent reversible wheezing episodes and were required to fulfil at least 3 of the 4: clinical, allergic, immunological or functional (improvement of > 15% in FEV1 after bronchodilator) criteria.

Interventions Indoor swimming pool training, twice a week for 3 months. Each session lasted for an hour (i.e. 10 minutes on and 10 minutes off).

Outcomes FEV1 and FVC

Notes Study had 2 stages and went for 6 months but we only used the first 3 months data, because the second 3 months was specialised high intensity training.

Allocation concealment A – Adequate

Study Varray 1995

Methods Randomised controlled trial with no run-in period. Authors update: randomisation was ensured by drawing lots.

Participants Subjects included presented a functional improvement of 15% at least in FEV1 by inhaling a bronchodilator. In addition all subjects were required to fulfil: clinical, allergic and immunological criteria. Eighteen asthmatic children (7 boys and 2 girls in each group), mean age was 10.3 for the exercise group and 11.7 for the control group. Authors update: Age range in both groups was 9-13 years.

Interventions Indoor swimming pool, individualised training intensity was used during the sessions. Twice a week for 3 months with each session lasting for total 30 minutes for an hour (i.e. 10 minutes on and 10 minutes off). Individualised training intensity used during study for each subject.

Outcomes VO2max and Vth

Notes Nil

Allocation concealment A – Adequate

Study Weisgerber 2003

Methods Randomised controlled trial with no run-in period.

Participants Subjects were recruited from the Medical College of Georgia Pediatric Pulmonary Allergy/Immunology and General Pediatric clinics. Children included in the study were between 7 and 14 years of age. The study was performed from August 2001 to May 2002. Criteria for inclusion was moderate persistent asthma according to symptom criteria and a need for preventive daily asthma therapy. Exclusion criteria were other comorbidities that would make training unsafe or difficult, asthma therapy changed during trial duration or if an exacerbation occurred during the trial period. Mean baseline values: FEV1 (L) 1.44 (training group), 1.19 (control); FVC (L) 1.84; 1.45; PEFR (L/s) 3.47, 2.89; age 8.4, 7.3.

Interventions Swimming training according to the child's ability. Lessons were conducted twice per week for 5 to 6 weeks, depending on the time of the year, for 45 minutes each. Lessons were taught by certified swim lesson instructors who were not aware of the child's involvement in the study. Children were excluded from the study if they did not attend at least 80% of the lessons. However, all children assigned to the swim group met this attendance requirement.

Outcomes FEV1
FVC

	PEFR
Notes	Randomisation was conducted using random number table.
Allocation concealment	A – Adequate
Study van Veldhoven 2001	
Methods	Randomised controlled trial with no run in period.
Participants	47 children with asthma aged 8-13 years were randomly assigned to a control group (n=24) or a training group (n=23). Participants were recruited from an asthma centre (n=9), following an advertisement in a local paper (n=19), and from a special school (n=20). One child in the experimental group dropped out because of a physical problem not related to asthma & was omitted from further analysis. Severity of asthma was diagnosed using the questionnaire of the classification of the Dutch Central Advisory Committee for Peer Review.
Interventions	The 3 month exercise programme consisted of group exercises twice a week for one hour in a gymnasium and one 20-minute exercise session per week at home. The gym sessions started with 10 minutes warming up, 20 minutes of fitness training then 15-20minutes different physical activities followed. The training group also received information about asthma and exercise to improve coping behaviour with asthma. Medication was taken before training as prescribed by the child's paediatrician. If wheezing following exercise occurred this was relieved by inhalation of salbutamol. Children in the control group did not receive an extra care or treatment.
Outcomes	A maximum incremental exercise test was used to determine maximum workload, HR, minute ventilation, oxygen uptake, CO2 production and a treadmill endurance test at submaximal heart rate was also taken. A translated version of the Self-Perception Profile for Children was used to measure perceived competence and the Asthma Coping Test was also administered. Lung function measures (FCV, FEV1, PEF) were recorded and exercise provocation was measured on a treadmill.
Notes	Assessments took place immediately before and after the intervention.
Allocation concealment	B – Unclear

Characteristics of excluded studies

Study	Reason for exclusion
Altintas 2003	Not an RCT but a CCT (controlled clinical trial with randomisation).
Bauer 2002	Study does not included physical training using whole body.
Bundgaard 1983	Both the groups were trained and the only difference was the intensity of training with no difference in duration or frequency of training.
Cambach 1997	Study included a composite intervention and included both subjects with asthma and COPD. A physiotherapist run program included breathing retraining, mucus evacuation and exercise.
Cox 1989	Not an RCT.
Dean 1988	The study was too short, being only for 5 days.
Edenbrandt 1990	Duration did not meet our minimum. Subjects only exercised once per week .
Emtner 1998	Follow up analysis where either all groups had physical training or where study was a before & after assessment. Also includes retrospective interview results.
Emtner 1999	Not an RCT. a review.
Foglio 2001	All patients had already undergone an 8 week rehabilitation program training prior to being included in the current trial.
Graff-Lonnevig 1980	Study was not truly randomised. Allocation was based on who lived closer to the gymnasium and this group being included in the exercise training arm.

Characteristics of excluded studies (Continued)

Hallstrand 2000	Health control subjects used, not participants with asthma.
Henriksen 1983	Subjects are said to be randomly chosen but the intervention group of 28 were chosen from a total of 42 because they were inactive in sports and related physical games and had poor physical fitness. Control groups were more physically active than the subjects in the intervention group.
Hirt 1964	Mentioned as randomised, but all patients who were in hospital were assigned to the control group. Subjects who had severe asthma were assigned to the control group.
Kendrick 2000	Not an RCT.
Kennedy 2002	Not an RCT.
Kriegel 1998	not an RCT, but a long term observational study.
Malkia 1998	Not an RCT, but a questionnaire based study.
Meyer 1999	Not an RCT.
Meyer 2002	Questionnaire based study.
Muzembo 2001	Not an RCT and composite patient group and not able to obtain data for asthma patients only.
Neder 1999	Study not randomised, subjects were consecutively allocated to the training and placebo groups, where the first 26 subjects were allocated to the training group and the next 16 to the placebo group.
Orenstein 1985	Not truly randomised, subjects were assigned to groups according to the availability of transport.
Pin 1993	Both study groups underwent physical training. One had intermittent training and the other group had aerobic training.
Postolache 2002	Not an RCT but a CCT.
Riegels-Nielsen 2000	Not an RCT.
Rosimini 2003	Not an RCT.
Rothe 1990	Exercise prescription is of too short a duration.
Satta 2000	Not an RCT.
Schmidt 1997	Not a truly randomised study. Participants were randomised on the basis of distance from training centre.
Stiefelhagen 2003	Recommendations for sports training in asthma, not a RCT.
Svenonius 1983	Not randomised since the subjects could choose which one of the four groups they would like to be in.
Turchetta 2002	Not an RCT.
Weller 1999	Not an RCT.
Worth 2000	Not an RCT.
van Veldhoven 2000	Not an RCT, but a before and after study.

ANALYSES

Comparison 01. Physical Training vs Control

Outcome title	No. of studies	No. of participants	Statistical method	Effect size
01 PEFr-l/min	4	103	Weighted Mean Difference (Fixed) 95% CI	-5.47 [-27.55, 16.60]
02 FEV1-litres	5	129	Weighted Mean Difference (Fixed) 95% CI	0.01 [-0.14, 0.16]
03 FVC-litres	4	93	Weighted Mean Difference (Fixed) 95% CI	0.09 [-0.12, 0.30]
04 VEmax-l/min	4	111	Weighted Mean Difference (Fixed) 95% CI	6.00 [1.57, 10.43]
05 HRmax (bpm)	5	121	Weighted Mean Difference (Fixed) 95% CI	7.70 [5.57, 9.83]
06 VO2max-ml/kg/min	7	175	Weighted Mean Difference (Fixed) 95% CI	5.43 [4.24, 6.61]
07 Episodes of Wheeze (days)	1	24	Weighted Mean Difference (Fixed) 95% CI	-7.50 [-22.42, 7.42]
08 Work Capacity-W	3	83	Weighted Mean Difference (Fixed) 95% CI	14.95 [11.52, 18.38]

INDEX TERMS

Medical Subject Headings (MeSH)

Asthma [*rehabilitation]; *Exercise; Physical Fitness; Randomized Controlled Trials as Topic; Respiratory Function Tests

MeSH check words

Humans

COVER SHEET

Title	Physical training for asthma
Authors	Ram FSF, Robinson SM, Black PN, Picot J
Contribution of author(s)	FR, PB and SR wrote the draft protocol and the final review. FR and SR selected trials for inclusion, trials were reviewed and quality assessment carried out by FR & SR. Outcome data was extracted by FR & SR. The draft manuscript was written by FR, SR and and the final manuscript was written by FR, SR & PB for the Cochrane Library. FR & SR updated the review in December 1998, FR sought further studies in December 1999, none found. FR reformatted the review from version Revman 3.1 to Revman 4.0.4. October 2003, Review updated by FR and JP in May 2005.
Issue protocol first published	1998/4
Review first published	1999/1
Date of most recent amendment	02 August 2005
Date of most recent SUBSTANTIVE amendment	05 July 2005
What's New	Five new studies added (Council 2003 with 16 participants; Huang 1989 with 90 participants; Matsumoto 1999 with 16 participants; van Veldhoven 2001 with 47 participants; Weisgerber 2003 with eight participants). Twenty-five studies were added to the excluded studies list. Maximum expiratory ventilation is now significantly better with physical training. This is in line with the increases previously seen in cardiopulmonary fitness as measured by increases in maximum oxygen uptake. Although the results of the review now have narrower confidence intervals compared to the original review the conclusion remains unchanged.
Date new studies sought but none found	10 May 2005
Date new studies found but not yet included/excluded	Information not supplied by author
Date new studies found and included/excluded	08 May 2005
Date authors' conclusions section amended	10 May 2005
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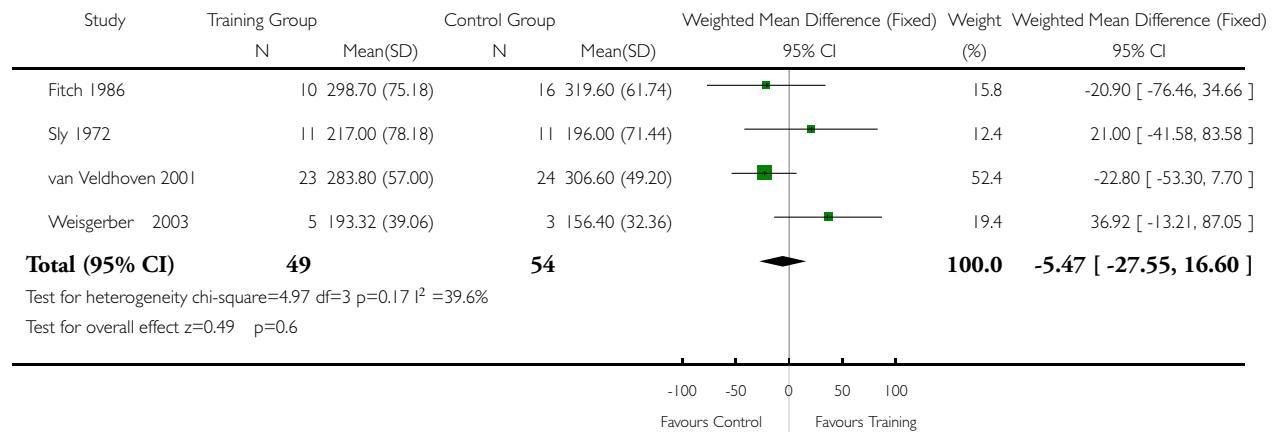
GRAPHS AND OTHER TABLES

Analysis 01.01. Comparison 01 Physical Training vs Control, Outcome 01 PEFR-l/min

Review: Physical training for asthma

Comparison: 01 Physical Training vs Control

Outcome: 01 PEFR-l/min

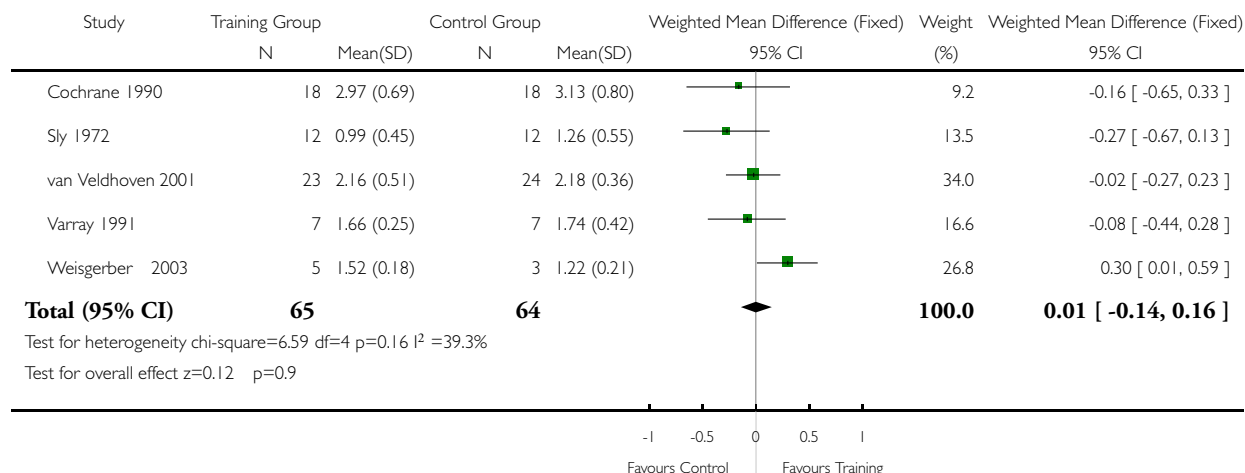


Analysis 01.02. Comparison 01 Physical Training vs Control, Outcome 02 FEV1-litres

Review: Physical training for asthma

Comparison: 01 Physical Training vs Control

Outcome: 02 FEV1-litres

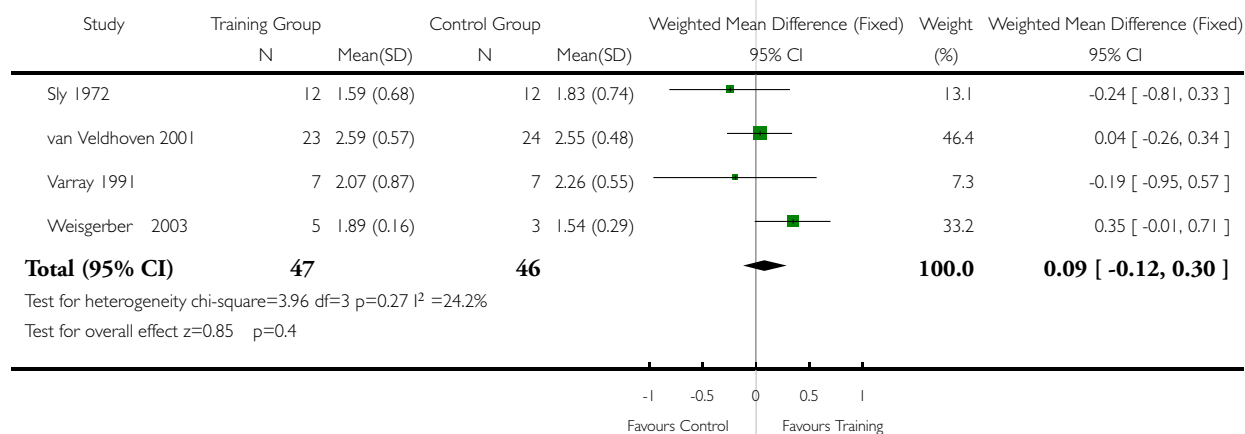


Analysis 01.03. Comparison 01 Physical Training vs Control, Outcome 03 FVC-litres

Review: Physical training for asthma

Comparison: 01 Physical Training vs Control

Outcome: 03 FVC-litres

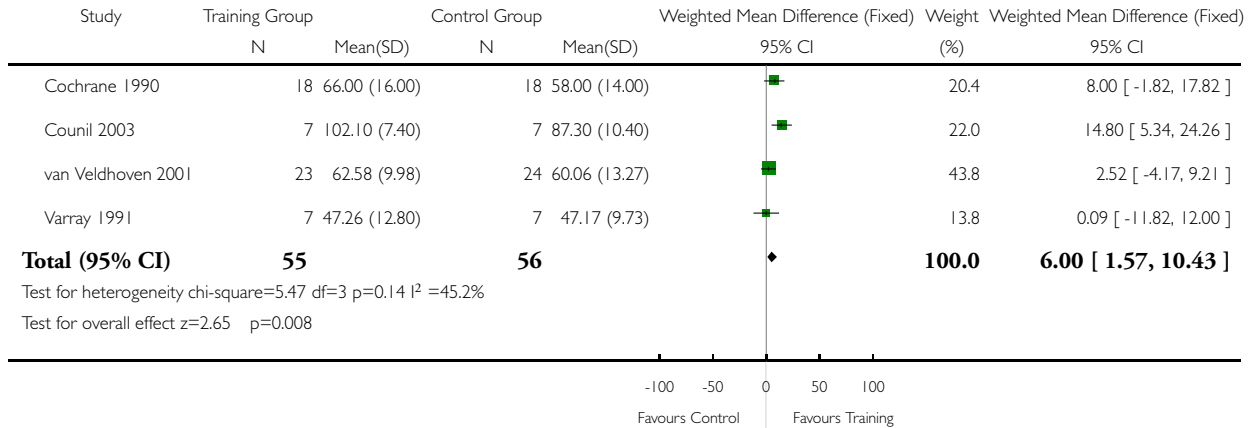


Analysis 01.04. Comparison 01 Physical Training vs Control, Outcome 04 VEmax-l/min

Review: Physical training for asthma

Comparison: 01 Physical Training vs Control

Outcome: 04 VEmax-l/min

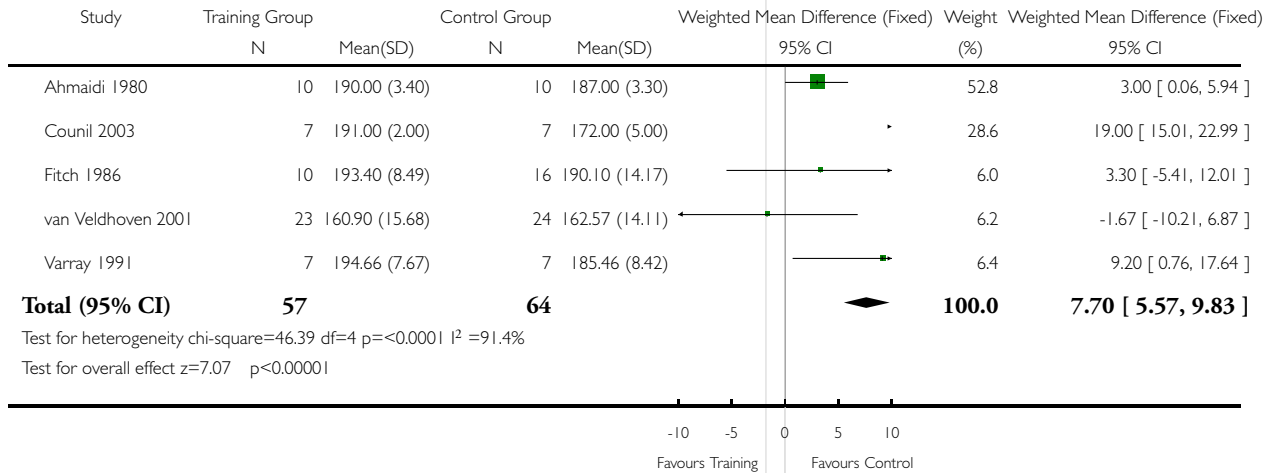


Analysis 01.05. Comparison 01 Physical Training vs Control, Outcome 05 HRmax (bpm)

Review: Physical training for asthma

Comparison: 01 Physical Training vs Control

Outcome: 05 HRmax (bpm)

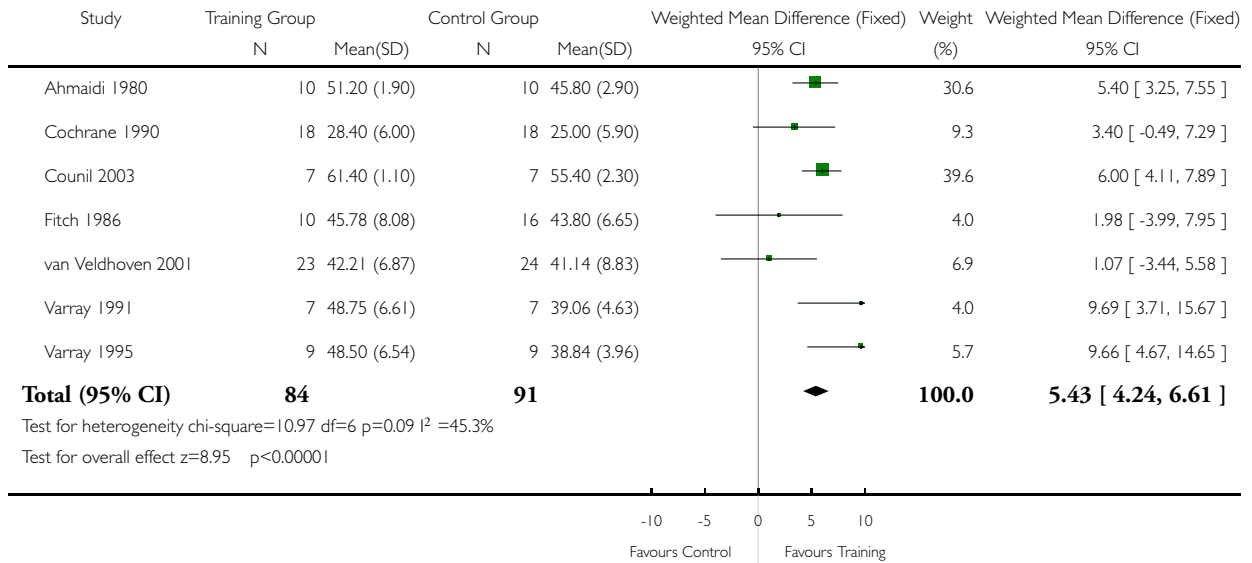


Analysis 01.06. Comparison 01 Physical Training vs Control, Outcome 06 VO2max-ml/kg/min

Review: Physical training for asthma

Comparison: 01 Physical Training vs Control

Outcome: 06 VO2max-ml/kg/min

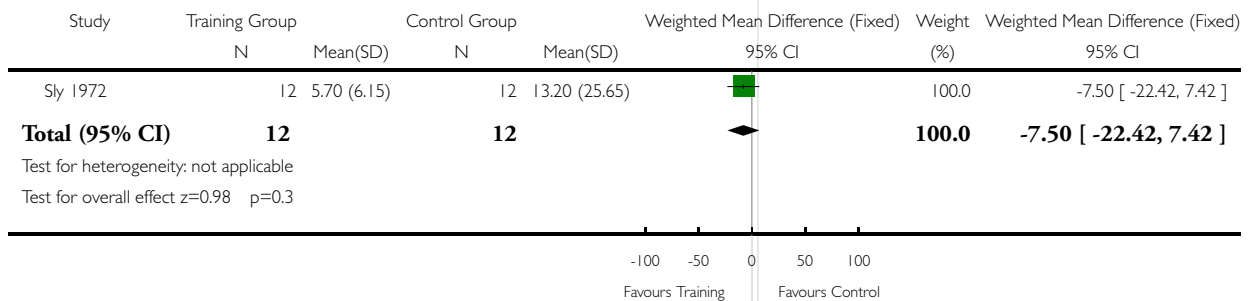


Analysis 01.07. Comparison 01 Physical Training vs Control, Outcome 07 Episodes of Wheeze (days)

Review: Physical training for asthma

Comparison: 01 Physical Training vs Control

Outcome: 07 Episodes of Wheeze (days)



Analysis 01.08. Comparison 01 Physical Training vs Control, Outcome 08 Work Capacity-W

Review: Physical training for asthma

Comparison: 01 Physical Training vs Control

Outcome: 08 Work Capacity-W

