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Water-based exercise training for chronic obstructive pulmonary disease (Review)

McNamara RJ, McKeough ZJ, McKenzie DK, Alison JA

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[Intervention Review]

Water-based exercise training for chronic obstructive pulmonary disease

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ABSTRACT

Background

Land-based exercise training improves exercise capacity and quality of life in people with chronic obstructive pulmonary disease (COPD). Water-based exercise training is an alternative mode of physical exercise training that may appeal to the older population attending pulmonary rehabilitation programmes, those who are unable to complete land-based exercise programmes and people with COPD with comorbid physical and medical conditions.

Objectives

To assess the effects of water-based exercise training in people with COPD.

Search methods

A search of the Cochrane Airways Group Specialised Register of trials, which is derived from systematic searches of bibliographic databases, including the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE, CINAHL, AMED and PsycINFO, was conducted (from inception to August 2013). Handsearching was done to identify further qualifying studies from reference lists of relevant studies.

Selection criteria

Review authors included randomised or quasi-randomised controlled trials in which water-based exercise training of at least four weeks' duration was compared with no exercise training or any other form of exercise training in people with COPD. Swimming was excluded.

Data collection and analysis

We used standard methodological procedures expected by The Cochrane Collaboration.

Main results

Five studies were included with a total of 176 participants (71 people participated in water-based exercise training and 54 in land-based exercise training; 51 completed no exercise training). All studies compared supervised water-based exercise training versus land-based exercise training and/or no exercise training in people with COPD (with average forced expiratory volume in one second (FEV_1) %predicted ranging from 39% to 62%). Sample sizes ranged from 11 to 53 participants. The exercise training programmes lasted from

four to 12 weeks, and the mean age of participants ranged from 57 to 73 years. A moderate risk of bias was due to lack of reporting of randomisation, allocation and blinding procedures in some studies, as well as small sample sizes.

Compared with no exercise, water-based exercise training improved the six-minute walk distance (mean difference (MD) 62 metres; 95% confidence interval (CI) 44 to 80 metres; three studies; 99 participants; moderate quality evidence), the incremental shuttle walk distance (MD 50 metres; 95% CI 20 to 80 metres; one study; 30 participants; high quality evidence) and the endurance shuttle walk distance (MD 371 metres; 95% CI 121 to 621 metres; one study; 30 participants; high quality evidence). Quality of life was also improved after water-based exercise training compared with no exercise (standardised mean difference (SMD) -0.97, 95% CI -0.37 to -1.57; two studies; 49 participants; low quality evidence). Compared with land-based exercise training, water-based exercise training did not significantly change the six-minute walk distance (MD 11 metres; 95% CI -11 to 33 metres; three studies; 62 participants; moderate quality evidence) or the incremental shuttle walk distance (MD 9 metres; 95% CI -15 to 34 metres; two studies; 59 participants; low quality evidence). However, the endurance shuttle walk distance improved following water-based exercise training compared with land-based exercise training (MD 313 metres; 95% CI 232 to 394 metres; two studies; 59 participants; moderate quality evidence). No significant differences were found between water-based exercise training and land-based exercise training for quality of life, as measured by the St George's Respiratory Questionnaire or by three of four domains of the Chronic Respiratory Disease Questionnaire (CRDQ); however, the fatigue domain of the CRDQ showed a statistically significant difference in favour of water-based exercise (MD -3.00; 95% CI -5.26 to -0.74; one study; 30 participants). Only one study reported long-term outcomes after water-based exercise training for quality of life and body composition, and no significant change was observed between baseline results and six-month follow-up results. One minor adverse event was reported for water-based exercise training (based on reporting from two studies; 20 participants). Impact of disease severity could not be examined because data were insufficient.

Authors' conclusions

There is limited quality evidence that water-based exercise training is safe and improves exercise capacity and quality of life in people with COPD immediately after training. There is limited quality evidence that water-based exercise training offers advantages over land-based exercise training in improving endurance exercise capacity, but we remain uncertain as to whether it leads to better quality of life. Little evidence exists examining the long-term effect of water-based exercise training.

PLAIN LANGUAGE SUMMARY

Water-based exercise training for people with chronic obstructive pulmonary disease

Question: We wanted to compare the safety and effectiveness of water-based exercise (but not swimming) training in people with chronic obstructive pulmonary disease (COPD) versus no exercise or a different kind of exercise in terms of exercise capacity and quality of life.

Background: Land-based exercise training (such as walking or cycling) improves exercise capacity and quality of life in people with COPD. Water-based exercise training is an alternative mode of physical exercise training that may appeal to the older population, those who are unable to complete land-based exercise programmes and people with COPD who also have other physical and medical conditions. We did not include swimming interventions.

Study characteristics: Five studies were identified up to August 2013. These studies included a total of 176 participants, with 71 people participating in water-based exercise training, 54 people participating in land-based exercise training and 51 people completing no exercise training. The average age of participants ranged from 57 to 73 years. The water-based exercise training programmes varied from four to 12 weeks in duration with attendance two to three times a week for between 35 and 90 minutes. The water-based exercises were designed to be as similar as possible to the exercises conducted in the land-based exercise sessions. The most common types of exercises were walking and cycling-type movements in the water, as well as strength training, most often using floats to increase the intensity.

Key results: Participants who completed a water-based exercise training programme could walk an average of 371 metres farther than those who completed no exercise training and 313 metres farther than those who completed land-based exercise training. Quality of life also improved in participants who completed water-based exercise training, and significantly better quality of life was reported in these participants compared with those who completed no exercise training. Little information was provided to show whether these effects last for a long time after training has ceased. The effect that severity of COPD may have on benefits of water-based exercise training needs further examination. Two studies reported on adverse events; one minor adverse event was documented (from 20 people participating in water-based exercise training).

Quality of the evidence: The quality of evidence contributing to these results was generally low to moderate. This was mainly a result of poor study design and not enough data.

SUMMARY OF FINDINGS FOR THE MAIN COMPARISON [Explanation]

Water-based exercise training compared with no exercise training for people with chronic obstructive pulmonary disease (COPD)

Patient or population: people with COPD
Settings: pulmonary rehabilitation centres
Intervention: water-based exercise training
Comparison: no exercise training

Outcomes	Illustrative comparative risks* (95% CI)		No. of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk			
	No exercise training	Water-based exercise training			
Exercise capacity - functional Six-minute walk test (mean distance change in metres)	Mean change in six-minute walk distance ranged across control groups from -39 metres to -16 metres	Mean change in six-minute walk distance in the intervention groups was 62 metres higher (44 metres to 80 metres higher)	99 (three)	⊕⊕⊕◯ **moderate**[1]	
Exercise capacity - peak Incremental shuttle walk test (mean distance change in metres)	Mean change in incremental shuttle walk distance in the control group was -1 metre	Mean change in incremental shuttle walk distance in the intervention group was 50 metres higher (20 metres to 80 metres higher)	30 (one)	⊕⊕⊕⊕ **high**	
Exercise capacity - endurance Endurance shuttle walk test (mean distance change in metres)	Mean change in endurance shuttle walk distance in the control group was -50 metres	Mean change in endurance shuttle walk distance in the intervention group was 371 metres higher (121 metres to 621 metres higher)	30 (one)	⊕⊕⊕⊕ **high**	

Quality of life St George's Respiratory Questionnaire (total score) Lower value post intervention is favourable, indicating improvement in QoL	Mean change in St George's Respiratory Questionnaire total score in the control group was +6 points	Mean change in St George's Respiratory Questionnaire total score in the intervention group was 10 points lower (1 point to 19 points lower)	19 (one)	⊕⊕○○ **low**[2]

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: Confidence interval.

GRADE Working Group grades of evidence.
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1]Two studies showed limitations in design; selection and performance bias unknown.
[2]Study showed limitations in design (selection and performance bias unknown).

BACKGROUND

Description of the condition

Chronic obstructive pulmonary disease (COPD) is a progressive disease state characterised by airflow limitation that is not fully reversible (McKenzie 2007). COPD is a major cause of morbidity, mortality and healthcare costs worldwide (Chapman 2006). People with COPD frequently experience breathlessness both at rest and on exertion, which limits their physical functioning and quality of life.

One of the most effective strategies for the management of COPD is land-based exercise training as part of integrated pulmonary rehabilitation. Land-based exercise training improves exercise capacity and quality of life (Lacasse 2006), and reduces admissions to hospital (Ries 2007) and length of stay (Golmohammadi 2004). However, land-based training is not always possible. COPD is prevalent in the older population (Cockram 2006), which includes a high proportion of physical co-morbidities (Fabbri 2008) that may preclude the elderly from participating in land-based training. This, combined with a high rate of non-completion of pulmonary rehabilitation programmes (Garrod 2006), means that it is important to explore alternative exercise options to enable people with COPD to complete some form of exercise training.

Description of the intervention

In the past, water-based exercise had been thought unsafe for people with COPD because of potential increases in cardiac and respiratory work as a consequence of increased venous return and increased chest wall pressure resulting from water immersion (Arborelius 1972). However, recent data have shown that a single head out of water exercise session in water can be performed safely without adverse events and with maintenance of oxygen saturation even in those with severe disease (Perk 1996). It is important to note that swimming is not considered in this review because of associated submersion of the head in water.

How the intervention might work

As a result of evidence that head out of water immersion and exercise in water are safe, water-based exercise can be considered as an alternative means of exercise training for people with COPD. It is hypothesised that when individuals complete a water-based exercise training programme of similar intensity and duration as land-based exercise training programmes that have previously been shown to be effective, exercise capacity and quality of life may improve to a similar degree. The unique properties of water, including buoyancy to support body weight and reduce mechanical impact on the body, water turbulence and resistance to increased muscle work when moving the body and limbs through the water, and warm water temperature, which may improve blood flow to muscles, may enable a higher intensity and duration of exercise, especially in people who have difficulty completing a land-based exercise training programme. These features of the water environment may mean that water-based exercise training is more suitable for people with comorbid conditions such as musculoskeletal or orthopaedic conditions.

Why it is important to do this review

Thus far, a systematic review of studies of water-based exercise training for people with COPD has not been conducted.

It is important to perform this review to evaluate the safety of water-based exercise training in people with COPD and to determine the effect of water-based training on exercise capacity and quality of life as described in the available literature.

OBJECTIVES

To assess the effects of water-based exercise training in people with COPD.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised or quasi-randomised controlled trials in which water-based exercise training of at least four weeks' duration was compared with no exercise training or any other form of exercise training in people with COPD.

Types of participants

Adults with a clinical diagnosis of COPD based on the investigators' definition. The COPD should be stable (i.e. optimal and stable respiratory medications with no exacerbation or hospital admission within the previous month), and supplemental oxygen may be used.

Types of interventions

Studies examining water-based exercise training, supervised or unsupervised, were included if they included a comparison with no exercise training, a land-based exercise training programme or a sham water-based treatment. Trials in which water-based training was combined with another training intervention (e.g. land-based

exercise training) were eligible for inclusion provided more than 50% of the training incorporated water-based exercise training. Swimming interventions were excluded.

Types of outcome measures

Primary outcomes

- Exercise capacity (functional or maximal), measured during formal exercise tests or field exercise tests.
- Quality of life, measured by generic or respiratory-specific quality of life questionnaires.

Secondary outcomes

- Pulmonary function.
- Respiratory muscle strength.
- Upper and lower limb strength.
- Oxygen saturation.
- Symptoms.
- Level of activity.
- Psychological status.
- Self management/self efficacy.
- Healthcare utilisation.
- Cost-effectiveness.
- Adverse events.
- Withdrawal.
- Body composition.
- Attendance.
- Exercise training mode preference.
- Arterial blood gases.

Search methods for identification of studies

Electronic searches

We identified trials from the Cochrane Airways Group Specialised Register of trials, which is derived from systematic searches of bibliographic databases including the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE, CINAHL, AMED and PsycINFO, and we performed handsearching of respiratory journals and meeting abstracts (please see Appendix 1 for further details).

All records added to the Specialised Register and coded as 'COPD' were searched using the following terms: water* or aqua* or bath or pool or hydrotherap* or hydro-therap* or immers*.

We also conducted a search of ClinicalTrials.gov using the same terms. All databases were searched from their inception to August 2013, and no restriction regarding language of publication was imposed.

Searching other resources

We handsearched reference lists of all relevant studies to look for additional qualifying studies. Authors of identified and potentially eligible trials were contacted and were asked to identify further published and unpublished studies.

Data collection and analysis

Selection of studies

Studies identified through the literature searches were independently coded by two review authors (RJM and ZJM) for inclusion upon examination of titles and abstracts. Studies were categorised as follows.

- Include: Study categorically meets all review criteria.
- Unclear: Study appears to meet some review criteria, but insufficient information is available to categorically determine relevance.
- Exclude: Study does not categorically meet all review criteria.

The two review authors then used a full-text copy of each study in the first two categories to determine study inclusion. Disagreements were resolved by consensus, and when any disagreement could not be resolved, we consulted a third review author (JAA). A full record of decisions was kept, and simple agreement and kappa statistics were calculated.

Data extraction and management

Two review authors (RJM and ZJM) independently extracted data using a standard checklist before the primary review author (RJM) entered them into Review Manager (RevMan), and the second review author (ZJM) conducted random checks on accuracy. Disagreements were resolved by consensus. When two or more detailed reports described findings of the same study, data were extracted separately and then collated. Data collected included characteristics of included studies (methods, participants, interventions, outcomes) and results of the included studies. We recorded the specific details of exercise training (intensity, frequency, duration, type). Authors of included studies were contacted and were asked to provide missing data.

Assessment of risk of bias in included studies

Two review authors (RJM and ZJM) independently assessed the internal validity of included studies using The Cochrane Collaboration's 'Risk of bias assessment' tool (Higgins 2011) (including randomisation sequence generation; allocation concealment; blinding of participants, assessors and outcome assessments; completeness of outcome data; selective outcome reporting and any other possible sources of bias). Each item for each study was judged

as having high, low or unclear risk of bias. Disagreements were resolved by consensus. Study authors were contacted to seek clarification in cases where quality was unclear.

Measures of treatment effect

The mean change from baseline with standard deviation (SD) for each group was recorded or calculated from available data for continuous variables. The mean difference (MD) for outcomes measured using the same measurement tool and the standardised mean difference (SMD) for outcomes measured with different measuring tools, as well as 95% confidence intervals (95% CIs), were calculated using RevMan 5.2. A pooled quantitative analysis was performed when trials were clinically homogeneous.

Unit of analysis issues

One study used a randomised cross-over trial design. Only the data from the first arm of this trial were incorporated in this review, given that a significant period of treatment interaction was found in the study. Another study used a semi-randomised design methodology whereby participants were randomly assigned to the two intervention groups, but the control (no intervention group) was not randomly assigned. Data from this non-randomised comparison control group were not used in this review.

Dealing with missing data

The original study investigators were contacted for further information when data were missing or could not be interpreted in the presented form.

Assessment of heterogeneity

Heterogeneity was assessed using the I^2 statistic to measure the proportion of variability resulting from between-trial differences.

Assessment of reporting biases

We planned to create a funnel plot to test for publication bias and small-study effects if we had been able to pool ten or more trials.

Data synthesis

A fixed-effect model was used in the analysis.

Subgroup analysis and investigation of heterogeneity

One subgroup analysis was specified a priori to explore possible sources of heterogeneity.

- Severity of lung disease: forced expiratory volume in one second (FEV_1) less than 40% predicted.

The small number of studies precluded this subgroup analysis. If in future updates, more studies are included, subgroup analysis will be performed.

Sensitivity analysis

A sensitivity analysis was not conducted because of the small number of studies. If more studies are included in future review updates, a sensitivity analysis will be performed to analyse the effects of allocation concealment and intention-to-treat analysis on results.

RESULTS

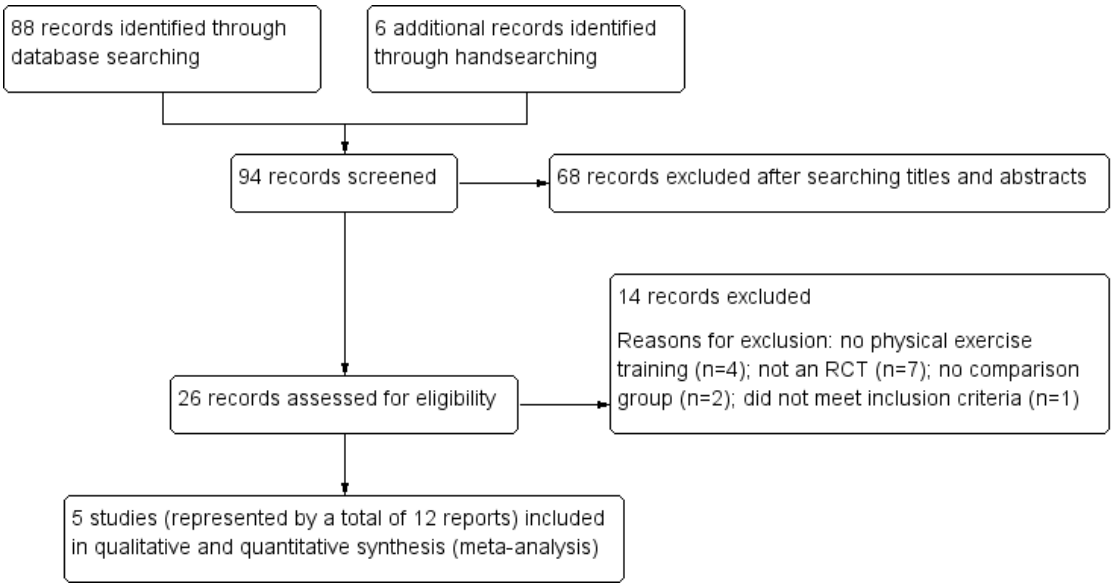
Description of studies

See Characteristics of included studies and Characteristics of excluded studies.

Results of the search

A total of 88 citations were identified by searching the databases. Six additional studies were identified upon handsearching of reference lists and completion of further searches by the review authors. From study titles and abstracts of references in this list, we identified and retrieved 26 papers for closer inspection. Study evaluation revealed that five studies (represented by a total of 12 citations) met the inclusion criteria for this review. A flow diagram of the search results is provided in Figure 1. Of the 26 studies analysed, the review authors agreed on 25 articles (96%) with kappa = 0.90, indicating excellent agreement. Disagreement was resolved by consultation with the third review author (JAA).

Figure 1. Study flow diagram.



Included studies

Five studies (a total of 176 participants) met the inclusion criteria for this review. Full details can be found in the Characteristics of included studies table. One study was published in abstract form only; however, we were able to obtain unpublished data from the trialists (O'Brien 2004). Three studies were randomised controlled trials (de Souto Araujo 2012; McNamara 2013; Ozdemir 2010), one study was a semi-randomised controlled trial (Wadell 2004) and the remaining study was a randomised cross-over trial (O'Brien 2004). Only data from the first arm of the cross-over trial and only data from the randomised intervention groups in the semi-randomised controlled trial were used in analyses. All studies compared supervised water-based exercise training versus land-based exercise training and/or no exercise training in people with COPD (average FEV_1 % predicted ranging from 39% to 62%). It is important to note that the McNamara 2013 study specifically recruited people with COPD who had concurrent physical co-morbidities such as obesity or musculoskeletal or orthopaedic conditions. Sample sizes ranged from 11 to 53 participants. The mean ages of participants ranged from 57 to 73 years. The length of the exercise training programmes varied from four to 12 weeks; programmes consisted of two to three sessions per week, and each session lasted from 35 to 90 minutes. The water-based exercise training sessions were designed to be as similar as possible to the land-based exercise training sessions (de Souto Araujo 2012; McNamara 2013; O'Brien 2004; Wadell 2004). Upper limb and/or lower limb endurance exercise training, strength training and use of weights or floats were described by all studies (for additional details, see Table 1). All studies measured exercise capacity; the test most commonly performed was the six-minute walk test (de Souto Araujo 2012; McNamara 2013; O'Brien 2004; Ozdemir 2010). Quality of life was assessed in all five studies by the Chronic Respiratory Disease Questionnaire (McNamara 2013; Ozdemir 2010) or the St George's Respiratory Questionnaire (de Souto Araujo 2012; O'Brien 2004; Wadell 2004).

Excluded studies

Fourteen studies were excluded from this review upon evaluation against the inclusion and exclusion criteria. The most common reason for exclusion of studies was that they were not randomised controlled trials (n = 11). Full details can be found in the Characteristics of excluded studies table.

Risk of bias in included studies

An overview of risk of bias is illustrated in Figure 2 and Figure 3.

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

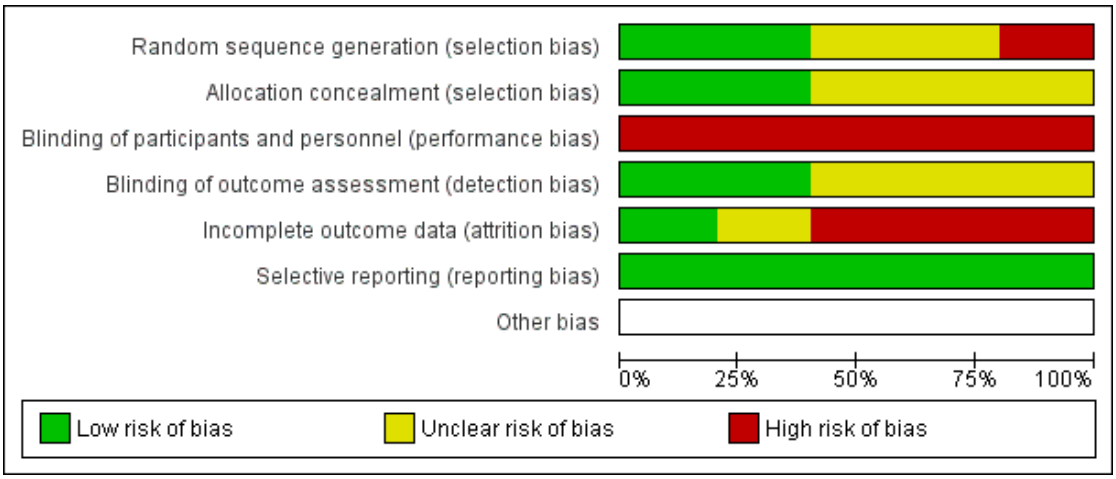
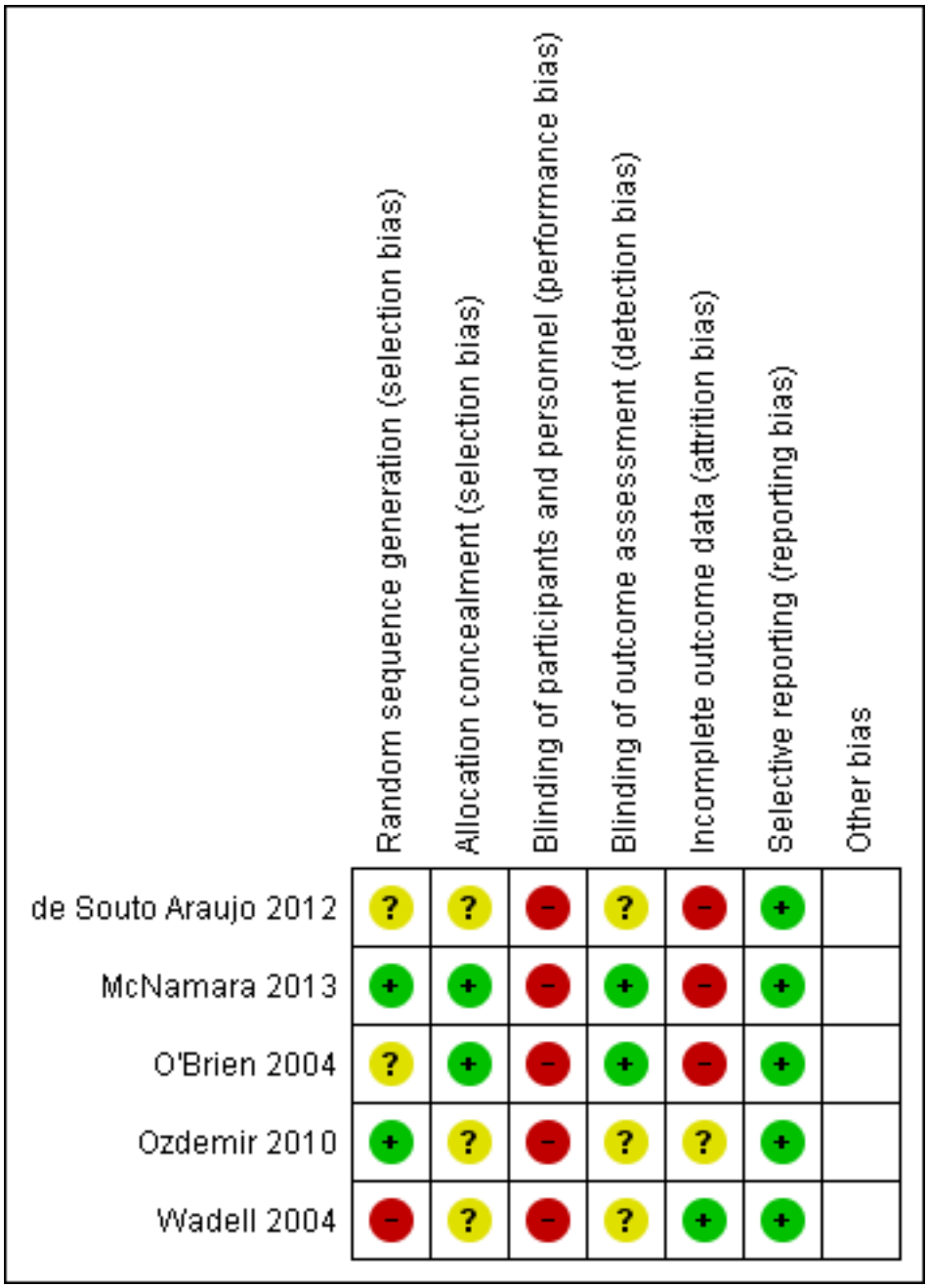


Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.



Allocation

All studies reported random allocation to groups; however, the amount of information provided was highly variable. Randomisation for sequence generation was reported by two studies (McNamara 2013; Ozdemir 2010). The remaining three studies provided insufficient information (de Souto Araujo 2012; O'Brien 2004) or did not conduct random sequence generation for the control (no exercise) group (Wadell 2004). Allocation sequence concealment with the use of sealed envelopes was reported by two studies (McNamara 2013; O'Brien 2004). Information regarding concealment of allocation sequence was insufficient in the remaining studies (de Souto Araujo 2012; Ozdemir 2010; Wadell 2004).

Blinding

Participant and personnel blinding was not possible in any of the studies because of the physical nature of the intervention. Use of a blinded assessor to measure outcomes was reported in two studies (McNamara 2013; O'Brien 2004). Adequate assessment of assessor blinding in the three remaining studies could not be determined because sufficient information was lacking.

Incomplete outcome data

Four studies reported dropouts and losses to follow-up (de Souto Araujo 2012; McNamara 2013; O'Brien 2004; Wadell 2004). The single remaining study did not report dropouts or losses to follow-up (Ozdemir 2010).

Selective reporting

All studies documented outcome measures, which were reported in the prespecified methods (see Characteristics of included studies).

Effects of interventions

See: **Summary of findings for the main comparison** Summary of findings (water exercise vs no exercise); **Summary of findings 2** Summary of findings (water exercise vs land exercise)

The Data and analyses tables summarise the results of the meta-analyses for the two comparison pairs analysed in this review: (1) water-based exercise versus no exercise; and (2) water-based exercise versus land-based exercise. Meta-analyses are presented for all of the primary outcomes and for the two comparison pairs (regardless of the number of studies providing data), and for secondary outcomes only when sufficient data were available from at least two studies. Summary of findings for the main comparison and Summary of findings 2 summarise the quality of the evidence. For exercise capacity tests and tests of pulmonary function, positive values reflect an improvement. For quality of life measurement tools, negative values reflect benefit.

Exercise capacity-functional

Four studies used the six-minute walk test to measure functional exercise capacity (de Souto Araujo 2012; McNamara 2013; O'Brien 2004; Ozdemir 2010). Results from three trials could be combined in a meta-analysis comparing water-based exercise (n = 48) versus no exercise (n = 51) (de Souto Araujo 2012; McNamara 2013; Ozdemir 2010), and results from three trials could be combined in a meta-analysis comparing water-based exercise (n = 28) versus land-based exercise (n = 34) (de Souto Araujo 2012; McNamara 2013; O'Brien 2004). When compared with no exercise, water-based exercise resulted in a mean difference change in distance walked of 62 metres (95% CI 44 to 80 metres; Figure 4). When compared with land-based exercise, water-based exercise resulted in a non-significant mean difference change in distance walked of 11 metres (95% CI -11 to 33 metres; Figure 5).

Figure 4. Forest plot of comparison: 1 Water-based exercise versus no exercise, outcome: 1.1 Exercise capacity (mean change in metres).

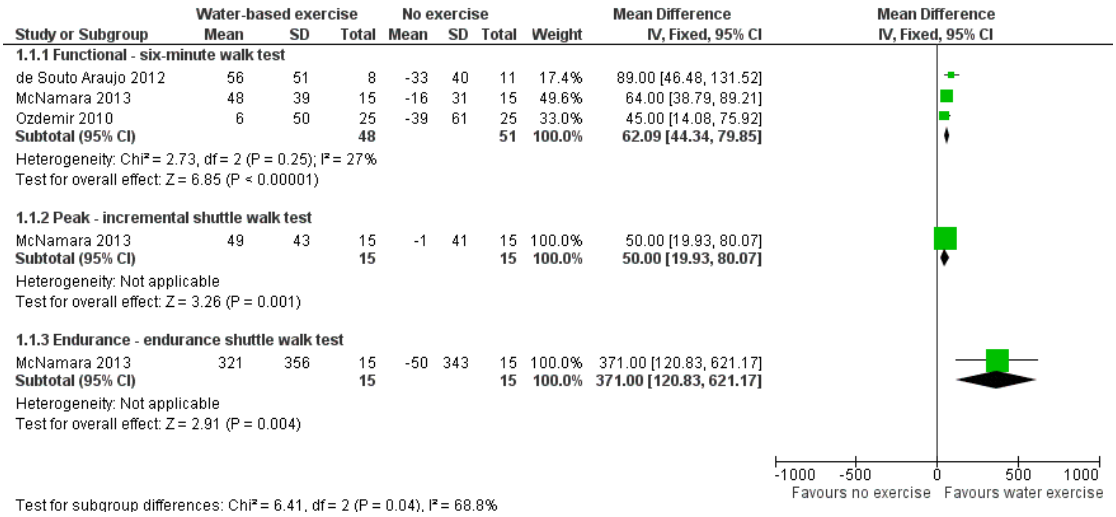
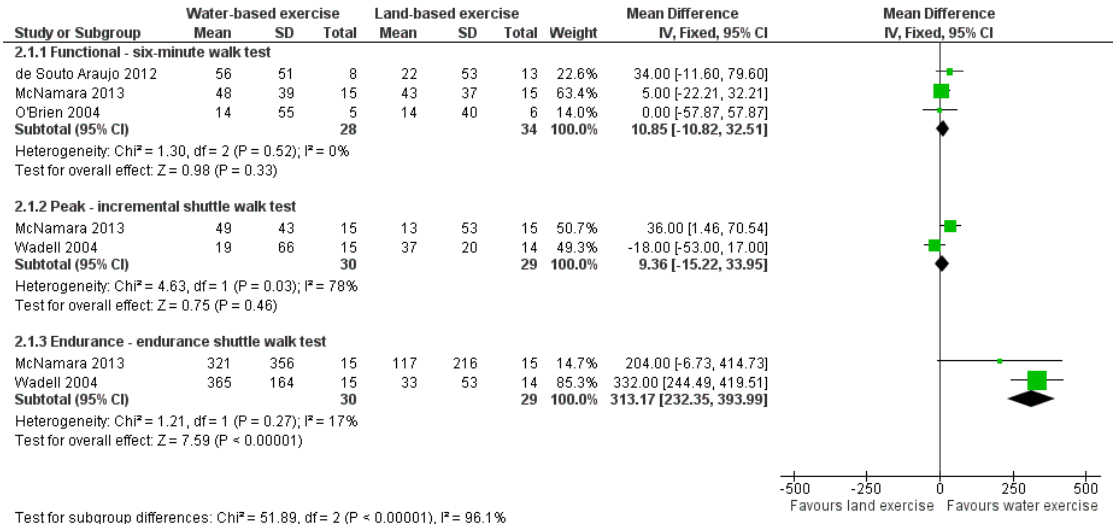


Figure 5. Forest plot of comparison: 2 Water-based exercise versus land-based exercise, outcome: 2.1 Exercise capacity (mean change in metres).



Exercise capacity-peak

Two studies used the incremental shuttle walking test (McNamara 2013; Wadell 2004). The mean difference for change in distance walked of 50 metres (95% CI 20 to 80 metres) favoured water-based exercise (one study; n = 15) over no exercise (one study; n = 15) (Figure 4). No significant difference was found between water-based exercise (two studies; n = 30) and land-based exercise (two studies; n = 29) (MD 9 metres; 95% CI -15 to 34 metres) and high statistical heterogeneity was noted (I^2 = 78%) (Figure 5).

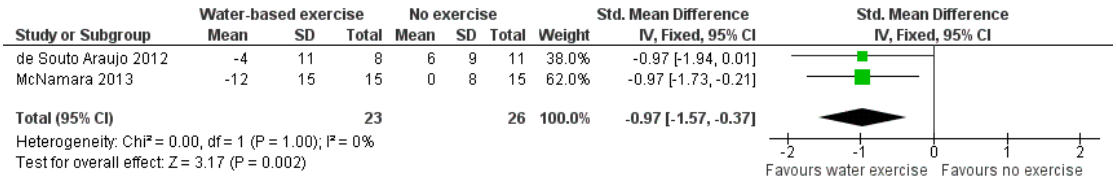
Exercise capacity-endurance

Two studies used the endurance shuttle walk test (McNamara 2013; Wadell 2004). The mean difference for change in distance walked was significant at 371 metres (95% CI 121 to 621 metres) in favour of water-based exercise (one study; n = 15) over no exercise (one study; n = 15) (Figure 4) and 313 metres (95% CI 232 to 394 metres) in favour of water-based exercise (two studies; n = 30) over land-based exercise (two studies; n = 29) (Figure 5).

Quality of life

Health-related quality of life was measured in all studies; however, insufficient data were available for all studies to enable pooling of results in a meta-analysis. The potential impact of the fact that one study (Ozdemir 2010) did not contribute data to the synthesis is most likely small. In the water-based exercise versus no exercise comparison, data could be pooled from two studies (n = 23 water-based exercise; n = 26 no exercise). The Chronic Respiratory Disease Questionnaire (CRDQ) was used by McNamara 2013, and the St George's Respiratory Questionnare (SGRQ) was used by de Souto Araujo 2012. A standardised mean difference of -0.97 (95% CI -0.37 to -1.57) favoured water-based exercise (Figure 6). In the water-based exercise versus land-based exercise comparison, data were available from three studies that used the SGRQ (de Souto Araujo 2012; O'Brien 2004; Wadell 2004) and from one study that used the CRDQ (McNamara 2013) (n = 42 water-based exercise and n = 47 land-based exercise). A standardised mean change in total scores of -0.14 (95% CI -0.57 to 0.28; Analysis 2.2) indicated no significant difference in total quality of life. Moderate to substantial heterogeneity was noted (I^2 = 53%). No significant differences between groups were reported for three of three domains of the SGRQ and for three of four domains of the CRDQ; however the fatigue domain of the CRDQ showed a statistically significant difference in favour of water-based exercise (MD -3.00, 95% CI -5.26 to -0.74; Analysis 2.3).

Figure 6. Forest plot of comparison: 1 Water-based exercise versus no exercise, outcome: 1.2 Quality of life (mean change in total scores).



Pulmonary function

In the comparison of water-based exercise versus no exercise, a mean difference change of 6.3% (95% CI 3.4 to 9.2) for FEV_1 % predicted favoured water-based exercise when the results of two studies were combined (de Souto Araujo 2012; McNamara 2013) (n = 23 water-based exercise; n = 26 no exercise). A weighted mean difference change of 3.8% (95% CI 0.3 to 7.4) for FVC % predicted was also found to favour water-based exercise when the results of three studies were combined (de Souto Araujo 2012; McNamara 2013; Ozdemir 2010) (n = 48 water-based exercise; n = 51 no exercise). No statistically significant effects on pulmonary function were found when water-based exercise was compared with land-based exercise.

Respiratory muscle strength

Two studies reported measures of respiratory muscle strength (de Souto Araujo 2012; McNamara 2013). All measures of respiratory muscle strength were seen to improve significantly when water-based exercise (n = 23) was compared with no exercise (n = 26); however significant heterogeneity was noted between the studies. The mean difference change for maximal inspiratory pressure was 14 cm H_2O (95% CI 5 to 22) and 20% predicted (95% CI 9 to 30) in favour of water-based exercise. Maximal expiratory pressure also improved significantly after water-based exercise (mean difference change of 14 cm H_2O, 95% CI 5 to 23; 15% predicted, 95% CI 5 to 26). No statistically significant effects on respiratory muscle strength were found when water-based exercise (n = 23) was compared with land-based exercise (n = 28).

Adverse events

Two studies provided information regarding adverse events (McNamara 2013; O'Brien 2004) upon completion of water-based

exercise (n = 20). No adverse events were reported in the study by O'Brien 2004. One minor adverse event (an accidental skin tear from a fingernail scratch during the session in a water-based exercise group participant) was reported in the study by McNamara 2013.

Body composition

Measurement of body weight (kg) was reported by two studies (McNamara 2013; Wadell 2004). Upon completion of water-based exercise (n = 30), participants had a mean weight loss of 1.29 kg (95% CI -2.65 to 0.07) compared with land-based exercise (n = 29). This mean weight loss did not reach statistical significance.

Attendance

Exercise session attendance was reported by two studies (McNamara 2013; O'Brien 2004). No significant difference was observed in the number of exercise sessions attended between water-based exercise training and land-based exercise training (SMD 0.44, 95% CI -0.18 to 1.07).

Preference

Two studies examined participants' preferences for the exercise training environment upon completion of the training study period (McNamara 2013; O'Brien 2004). Of 41 participants who completed exercise training (i.e. water-based or land-based training), 49% (n = 20) reported that they would prefer exercise training in water, and 37% (n = 15) reported their preference for exercise training on land. Fifteen percent (n = 6) reported no preference for either environment for exercise training.

Long-term effects

One study reported long-term effects of water-based exercise training six months after completion of a 12-week training programme (Wadell 2004). For outcome measures for which data were reported (quality of life and body composition), no significant change was observed between baseline results and results obtained six months post water-based exercise training.

ADDITIONAL SUMMARY OF FINDINGS [Explanation]

Water-based exercise training compared with land-based exercise training for people with chronic obstructive pulmonary disease (COPD)

Patient or population: people with COPD
Settings: pulmonary rehabilitation centres
Intervention: water-based exercise training
Comparison: land-based exercise training

Outcomes	Illustrative comparative risks* (95% CI)		No. of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk			
	Land-based exercise training	Water-based exercise training			
Exercise capacity - functional Six-minute walk test (mean distance change in metres)	Mean change in six-minute walk distance ranged across control groups from 14 metres to 43 metres	Mean change in six-minute walk distance in the intervention groups was 11 metres higher (11 metres lower to 33 metres higher)	62 (three)	⊕⊕⊕◯ **moderate**[1]	
Exercise capacity - peak Incremental shuttle walk test (mean distance change in metres)	Mean change in incremental shuttle walk distance ranged across control groups from 13 metres to 37 metres	Mean change in incremental shuttle walk distance in the intervention groups was nine metres higher (15 metres lower to 34 metres higher)	59 (two)	⊕⊕◯◯ **low**[2]	
Exercise capacity - endurance Endurance shuttle walk test (mean distance change in metres)	Mean change in endurance shuttle walk distance ranged across control groups from 33 metres to 117 metres	Mean change in endurance shuttle walk distance in the intervention groups was 313 metres higher (232 metres to 394 metres higher)	59 (two)	⊕⊕⊕◯ **moderate**[2]	

Quality of life St George's Respiratory Questionnaire (SGRQ; total score) Lower value post intervention is favourable, indicating improvement in QoL	Mean change in SGRQ total score ranged across control groups from -1 points to -16 points	Mean change in SGRQ total score in the intervention groups was 0.3 points higher (4 points lower to 5 points higher)	60 (three)	⊕⊕◯◯ **low**[3]
Body composition Weight (mean change in kilograms)	Mean change in body weight ranged across control groups from -0.2 kilograms to +1.3 kilograms	The mean change in body weight in the intervention groups was 1.3 kilograms lower (2.7 kilograms lower to 0.1 kilograms higher)	59 (two)	⊕⊕⊕◯ **moderate**[2]

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: Confidence interval.

GRADE Working Group grades of evidence.
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1]Two studies showed limitations in design; selection and performance bias unknown in two studies and one study, respectively.
[2]One study had selection bias.
[3]All studies showed limitations in design; selection bias present in one study and unknown in two remaining studies; performance and detection bias unknown in all three studies.

DISCUSSION

Summary of main results

Five studies comparing water-based exercise training versus no exercise or land-based exercise training in people with COPD were identified for this review. Water exercise resulted in significant improvement in functional exercise capacity, peak exercise capacity, endurance exercise capacity and health-related quality of life when compared with no exercise. When compared with land exercise, water exercise elicited significantly greater improvement in endurance exercise capacity. To date, data are insufficient for conclusions to be drawn regarding the long-term effects of water-based exercise training in COPD.

Overall completeness and applicability of evidence

Significant mean improvements in functional, peak and endurance exercise capacity following water exercise compared with no exercise and in endurance exercise capacity following water-based exercise compared with land-based exercise surpassed the minimum clinically important differences (MCIDs) that have been reported in the literature. The mean improvement in the six-minute walk test of 62 metres compared with no exercise is greater than any of the previously recorded MCIDs of 25 metres (Holland 2010), 35 metres (Puhan 2008) and 54 metres (Redelmeier 1997) in people with COPD. The 50 metres mean improvement in incremental shuttle walk distance when water-based exercise training was compared with no exercise is greater than the 47.5 metres MCID reported by Singh 2008. Finally, improvement of 371 metres and 313 metres in the endurance shuttle walk test compared with no exercise and land exercise, respectively, clearly exceeded the MCID of 60 to 115 metres (Pepin 2011). The reason for the greater response in endurance walking capacity following water exercise is unclear; however, it is likely that a greater training stimulus is delivered in the water environment, where every motion in every direction of movement is resisted by the hydrostatic pressure of the water and the effect of water turbulence (Becker 2009). This greater endurance capacity may be better reflected in an endurance exercise test such as the endurance shuttle walk test rather than the six-minute walk test or the incremental shuttle walk test, in which the participant would have to walk faster rather than longer to demonstrate improvement.

Several components of health-related quality of life significantly improved upon completion of water-based exercise training compared with no exercise training. Significant changes were recorded by one study using the CRDQ (for total score, dyspnoea and fatigue subscores) (McNamara 2013) and by another study using the SGRQ (including total score and impact subscore) (de Souto Araujo 2012). However, no significant change in CRDQ emotional function and mastery subscores or in SGRQ symptom and activity subscores were found. When water-based exercise training was compared with land-based exercise training, the only significant change in quality of life favouring water-based exercise was seen in the CRDQ fatigue subscore. But this conclusion is based on the findings of only one study (McNamara 2013). It is important to note that most of the studies included in this review did not state their primary outcome measure, and only two studies calculated appropriate sample sizes, which were based on an exercise capacity outcome - not on quality of life (McNamara 2013; Wadell 2004). Therefore, based on the information provided, none of the studies in this review were adequately powered to determine a significant change in quality of life outcomes. Future studies will require sufficient sample sizes so it can be adequately determined whether water-based exercise training changes quality of life.

The studies in this review included COPD participants with an average FEV_1 % predicted ranging from 39% (de Souto Araujo 2012) to 62% (McNamara 2013). This classifies the participants as Global Initiative for Chronic Obstructive Lung Disease (GOLD) stage II (moderate) and III (severe); thus the results of this review may not apply to people with COPD GOLD stage I (mild) or IV (very severe). Furthermore, it should be noted that recruitment of participants for the McNamara 2013 study specifically targeted people with COPD with physical comorbid conditions that limited their ability to exercise on land (such as obesity, musculoskeletal conditions of the lumbar spine and lower limbs and orthopaedic conditions such as joint replacements with limited range of motion). Because of heavy weighting of this study in many of the meta-analyses, the overall results of this review are heavily influenced by this subgroup of people with COPD with physical comorbid conditions who may respond better to water-based exercise training because of the treatment effect of their physical comorbidity in the water environment.

Based on data from two studies (n = 20; GOLD stage II), water-based exercise was found to be safe for people with COPD, with only one minor adverse event reported. Future studies should report adverse events to further confirm the safety of water-based exercise training.

All studies in this review prescribed for both exercise training groups endurance exercise training or a combination of endurance and strength exercise training. The four studies that included comparisons of water-based exercise versus land-based exercise prescribed the water-based exercise training programme to match as closely as possible the land-based exercise training programme by using similar intensity, frequency and muscle groups trained (de Souto Araujo 2012; McNamara 2013; O'Brien 2004; Wadell 2004). This methodological feature gives assurance that the water exercise programmes adhered as closely as possible to current guidelines regarding exercise prescription in pulmonary rehabilitation (Nici 2006), especially given the difference in exercise training mediums.

Quality of the evidence

The quality of evidence for the primary outcomes in this review ranged from low to moderate. Interpretation of the findings of this review should be considered carefully because of potential sources of bias, especially the small sample size of each study. Lack of adequate randomisation in one study and unreported or poor random sequence generation, allocation concealment and blinding of outcome assessors are significant limitations.

Potential biases in the review process

Although the authors of all included studies were contacted to provide additional information and results, some information was not supplied, and this limited the data that could be included in some meta-analyses.

Agreements and disagreements with other studies or reviews

One previous review has examined the effect of water-based exercise training in people with COPD (McNamara 2011); however only one study was identified and reviewed. The inclusion of five studies in this current review (including the study previously examined in McNamara 2011) is a major strength.

AUTHORS' CONCLUSIONS

Implications for practice

There is limited quality evidence that water-based exercise training is safe for people with COPD (GOLD stage II) and improves exercise capacity and health-related quality of life immediately following training for people with COPD GOLD stage II and III when compared with no training. There is limited quality evidence that water-based exercise training offers advantages over land-based exercise training in improving endurance exercise capacity, but we remain uncertain as to whether it leads to better quality of life. It is, therefore, appropriate to offer people with GOLD stage II and III COPD a water-based exercise training programme, especially when they have concurrent physical co-morbidities, or when the alternative is no exercise training.

Implications for research

More high-quality randomised controlled trials are required to further confirm exercise capacity and health-related quality of life outcomes following water-based exercise training in people with COPD. In particular, larger studies need to be conducted to determine whether disease severity affects the benefits of water-based exercise training and whether water exercise results in long-term effects. Study methodology in future trials needs to be rigorous with adequate sample sizes, randomisation, allocation concealment and blinding of outcome assessors, and this information must be reported in publications.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

de Souto Araujo 2012

Methods	Randomised controlled trial
Participants	COPD, n = 32 Land-based exercise training, n = 13, eight male, age mean (SD) 57 (8) years, FEV_1 39 (11) % predicted Water-based exercise training, n = 8, four male, age mean (SD) 62 (10) years, FEV_1 44 (10) % predicted No exercise training, n = 11, eight male, age mean (SD) 71 (10) years, FEV_1 45 (13) % predicted
Interventions	Land-based exercise training: eight-week exercise programme, three times a week, 90 minutes, consisting of continuous exercise for upper and lower limbs (callisthenic activities with the respiratory cycle) for 15 minutes without weights; unsupported upper limb exercises using weights (initial weight 50% of maximum load and increased weekly) and diagonal movements for two minutes with equal rest periods; lower limb cycling for 30 minutes (intensity determined by Borg dyspnoea and perceived effort score of 5); 15 minutes of cool-down exercise for muscle groups used during the session Water-based exercise training: eight-week exercise programme, three times a week, 90 minutes, consisting of continuous warm-up exercises for upper and lower limbs (callisthenic activities with the respiratory cycle) for 15 minutes without weights; unsupported upper limb exercises using two diagonal movements and weights for two minutes with an equal rest period (initial weight 50% of maximum load and increased weekly); lower limb training using floats positioned between the legs and performing bicycling movements for 30 minutes (intensity determined by Borg dyspnoea and perceived effort score of 5); 15 minutes of cool-down exercise for muscle groups used during the session No exercise training: no exercise training
Outcomes	Spirometry Respiratory muscle strength Six-minute walk test BODE (body mass, airway obstruction, dyspnoea, exercise capacity) index St George's Respiratory Questionnaire All measured before and after intervention period
Notes	

Risk of bias ***Risk of bias***

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Insufficient information provided; 'randomly assigned'
Allocation concealment (selection bias)	Unclear risk	Not specified

de Souto Araujo 2012 (*Continued*)

Blinding of participants and personnel (performance bias) All outcomes	High risk	Not possible to blind participants or personnel because of the physical nature of the intervention
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not specified
Incomplete outcome data (attrition bias) All outcomes	High risk	Ten dropouts with no reporting of data
Selective reporting (reporting bias)	Low risk	Study protocol documented in methods and prespecified outcomes reported in prespecified methods

McNamara 2013

Methods	Randomised controlled trial
Participants	COPD with physical comorbid conditions, n = 53 Land-based exercise training, n = 20, 10 male, age mean (SD) 73 (7) years, FEV_1 62 (15) % predicted Water-based exercise training, n = 18, five male, age mean (SD) 72 (10) years, FEV_1 60 (10) % predicted No exercise training, n = 15, seven male, age mean (SD) 70 (9) years, FEV_1 55 (20) % predicted
Interventions	Land-based exercise training: eight-week outpatient exercise programme, three times a week, 60 minutes, supervised sessions consisting of upper limb endurance exercise and lower limb endurance exercise (walking and cycling) in a gym with initial intensity at 80% of walking speed on initial six-minute walk test either over-ground or on a treadmill, and progressed to maintain an intensity rating of three to five on the modified category ratio 0 to 10 dyspnoea and rating of perceived exertion scales Water-based exercise training: eight-week outpatient exercise programme, three times a week, 60 minutes, supervised sessions consisting of exercises in hydrotherapy pool matched as closely as possible for intensity, duration and muscle groups trained to the land-based training exercises, and progressed by increasing water turbulence, speed and range of motion (specific exercise programme detailed in main publication) No exercise training: usual medical care, no exercise training, requested not to alter exercise level over study period
Outcomes	Spirometry Respiratory muscle strength Six-minute walk test Incremental shuttle walk test Endurance shuttle walk test Chronic Respiratory Disease Questionnaire Hospital Anxiety and Depression Scale All measured before and after intervention period

Notes	Supported by the Physiotherapy Research Foundation

Risk of bias ***Risk of bias***

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Computer-generated random number sequence
Allocation concealment (selection bias)	Low risk	Sequentially numbered, opaque, sealed envelopes
Blinding of participants and personnel (performance bias) All outcomes	High risk	Not possible to blind participants or personnel because of the physical nature of the intervention
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Data collected by investigator blinded to treatment allocation
Incomplete outcome data (attrition bias) All outcomes	High risk	No missing outcome data for participants who completed the study; information about participants withdrawing from the study provided but not included in intention-to-treat analysis
Selective reporting (reporting bias)	Low risk	Study protocol documented in methods and prespecified outcomes reported in prespecified methods

O'Brien 2004

Methods	Randomised cross-over trial
Participants	COPD, n = 11 Land followed by water training, n = 6, four male, age mean (SD) 63 (23) years, FEV_1 61 (18) % predicted Water followed by land training, n = 5, four male, age mean (SD) 71 (11) years, FEV_1 58 (32) % predicted
Interventions	Land-based exercise training: six weeks, twice a week, 45 minutes, supervised in gym, including warm-up of walking and stretches, aerobic training and strength and resistance training using free weights, at an intensity of three to four on the modified Borg rating of perceived exertion scale Water-based exercise training: six weeks, twice a week, 45 minutes, supervised in hydrotherapy pool using similar muscle groups to ensure standardisation to land-based exercise programme and using properties of water to provide resistance, at an intensity of three to four on the modified Borg rating of perceived exertion scale Both groups were also encouraged to complete a 20-minute home walking programme twice per week with distance calculated at 80% of the average speed of the baseline six-minute walk test

O'Brien 2004 (*Continued*)

Outcomes	Spirometry Six-minute walk test St George's Respiratory Questionnaire All measured before and after each six-week intervention period
Notes	Abstract: full text copy of thesis was obtained Only data from the first arm of the cross-over trial were used

Risk of bias ***Risk of bias***

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Insufficient information provided 'Subjects were randomly assigned into two groups'
Allocation concealment (selection bias)	Low risk	'Randomisation was conducted via the sealed envelope method, with envelopes created previously, by investigators other than the principal, who was blinded to the randomisation process'
Blinding of participants and personnel (performance bias) All outcomes	High risk	Not possible to blind participants or personnel because of the physical nature of the intervention
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Data collected by investigator blinded to treatment allocation
Incomplete outcome data (attrition bias) All outcomes	High risk	One dropout with no reporting of data
Selective reporting (reporting bias)	Low risk	Study protocol documented in methods and prespecified outcomes reported in prespecified methods

Ozdemir 2010

Methods	Randomised controlled trial
Participants	COPD, n = 50 Water-based exercise training, n = 25, all male, age mean (SD) 61 (9) years, FEV_1 55 (16) % predicted No exercise training, n = 25, all male, age mean (SD) 64 (9) years, FEV_1 54 (20) % predicted
Interventions	Water-based exercise training: four weeks, three times a week, 35 minutes, supervised in an aquatic centre with a warm-up, stretches and strengthening exercises for shoulder girdle and upper extremity muscles utilising floatation devices for resistance No exercise training: medical therapy only

Ozdemir 2010 (*Continued*)

Outcomes	Spirometry Arterial blood gases Six-minute walk test Chronic Respiratory Disease Questionnaire Hospital Anxiety and Depression Scale All measured before and after intervention period
Notes	

Risk of bias ***Risk of bias***

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Randomly assigned according to table of random numbers
Allocation concealment (selection bias)	Unclear risk	Not specified
Blinding of participants and personnel (performance bias) All outcomes	High risk	Not possible to blind participants or personnel because of the physical nature of the intervention
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not specified
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Not specified
Selective reporting (reporting bias)	Low risk	Study protocol documented in methods and prespecified outcomes reported in prespecified methods

Wadell 2004

Methods	Semi-randomised controlled trial
Participants	COPD, n = 43 Land-based exercise training, n = 15, five male, age mean (SD) 65 (7) years, FEV_1 53 (12) % predicted Water-based exercise training, n = 15, four male, age mean (SD) 65 (4) years, FEV_1 56 (11) % predicted No exercise training, n = 13, seven male, age mean (SD) 63 (7) years, FEV_1 49 (12) % predicted
Interventions	Land-based exercise training: 12 week outpatient group programme, three times a week, 45 minutes, supervised, intensity guided by music to achieve a mean heart rate of 80% to 100% of peak heart rate according to maximal cycle ergometer test and a Borg dyspnoea score of 5 and rating of perceived exertion score of 15, including warm-up and flexibility

Wadell 2004 (*Continued*)

	exercises, followed by four minutes of endurance exercises and three minutes of strength exercises (repeated three times while focusing on the legs, arms and torso each time) and finally flexibility, stretching and cool-down exercises Water-based exercise training: as per land-based exercise training but in water No exercise training: no intervention
Outcomes	Spirometry Incremental shuttle walk test Endurance shuttle walk test Incremental cycle ergometer test St George's Respiratory Questionnaire Short Form-36 questionnaire All measured before and after intervention period
Notes	Supported by the Swedish Heart and Lung Foundation, the National Patient Federation for Heart and Lung Diseases in Sweden and the Swedish Vardal Foundation Data from the control group were not used because of the non-randomised nature of the group

Risk of bias ***Risk of bias***

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Randomly assigned on the basis of distance living away from study location
Allocation concealment (selection bias)	Unclear risk	Not specified
Blinding of participants and personnel (performance bias) All outcomes	High risk	Not possible to blind participants or personnel because of the physical nature of the intervention
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	Intention-to-treat analysis
Selective reporting (reporting bias)	Low risk	Study protocol documented in methods and prespecified outcomes reported in prespecified methods

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Kurabayashi 1997	Not a randomised controlled trial; no physical exercise training
Kurabayashi 1998	Not a randomised controlled trial; no physical exercise training
Kurabayashi 2000	No physical exercise training
Kurabyashi 1997	Not a randomised controlled trial; no physical exercise training
Lopez Varela 2006	Abstract; randomisation not stated; author of study did not respond to review author's request for clarification; no full text published
Lopez Varela 2008	Water-based exercise training combined with land-based exercise training in 50:50 ratio (i.e. water-based exercise training not greater than 50%)
Lotshaw 2001	Not a randomised controlled trial
Lotshaw 2002	Not a randomised controlled trial
Lotshaw 2003	Not a randomised controlled trial
Lotshaw 2007	Not a randomised controlled trial
Millard 1999	Not a randomised controlled trial
Mitsunobu 2004	Not a randomised controlled trial
Perk 1996	Not a randomised controlled trial
Rae 2009	Not a randomised controlled trial

DATA AND ANALYSES

Comparison 1. Water-based exercise versus no exercise

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Exercise capacity (mean change in metres)	3		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
1.1 Functional - six-minute walk test	3	99	Mean Difference (IV, Fixed, 95% CI)	62.09 [44.34, 79.85]
1.2 Peak - incremental shuttle walk test	1	30	Mean Difference (IV, Fixed, 95% CI)	50.0 [19.93, 80.07]
1.3 Endurance - endurance shuttle walk test	1	30	Mean Difference (IV, Fixed, 95% CI)	371.0 [120.83, 621.17]
2 Quality of life (mean change in total scores)	2	49	Std. Mean Difference (IV, Fixed, 95% CI)	-0.97 [-1.57, -0.37]
3 Quality of life (mean change in individual domain scores)	2		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
3.1 Chronic Respiratory Disease Questionnaire - total score	1	30	Mean Difference (IV, Fixed, 95% CI)	-10.00 [-20.60, -3.40]
3.2 Chronic Respiratory Disease Questionnaire - dyspnoea score	1	30	Mean Difference (IV, Fixed, 95% CI)	-3.0 [-5.73, -0.27]
3.3 Chronic Respiratory Disease Questionnaire - emotional function score	1	30	Mean Difference (IV, Fixed, 95% CI)	-2.0 [-5.24, 1.24]
3.4 Chronic Respiratory Disease Questionnaire - fatigue score	1	30	Mean Difference (IV, Fixed, 95% CI)	-5.0 [-7.53, -2.47]
3.5 Chronic Respiratory Disease Questionnaire - mastery score	1	30	Mean Difference (IV, Fixed, 95% CI)	-2.0 [-4.26, 0.26]
3.6 St George's Respiratory Questionnaire - total score	1	19	Mean Difference (IV, Fixed, 95% CI)	-10.0 [-19.29, -0.71]
3.7 St George's Respiratory Questionnaire - symptom score	1	19	Mean Difference (IV, Fixed, 95% CI)	2.0 [-13.49, 17.49]
3.8 St George's Respiratory Questionnaire - activity score	1	19	Mean Difference (IV, Fixed, 95% CI)	-13.00 [-26.18, 0.18]
3.9 St George's Respiratory Questionnaire - impact score	1	19	Mean Difference (IV, Fixed, 95% CI)	-13.0 [-21.59, -4.41]
4 Pulmonary function (mean change)	3		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
4.1 FEV_1 (% predicted)	2	49	Mean Difference (IV, Fixed, 95% CI)	6.32 [3.43, 9.22]
4.2 FVC (% predicted)	3	99	Mean Difference (IV, Fixed, 95% CI)	3.82 [0.25, 7.39]
4.3 FEV_1/FVC ratio (%)	3	99	Mean Difference (IV, Fixed, 95% CI)	2.79 [-0.74, 6.33]
5 Respiratory muscle strength (mean change)	2		Mean Difference (IV, Fixed, 95% CI)	Subtotals only

5.1 MIP (cm H_2O)	2	49	Mean Difference (IV, Fixed, 95% CI)	13.83 [5.30, 22.35]
5.2 MIP (% predicted)	2	49	Mean Difference (IV, Fixed, 95% CI)	19.80 [9.36, 30.24]
5.3 MEP (cm H_2O)	2	49	Mean Difference (IV, Fixed, 95% CI)	14.25 [5.23, 23.27]
5.4 MEP (% predicted)	2	49	Mean Difference (IV, Fixed, 95% CI)	15.22 [4.85, 25.59]

Comparison 2. Water-based exercise versus land-based exercise

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Exercise capacity (mean change in metres)	4		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
1.1 Functional - six-minute walk test	3	62	Mean Difference (IV, Fixed, 95% CI)	10.85 [-10.82, 32.51]
1.2 Peak - incremental shuttle walk test	2	59	Mean Difference (IV, Fixed, 95% CI)	9.36 [-15.22, 33.95]
1.3 Endurance - endurance shuttle walk test	2	59	Mean Difference (IV, Fixed, 95% CI)	313.17 [232.35, 393.99]
2 Quality of life (mean change in total scores)	4	89	Std. Mean Difference (IV, Fixed, 95% CI)	-0.15 [-0.58, 0.28]
3 Quality of life (mean change in individual domain scores)	4		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
3.1 Chronic Respiratory Disease Questionnaire - total score	1	30	Mean Difference (IV, Fixed, 95% CI)	-8.0 [-16.38, 0.38]
3.2 Chronic Respiratory Disease Questionnaire - dyspnoea score	1	30	Mean Difference (IV, Fixed, 95% CI)	-2.0 [-4.73, 0.73]
3.3 Chronic Respiratory Disease Questionnaire - emotional function score	1	30	Mean Difference (IV, Fixed, 95% CI)	-2.0 [-5.24, 1.24]
3.4 Chronic Respiratory Disease Questionnaire - fatigue score	1	30	Mean Difference (IV, Fixed, 95% CI)	-3.0 [-5.26, -0.74]
3.5 Chronic Respiratory Disease Questionnaire - mastery score	1	30	Mean Difference (IV, Fixed, 95% CI)	-1.0 [-3.26, 1.26]
3.6 St George's Respiratory Questionnaire - total score	3	60	Mean Difference (IV, Fixed, 95% CI)	0.31 [-4.14, 4.75]
3.7 St George's Respiratory Questionnaire - symptom score	3	59	Mean Difference (IV, Fixed, 95% CI)	7.84 [-3.06, 18.74]
3.8 St George's Respiratory Questionnaire - activity score	3	59	Mean Difference (IV, Fixed, 95% CI)	-2.82 [-7.67, 2.04]
3.9 St George's Respiratory Questionnaire - impact score	3	59	Mean Difference (IV, Fixed, 95% CI)	-0.49 [-4.44, 3.45]
4 Pulmonary function (mean change)	3		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
4.1 FEV_1 (litres)	2	41	Mean Difference (IV, Fixed, 95% CI)	0.08 [-0.04, 0.19]
4.2 FEV_1 (% predicted)	3	62	Mean Difference (IV, Fixed, 95% CI)	0.21 [-2.88, 3.31]

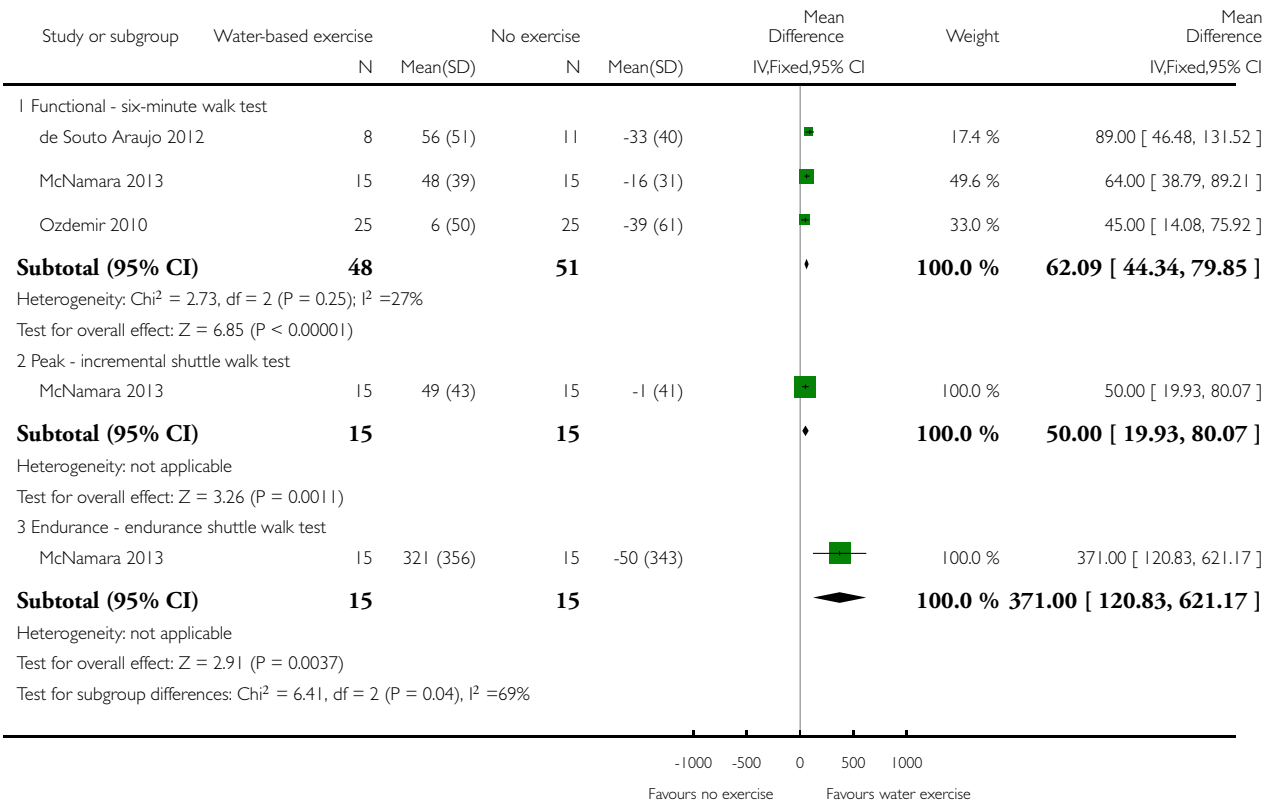
4.3 FVC (litres)	2	41	Mean Difference (IV, Fixed, 95% CI)	0.12 [-0.04, 0.28]
4.4 FVC (% predicted)	2	51	Mean Difference (IV, Fixed, 95% CI)	2.89 [-4.24, 10.02]
4.5 FEV_1/FVC ratio (%)	3	62	Mean Difference (IV, Fixed, 95% CI)	2.22 [-1.89, 6.34]
5 Respiratory muscle strength (mean change)	2		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
5.1 MIP (cm H_2O)	2	51	Mean Difference (IV, Fixed, 95% CI)	0.06 [-7.21, 7.34]
5.2 MIP (% predicted)	2	51	Mean Difference (IV, Fixed, 95% CI)	3.40 [-5.77, 12.58]
5.3 MEP (cm H_2O)	2	51	Mean Difference (IV, Fixed, 95% CI)	-6.80 [-16.42, 2.83]
5.4 MEP (% predicted)	2	51	Mean Difference (IV, Fixed, 95% CI)	-3.88 [-13.88, 6.12]
6 Body composition (mean change in kilograms)	2	59	Mean Difference (IV, Fixed, 95% CI)	-1.29 [-2.65, 0.07]
7 Attendance (mean number)	2		Std. Mean Difference (IV, Fixed, 95% CI)	Subtotals only
7.1 Attendance at supervised exercise sessions	2	41	Std. Mean Difference (IV, Fixed, 95% CI)	0.44 [-0.18, 1.07]

Analysis 1.1. Comparison 1 Water-based exercise versus no exercise, Outcome 1 Exercise capacity (mean change in metres).

Review: Water-based exercise training for chronic obstructive pulmonary disease

Comparison: 1 Water-based exercise versus no exercise

Outcome: 1 Exercise capacity (mean change in metres)



Analysis 1.2. Comparison 1 Water-based exercise versus no exercise, Outcome 2 Quality of life (mean change in total scores).

Review: Water-based exercise training for chronic obstructive pulmonary disease

Comparison: 1 Water-based exercise versus no exercise

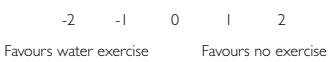
Outcome: 2 Quality of life (mean change in total scores)

Study or subgroup	Water-based exercise		No exercise		Std. Mean Difference	Weight	Std. Mean Difference
	N	Mean(SD)	N	Mean(SD)	IV,Fixed,95% CI		IV,Fixed,95% CI
de Souto Araujo 2012	8	-4 (11)	11	6 (9)		38.0 %	-0.97 [-1.94, 0.01]
McNamara 2013	15	-12 (15)	15	0 (8)		62.0 %	-0.97 [-1.73, -0.21]
Total (95% CI)	**23**		**26**			**100.0 %**	**-0.97 [-1.57, -0.37]**

Heterogeneity: $Chi^2 = 0.00$, df = 1 (P = 1.00); $I^2 = 0.0\%$

Test for overall effect: Z = 3.17 (P = 0.0015)

Test for subgroup differences: Not applicable

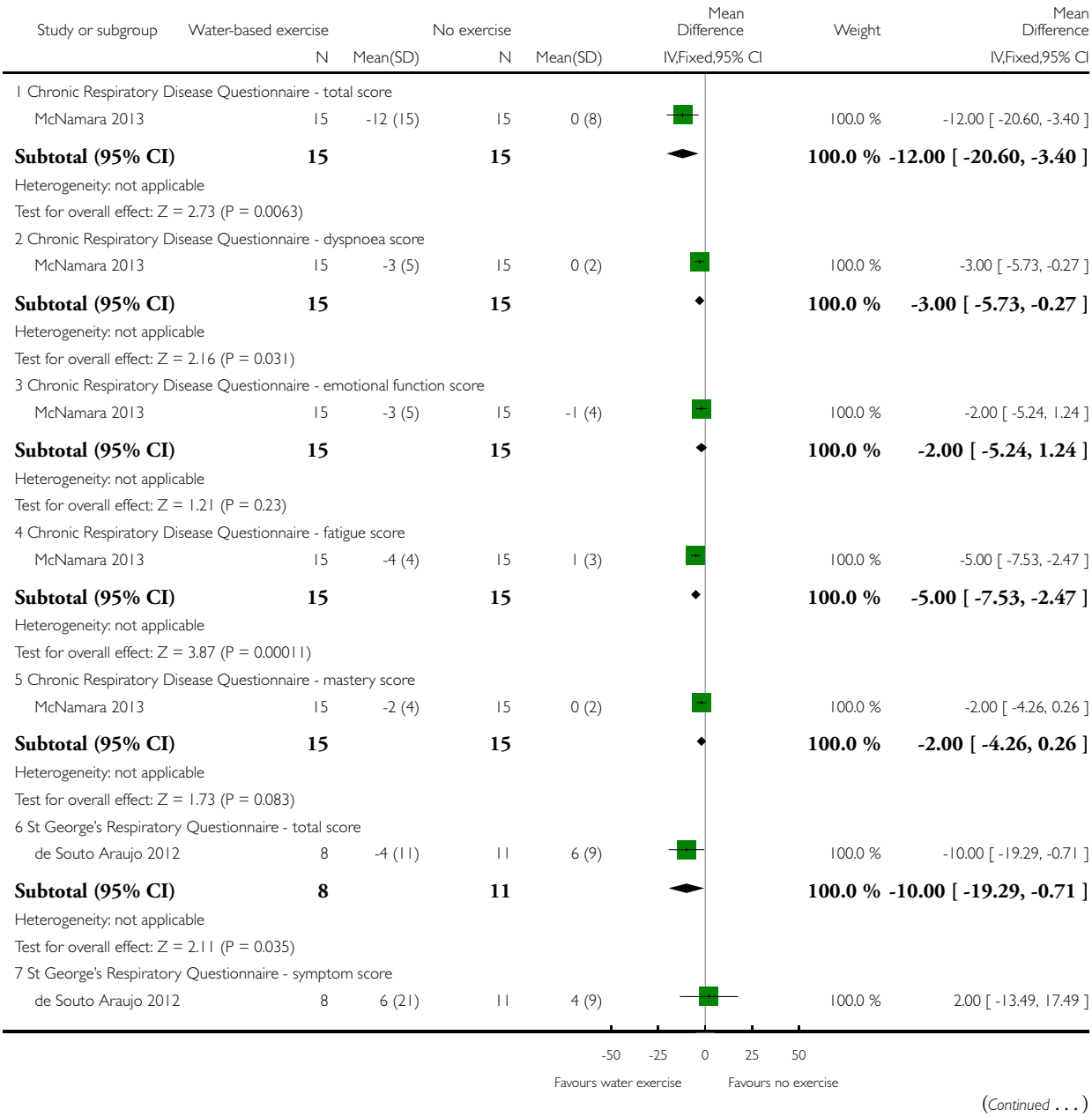


Analysis 1.3. Comparison 1 Water-based exercise versus no exercise, Outcome 3 Quality of life (mean change in individual domain scores).

Review: Water-based exercise training for chronic obstructive pulmonary disease

Comparison: 1 Water-based exercise versus no exercise

Outcome: 3 Quality of life (mean change in individual domain scores)



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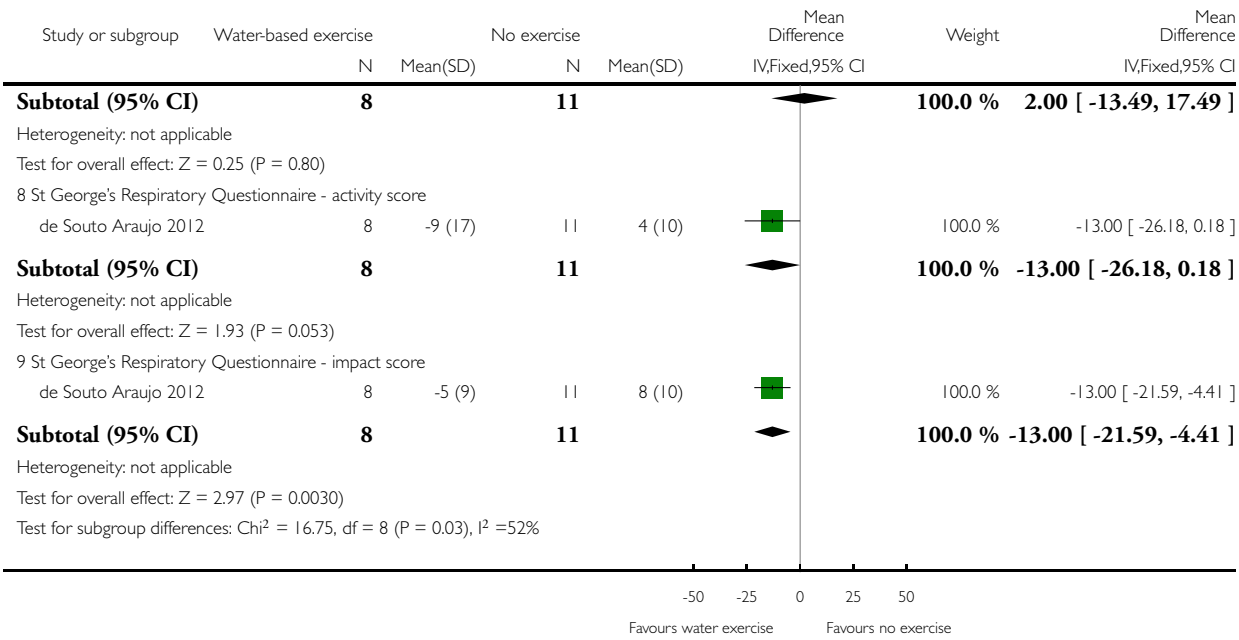


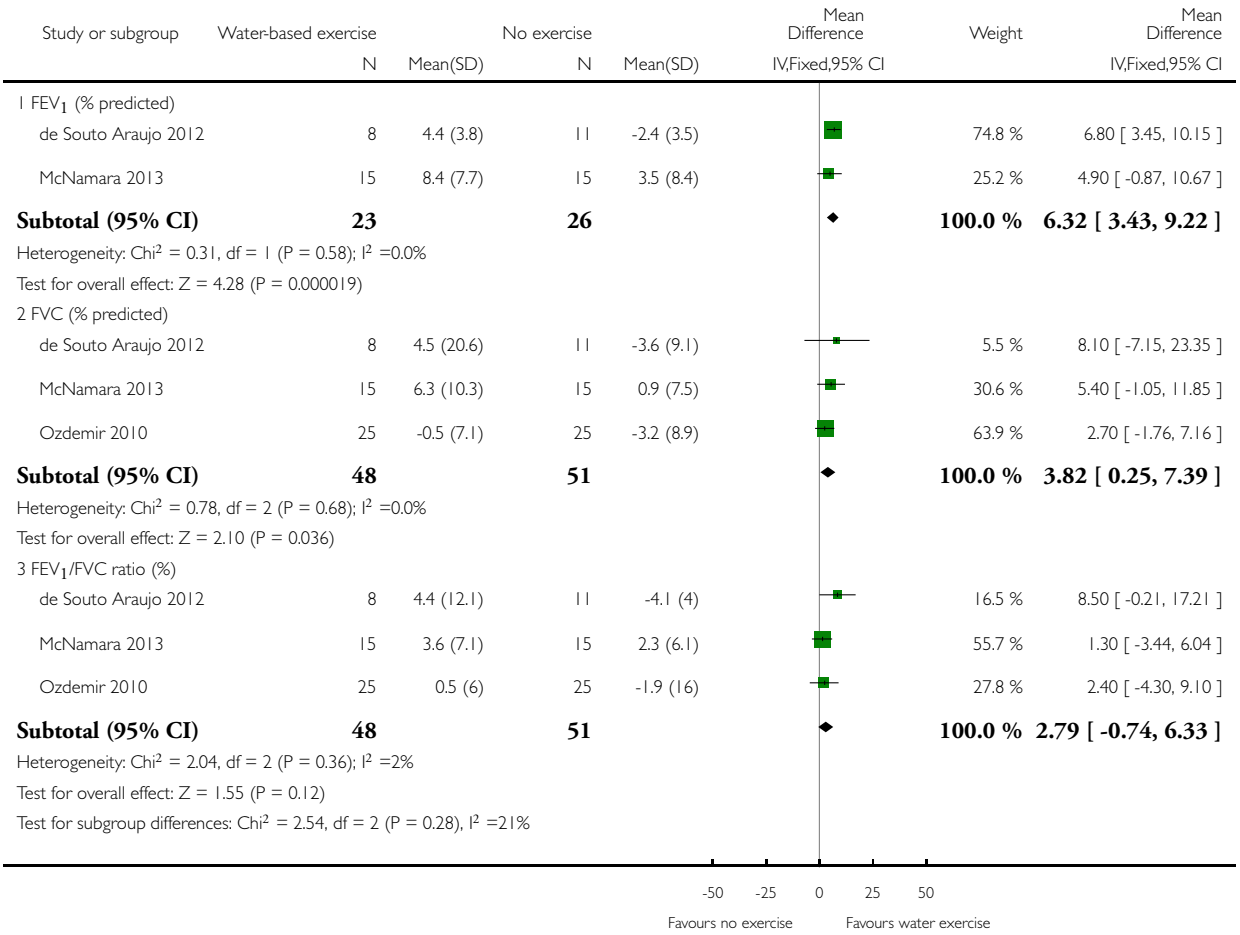
Analysis 1.4. Comparison 1 Water-based exercise versus no exercise, Outcome 4 Pulmonary function (mean change).

Review: Water-based exercise training for chronic obstructive pulmonary disease

Comparison: 1 Water-based exercise versus no exercise

Outcome: 4 Pulmonary function (mean change)

Study or subgroup	Water-based exercise N	Mean(SD)	No exercise N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
1 FEV_1 (% predicted)							
de Souto Araujo 2012	8	4.4 (3.8)	11	-2.4 (3.5)		74.8 %	6.80 [3.45, 10.15]
McNamara 2013	15	8.4 (7.7)	15	3.5 (8.4)		25.2 %	4.90 [-0.87, 10.67]
Subtotal (95% CI)	**23**		**26**			**100.0 %**	**6.32 [3.43, 9.22]**
Heterogeneity: Chi^2 = 0.31, df = 1 (P = 0.58); I^2 =0.0%							
Test for overall effect: Z = 4.28 (P = 0.000019)							
2 FVC (% predicted)							
de Souto Araujo 2012	8	4.5 (20.6)	11	-3.6 (9.1)		5.5 %	8.10 [-7.15, 23.35]
McNamara 2013	15	6.3 (10.3)	15	0.9 (7.5)		30.6 %	5.40 [-1.05, 11.85]
Ozdemir 2010	25	-0.5 (7.1)	25	-3.2 (8.9)		63.9 %	2.70 [-1.76, 7.16]
Subtotal (95% CI)	**48**		**51**			**100.0 %**	**3.82 [0.25, 7.39]**
Heterogeneity: Chi^2 = 0.78, df = 2 (P = 0.68); I^2 =0.0%							
Test for overall effect: Z = 2.10 (P = 0.036)							
3 FEV_1/FVC ratio (%)							
de Souto Araujo 2012	8	4.4 (12.1)	11	-4.1 (4)		16.5 %	8.50 [-0.21, 17.21]
McNamara 2013	15	3.6 (7.1)	15	2.3 (6.1)		55.7 %	1.30 [-3.44, 6.04]
Ozdemir 2010	25	0.5 (6)	25	-1.9 (16)		27.8 %	2.40 [-4.30, 9.10]
Subtotal (95% CI)	**48**		**51**			**100.0 %**	**2.79 [-0.74, 6.33]**
Heterogeneity: Chi^2 = 2.04, df = 2 (P = 0.36); I^2 =2%							
Test for overall effect: Z = 1.55 (P = 0.12)							
Test for subgroup differences: Chi^2 = 2.54, df = 2 (P = 0.28), I^2 =21%							

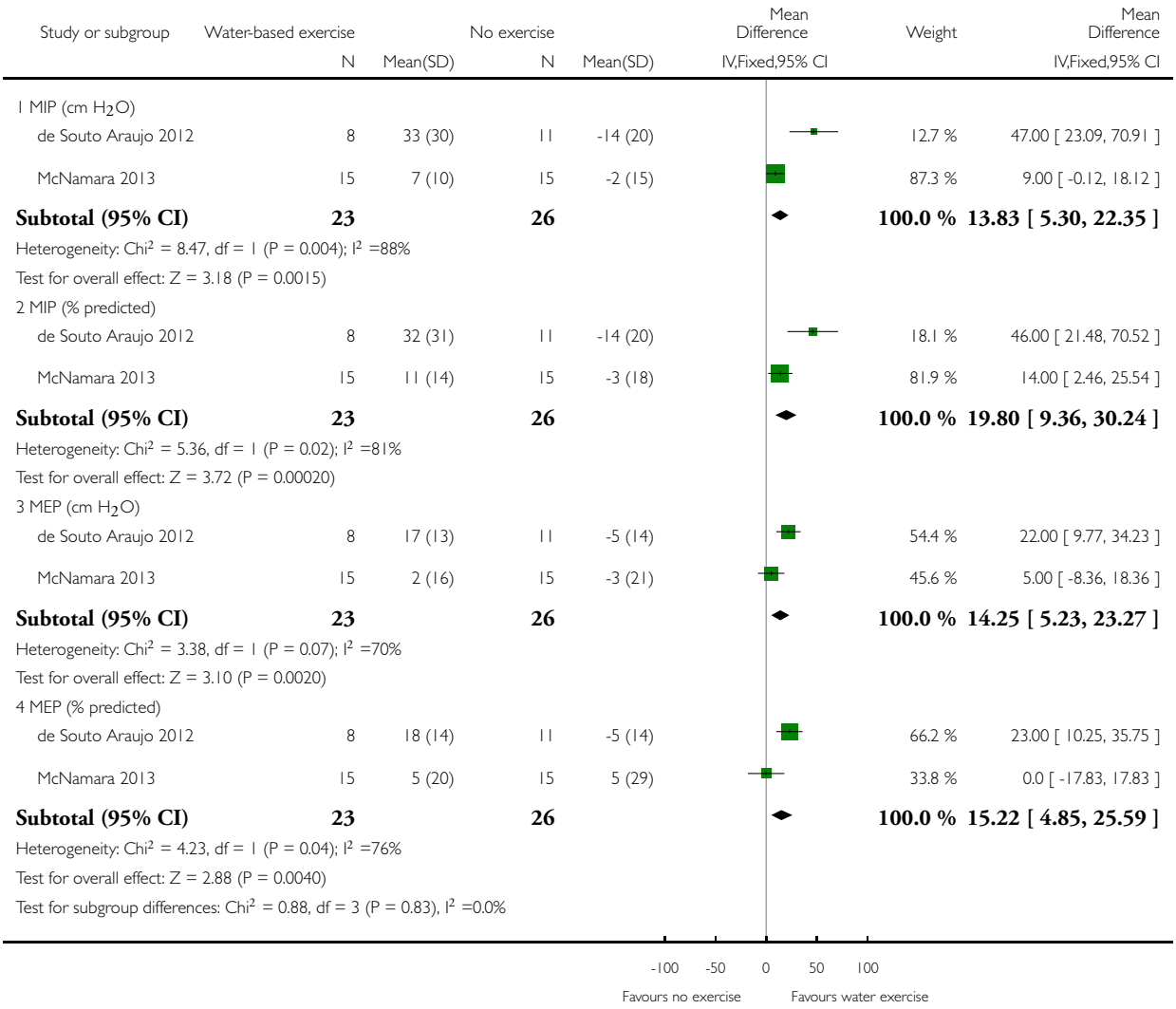


Analysis 1.5. Comparison 1 Water-based exercise versus no exercise, Outcome 5 Respiratory muscle strength (mean change).

Review: Water-based exercise training for chronic obstructive pulmonary disease

Comparison: 1 Water-based exercise versus no exercise

Outcome: 5 Respiratory muscle strength (mean change)

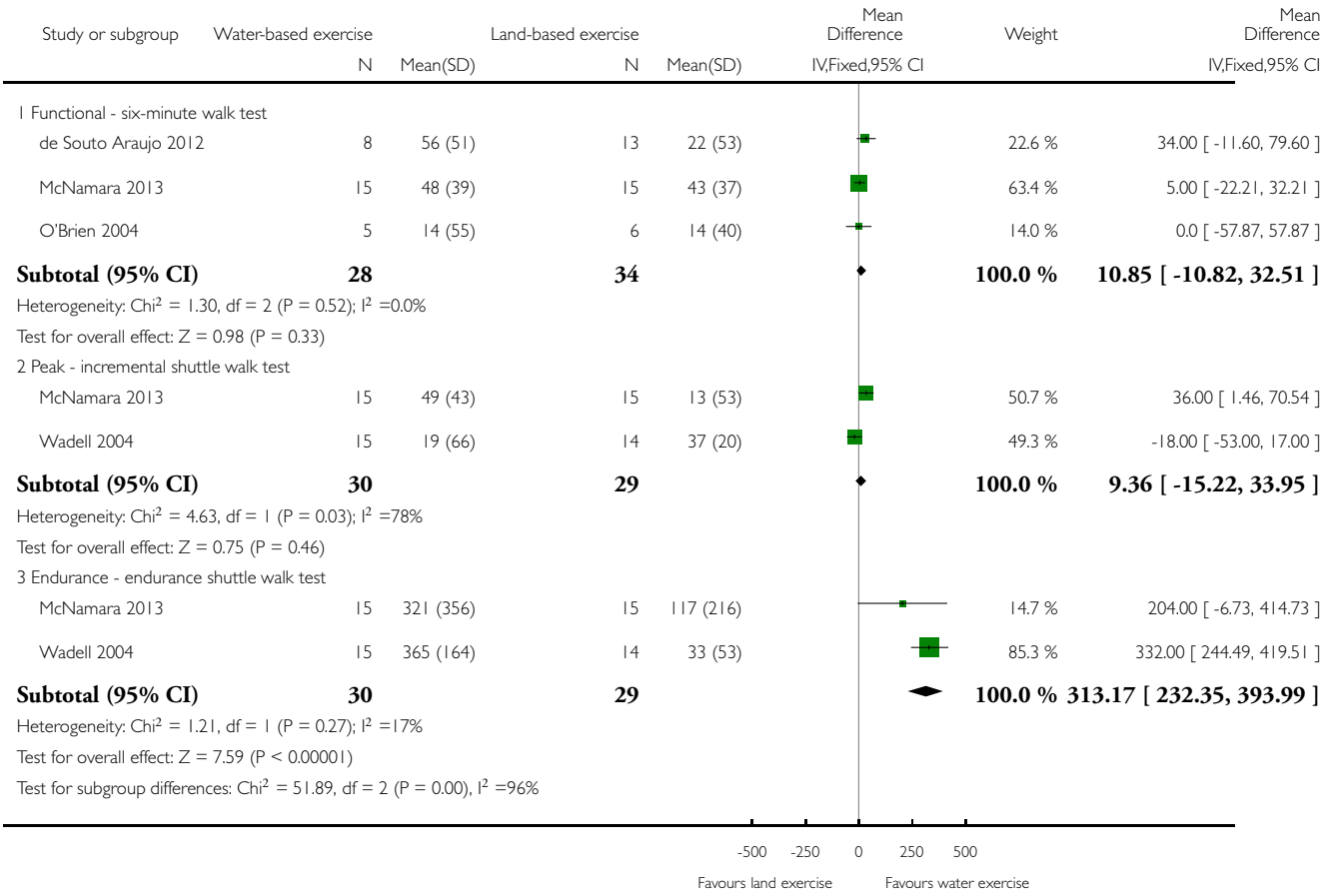


Analysis 2.1. Comparison 2 Water-based exercise versus land-based exercise, Outcome 1 Exercise capacity (mean change in metres).

Review: Water-based exercise training for chronic obstructive pulmonary disease

Comparison: 2 Water-based exercise versus land-based exercise

Outcome: 1 Exercise capacity (mean change in metres)

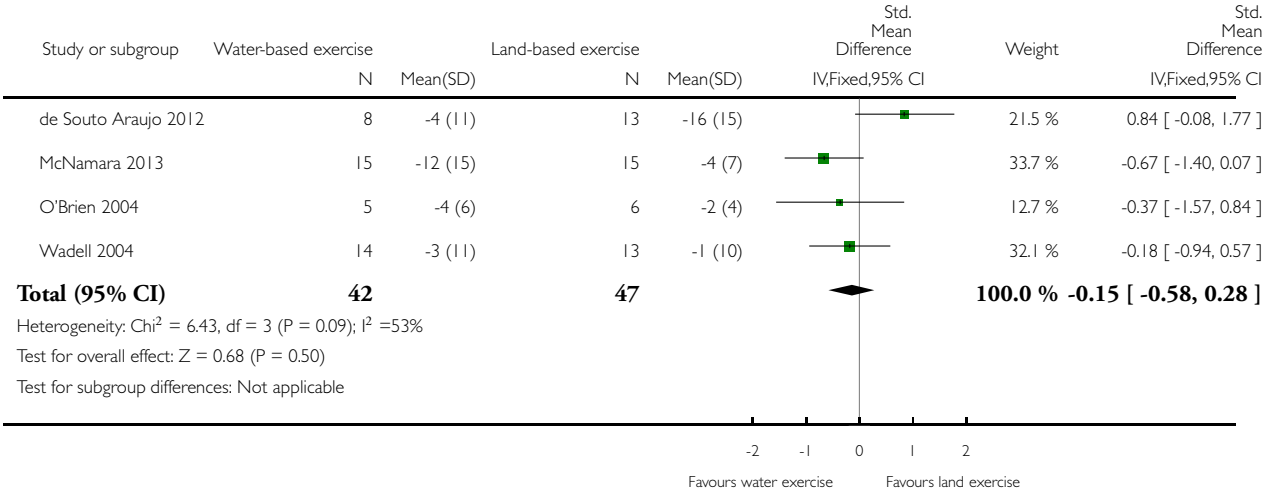


Analysis 2.2. Comparison 2 Water-based exercise versus land-based exercise, Outcome 2 Quality of life (mean change in total scores).

Review: Water-based exercise training for chronic obstructive pulmonary disease

Comparison: 2 Water-based exercise versus land-based exercise

Outcome: 2 Quality of life (mean change in total scores)

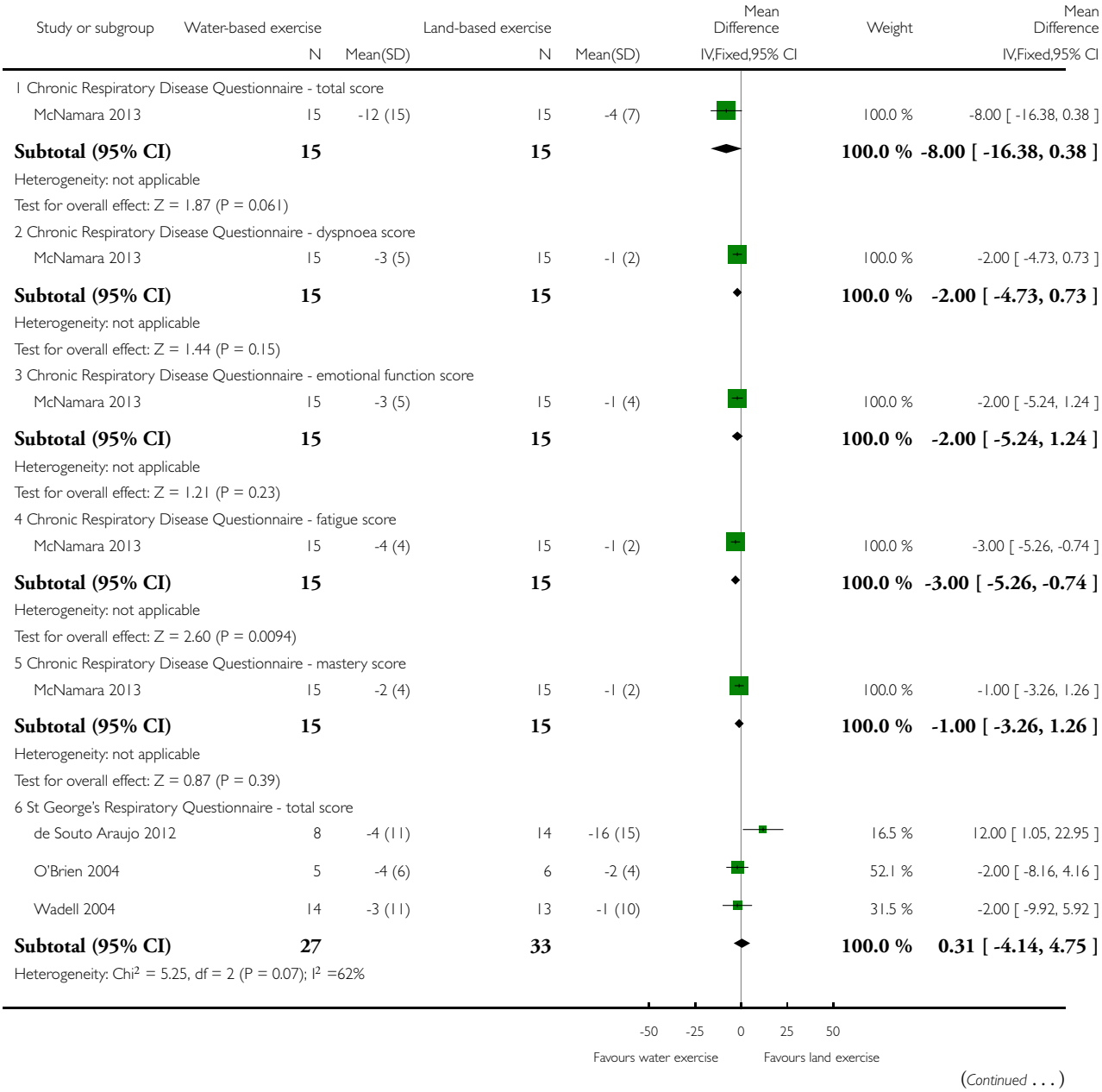


Analysis 2.3. Comparison 2 Water-based exercise versus land-based exercise, Outcome 3 Quality of life (mean change in individual domain scores).

Review: Water-based exercise training for chronic obstructive pulmonary disease

Comparison: 2 Water-based exercise versus land-based exercise

Outcome: 3 Quality of life (mean change in individual domain scores)



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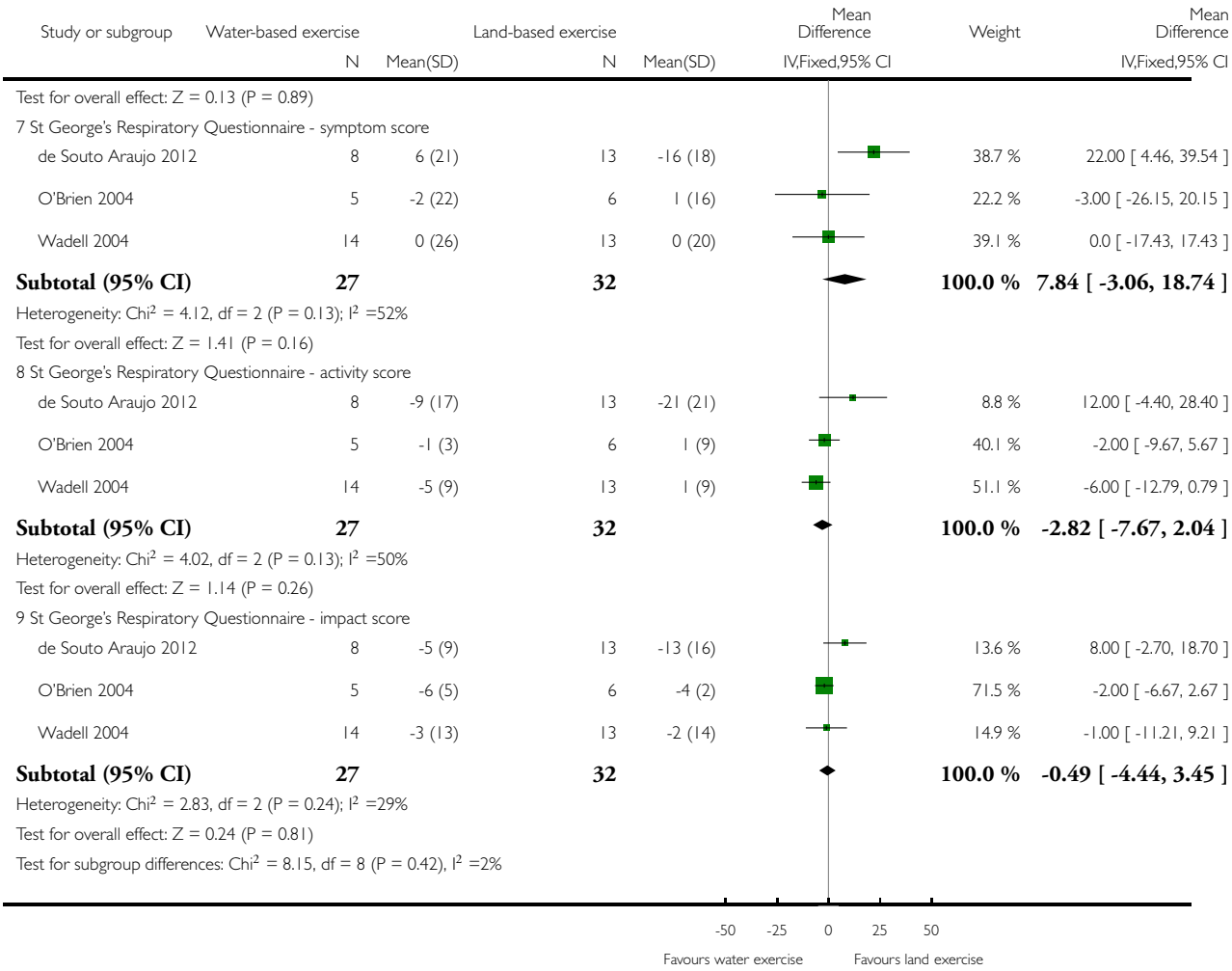
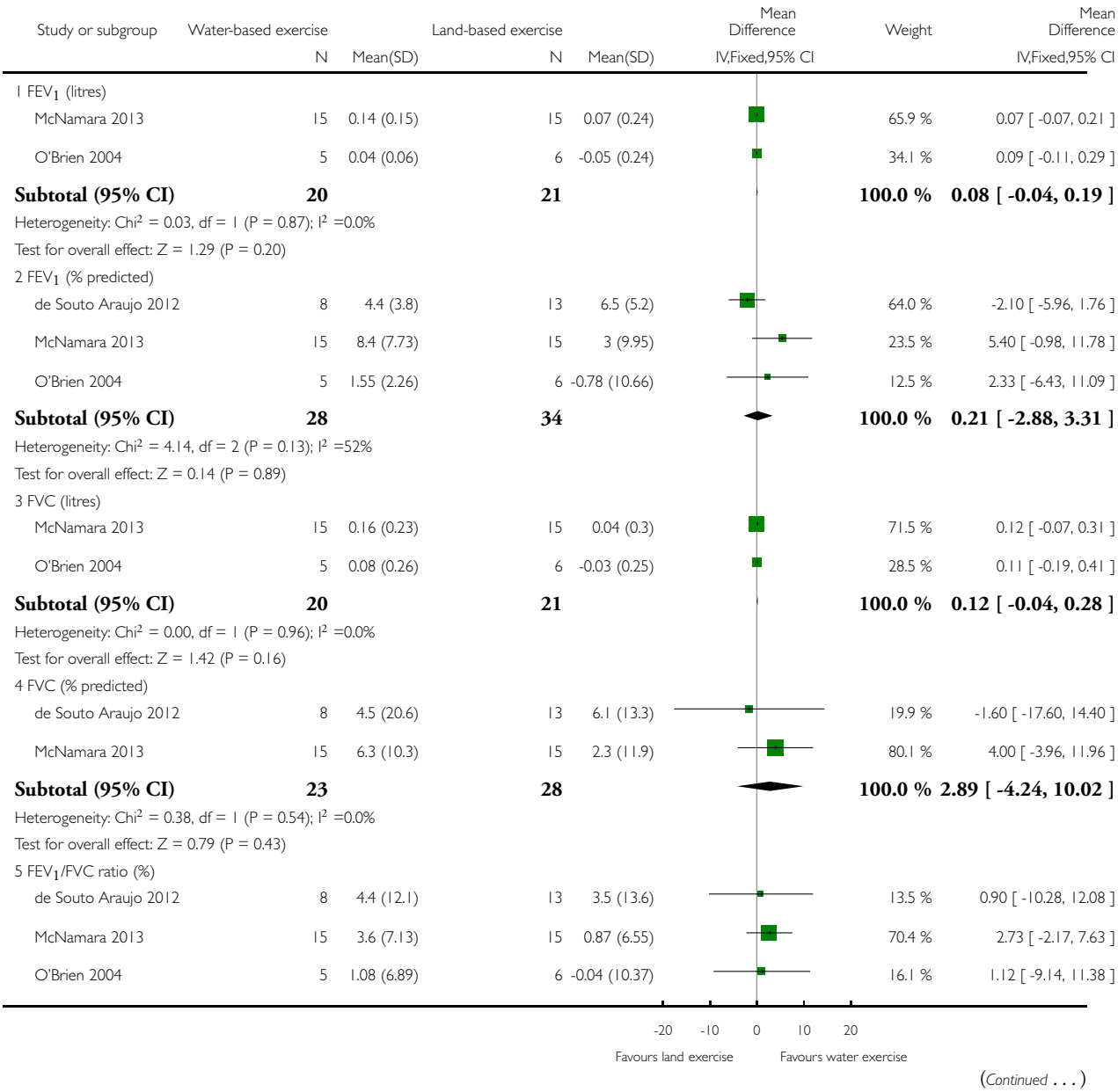


Analysis 2.4. Comparison 2 Water-based exercise versus land-based exercise, Outcome 4 Pulmonary function (mean change).

Review: Water-based exercise training for chronic obstructive pulmonary disease

Comparison: 2 Water-based exercise versus land-based exercise

Outcome: 4 Pulmonary function (mean change)



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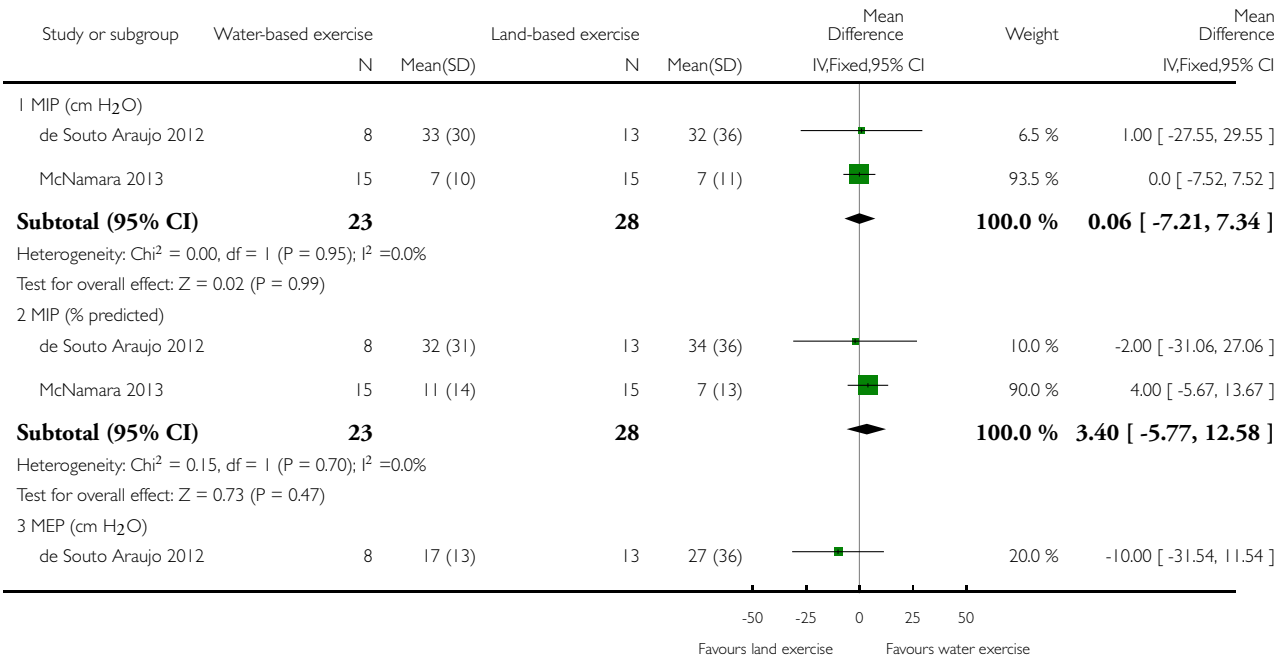
Analysis 2.5. Comparison 2 Water-based exercise versus land-based exercise, Outcome 5 Respiratory muscle strength (mean change).

Review: Water-based exercise training for chronic obstructive pulmonary disease

Comparison: 2 Water-based exercise versus land-based exercise

Outcome: 5 Respiratory muscle strength (mean change)



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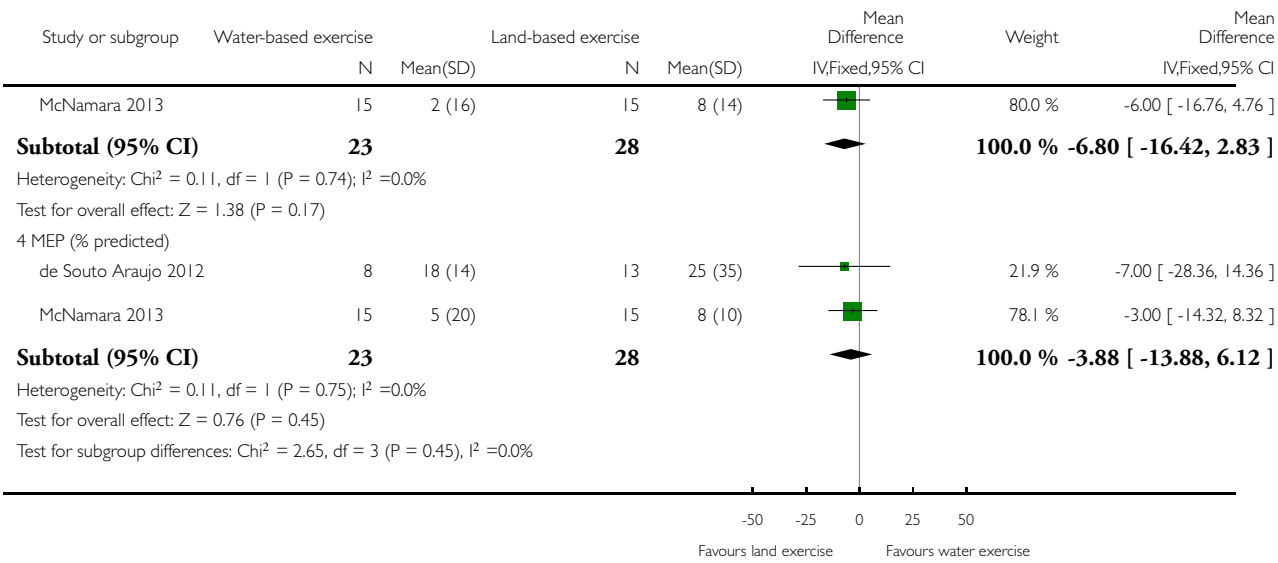
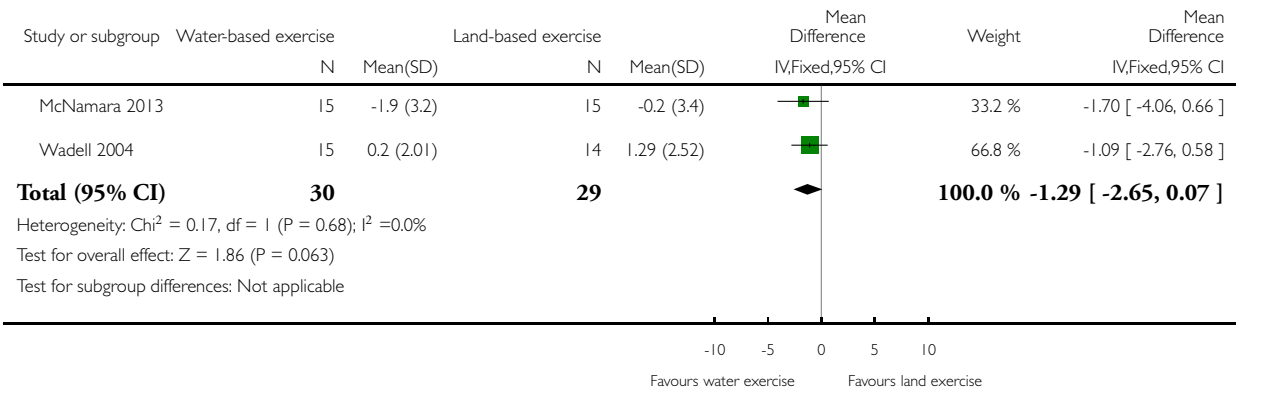


Analysis 2.6. Comparison 2 Water-based exercise versus land-based exercise, Outcome 6 Body composition (mean change in kilograms).

Review: Water-based exercise training for chronic obstructive pulmonary disease

Comparison: 2 Water-based exercise versus land-based exercise

Outcome: 6 Body composition (mean change in kilograms)

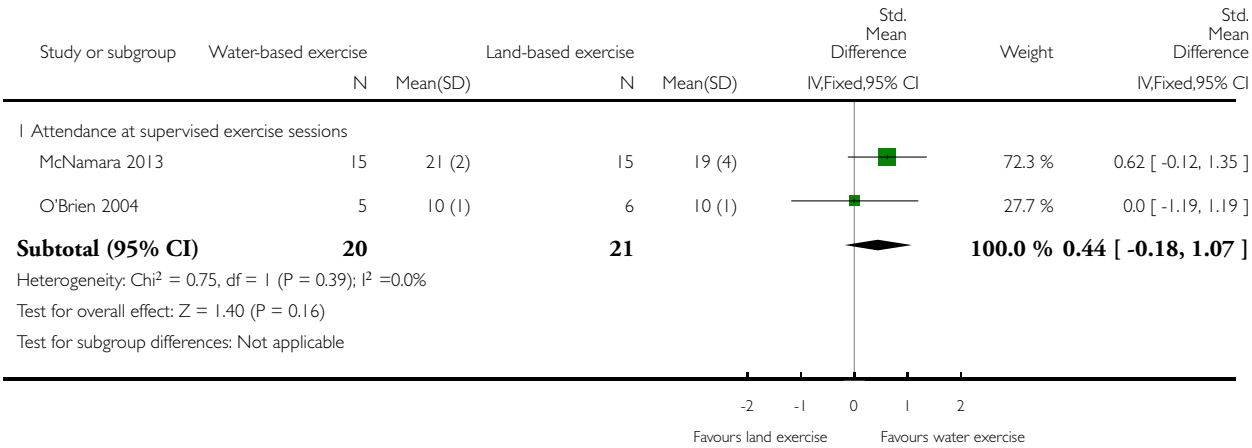


Analysis 2.7. Comparison 2 Water-based exercise versus land-based exercise, Outcome 7 Attendance (mean number).

Review: Water-based exercise training for chronic obstructive pulmonary disease

Comparison: 2 Water-based exercise versus land-based exercise

Outcome: 7 Attendance (mean number)



ADDITIONAL TABLES

Table 1. Intervention characteristics

Study	Water-based exercise		Land-based exercise		Other comparison group
	Description / Intensity	Frequency	Description / Intensity	Frequency	
de Souto Araujo 2012	Continuous warm-up exercises for upper and lower limbs (callisthenic activities with the respiratory cycle) for	Eight weeks, three times a week, 90 minutes	Continuous exercise for upper and lower limbs (callisthenic activities with the respiratory cycle) for 15 minutes without	Same as water-based exercise	No exercise training

Table 1. Intervention characteristics (*Continued*)

	15 minutes without weights; unsupported upper limb exercises using two diagonal movements and weights for two minutes with an equal rest period (initial weight 50% of maximum load and increased weekly) ; lower limb training using floats positioned between the legs and performing bicycling movements for 30 minutes (intensity determined by Borg dyspnoea and perceived effort score of 5); 15 minutes of cool-down exercise for muscle groups used during the session		weights; unsupported upper limb exercises using weights (initial weight 50% of maximum load and increased weekly) and diagonal movements for two minutes with equal rest periods; lower limb cycling for 30 minutes (intensity determined by Borg dyspnoea and perceived effort score of five); 15 minutes of cool-down exercise for muscle groups used during the session		
McNamara 2013	Supervised sessions consisting of exercises in hydrotherapy pool matched as closely as possible for intensity, duration and muscle groups trained to the land-based training exercises, and progressed by increasing water turbulence, speed and range of motion (specific exercise programme detailed in main publication)	Eight weeks, three times a week, 60 minutes	Supervised sessions consisting of upper limb endurance exercise and lower limb endurance exercise (walking and cycling) in a gym with initial intensity at 80% of walking speed on initial six-minute walk test either over-ground or on a treadmill, and progressed to maintain an intensity rating of three to five on the modified category ratio 0 to 10 dyspnoea and rating of perceived exertion scales	Same as water-based exercise	Usual medical care, no exercise training, requested not to alter exercise level over study period

Table 1. Intervention characteristics (*Continued*)

O'Brien 2004	Supervised in hydrotherapy pool using similar muscle groups to ensure standardisation to land-based exercise programme and using properties of water to provide resistance, at an intensity of three to four on the modified Borg rating of perceived exertion scale	Six weeks, two times a week, 45 minutes	Supervised warm-up of walking and stretches, aerobic training and strength and resistance training using free weights, at an intensity of three to four on the modified Borg rating of perceived exertion scale	Same as water-based exercise	-
Ozdemir 2010	Supervised in an aquatic centre with a warm-up, stretches and strengthening exercises for shoulder girdle and upper extremity muscles utilising floatation devices for resistance	Four weeks, three times a week, 35 minutes	-	-	Medical therapy only
Wadell 2004	As per land-based exercise training but in water	12 weeks, three times a week, 45 minutes	Supervised, intensity guided by music to achieve a mean heart rate of 80% to 100% of peak heart rate according to maximal cycle ergometer test and a Borg dyspnoea score of 5 and rating of perceived exertion score of 15, including warm-up and flexibility exercises, followed by four minutes of endurance exercises and three minutes of strength exercises (repeated three times while focusing on the legs, arms	Same as water-based exercise	No intervention

Table 1. Intervention characteristics (*Continued*)

			and torso each time) and finally flexibility, stretching and cool-down exercises		

APPENDICES

Appendix 1. Sources and search methods for the Cochrane Airways Group Specialised Register (CAGR)

Electronic searches: core databases

Database	Frequency of search
CENTRAL (*The Cochrane Library*)	Monthly
MEDLINE (Ovid)	Weekly
EMBASE (Ovid)	Weekly
PsycINFO (Ovid)	Monthly
CINAHL (EBSCO)	Monthly
AMED (EBSCO)	Monthly

Handsearches: core respiratory conference abstracts

Conference	Years searched
American Academy of Allergy, Asthma and Immunology (AAAAI)	2001 onwards
American Thoracic Society (ATS)	2001 onwards
Asia Pacific Society of Respirology (APSR)	2004 onwards

(*Continued*)

British Thoracic Society Winter Meeting (BTS)	2000 onwards
Chest Meeting	2003 onwards
European Respiratory Society (ERS)	1992, 1994, 2000 onwards
International Primary Care Respiratory Group Congress (IPCRG)	2002 onwards
Thoracic Society of Australia and New Zealand (TSANZ)	1999 onwards

MEDLINE search strategy used to identify trials for the CAGR

COPD search

1. Lung Diseases, Obstructive/
2. exp Pulmonary Disease, Chronic Obstructive/
3. emphysema$.mp.
4. (chronic$ adj3 bronchiti$).mp.
5. (obstruct$ adj3 (pulmonary or lung$ or airway$ or airflow$ or bronch$ or respirat$)).mp.
6. COPD.mp.
7. COAD.mp.
8. COBD.mp.
9. AECB.mp.
10. or/1-9

Filter to identify RCTs

1. exp "clinical trial [publication type]"/
2. (randomised or randomised).ab,ti.
3. placebo.ab,ti.
4. dt.fs.
5. randomly.ab,ti.
6. trial.ab,ti.
7. groups.ab,ti.
8. or/1-7
9. Animals/
10. Humans/
11. 9 not (9 and 10)
12. 8 not 11

The MEDLINE strategy and the RCT filter are adapted to identify trials in other electronic databases.

HISTORY

Protocol first published: Issue 1, 2010

Review first published: Issue 12, 2013

Date	Event	Description
25 November 2009	Amended	Conflicts of interest statement added.

CONTRIBUTIONS OF AUTHORS

RJM: protocol initiation, development and writing; search for and retrieval of studies; study screening, quality appraisal and data extraction; author contact; data entry and analysis; manuscript writing.

ZJM: protocol development; study screening, quality appraisal and data extraction; data entry review; manuscript review.

DKM: protocol development; manuscript review.

JAA: protocol development; study quality appraisal; manuscript review.

DECLARATIONS OF INTEREST

The review authors (RJM, ZJM, DKM and JAA) conducted one of the included studies before commencing this review (McNamara 2013).

SOURCES OF SUPPORT

Internal sources

- No sources of support supplied

External sources

- Australian Cochrane Airways Group Network Scholarship, Australia.

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

Types of interventions: The criterion 'trials where water-based training was combined with another training intervention were included provided 50% or more of the training was water-based' was changed to a criterion whereby 'trials where water-based training was combined with another training intervention were included provided the water-based exercise training accounted for *greater than 50%* of the total training period'.

Types of outcome measures-secondary outcomes: Additional outcomes reported in trials (but not prespecified for this review) were included in the secondary outcome measures list in this review for future updates. These include body composition, attendance, preference for exercise training mode and arterial blood gases.

Subgroup analysis: This analysis could not be performed for disease severity, as we did not identify any trials with data presented according to disease severity.

Sensitivity analysis: This was not performed and funnel plots were not constructed because of the small number of included studies. If in future updates more studies are included, these analyses will be performed.

INDEX TERMS

Medical Subject Headings (MeSH)

Breathing Exercises [methods]; Exercise Therapy [*methods]; Exercise Tolerance; Hydrotherapy [adverse effects; *methods]; Pulmonary Disease, Chronic Obstructive [*rehabilitation]; Quality of Life; Randomized Controlled Trials as Topic

MeSH check words

Humans