Best practice evidence for warm water exercise for people with musculoskeletal conditions

A systematic review of the literature - 2014

Arthritis VICTORIA
inc. OSTEOPOROSIS VICTORIA

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in Patient Safety

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EXECUTIVE SUMMARY

This paper seeks to inform Arthritis and Osteoporosis Victoria about the evidence relating to the benefits of warm water exercise for people with arthritis or related musculoskeletal conditions. It also aims to provide an overview of the characteristics of effective warm water exercise programs for this group.

This work draws on a literature review undertaken in 2013 as a collaboration between Arthritis and Osteoporosis Victoria and the Falls and Bone Health team within the Health Services Research Unit at Monash University.

What do we know from past literature reviews?

A number of studies have sought to establish the effectiveness of warm water exercise in the treatment of musculoskeletal conditions. Despite the increasing number of studies being undertaken, systematic reviews completed on the effects of warm water exercise for people with osteoarthritis[1, 2], fibromyalgia[3, 4] and low-back pain[5] have reported positive impacts but issued caution in their conclusions due to a lack of high quality studies.

How does this review build on those completed previously?

Additional studies have been published since these prior reviews highlighting the need for an updated review. In addition to including new evidence, we also sought to extend on previously completed reviews by pooling information from studies across different types of musculoskeletal conditions and to explore the effect of excluding low quality studies from the analysis. A pooled approach across a suite of musculoskeletal health conditions is important since the warm water exercise programs provided by Arthritis and Osteoporosis Victoria (including the 'Waves' warm water exercise program (http://www.arthritisvic.org.au/Useful-Information/Our-Services/Waves-Warm-Water-Exercise-Program) and warm water exercise classes conducted by Arthritis and Osteoporosis Victoria peer support groups) service people with a range of musculoskeletal health conditions. We also aimed to identify the characteristics of effective warm water exercise programs to specifically inform the review of the Arthritis and Osteoporosis Victoria programs.

About the literature review conducted

We undertook a systematic review of studies on warm water exercise published in peer-reviewed journals from Australia and overseas. Robust research methods were applied to synthesise findings from the highest quality studies—randomised controlled trials and quasi-randomised controlled trials —about the effects of warm water exercise in people with arthritis and other musculoskeletal conditions. Each identified study that met the predetermined inclusion criteria was reviewed and summarised in terms of: (i) participant characteristics; (ii) warm water exercise program characteristics (including frequency, duration and use of co-interventions such as education); (iii) exercise characteristics; (iv) outcomes; and (v) research methodology.

The review explored the impacts of warm water exercise on pain, physical function and quality of life, or 'intervention effects', using meta-analysis—a statistical technique that combines results from different studies to identify consistent patterns among study results. Information on the characteristics of effective programs was obtained by systematic analysis of high quality studies in which positive effects were reported and that were included in the meta-analysis.

What types of studies were included in the review?

Over 1,000 articles were found from the initial electronic search and were screened for inclusion in this review. 28 randomised controlled trials and 2 quasi-randomised controlled trials were identified as being relevant to this review. The quality of studies included in the review was variable, with many including only

a small number of participants. The majority of studies were conducted in people with osteoarthritis (53%; 16 studies) and reported on pain and physical function outcomes.

Summary of studies included in the review

	Number of studies		Pain		Physical function		Quality of life	
	All	Meta-analysis	All	Meta-analysis	All	Meta-analysis	All	Meta-analysis
Osteoarthritis	16	14	15	14	16	11	11	9
Rheumatoid Arthritis	2	2	2	2	1	2	2	2
Osteoarthritis or Rheumatoid Arthritis	2	2	2	-	2	1	-	-
Fibromyalgia	6	5	6	3	6	4	3	-
Low Back Pain	3	2	3	2	2	1	1	-
Osteoporosis	1	1	0	-	1	1	1	1
TOTAL	30	26	28	21	28	20	18	12

What does the evidence tell us?

There was considerable variability across the 30 included studies regarding the target population, key program characteristics, outcomes assessed, outcome measures used and the methodological quality of studies. Overall, there were many benefits of warm water exercise demonstrated by prior studies for a range of musculoskeletal conditions. Importantly, no harmful effects of warm water exercise were reported. Also of interest, five studies reported on participation outcomes (e.g. % of sessions attended). In these studies, participation in warm water exercise sessions was greater than participation in land based exercise sessions. This highlights that warm water exercise is a safe and effective form of exercise that is appealing to people with arthritis and other musculoskeletal conditions.

Warm water exercise intervention effects

The meta-analysis included 26 studies that measured the effect of warm water exercise compared to either land based exercise or non-active activities such as relaxation or no exercise using valid outcome measures. Key findings of the meta-analysis were:

- Compared to non-active controls, warm water exercise was associated with a:
    - Moderate reduction in pain (Standardised mean difference: -0.37, 95% CI -0.56 to -0.18; 15 studies);
    - Moderate improvement in physical function (Standardised mean difference: 0.32, 95% CI 0.13 to 0.51; 14 studies); and
    - Moderate improvement in quality of life (Standardised mean difference: 0.39, 95% CI 0.06 to 0.73; 11 studies).
- Compared to land based exercise, warm water exercise was associated with a:
    - Small non-significant reduction in pain (Standardised mean difference: -0.11, 95% CI -0.27 to 0.04; 10 studies);
    - Comparable effect on physical function (Standardised mean difference: -0.03, 95% CI -0.19 to 0.12; 10 studies); and
    - Comparable effect on quality of life (Standardised mean difference: -0.10, 95% CI -0.29 to 0.09; 7 studies).

When the analysis was repeated after removing low quality studies these findings persisted. The findings were also mostly consistent across the different musculoskeletal conditions studied. Some differences were noted for rheumatoid arthritis and osteoporosis populations with somewhat smaller benefits noted. However, there were only two studies in people with rheumatoid arthritis and one in people with

osteoporosis suggesting further studies are required to more accurately identify effects of warm water exercise in these populations. Therefore, on the basis of available evidence, warm water exercise offers benefits to people with different musculoskeletal health conditions compared to not undertaking some form of exercise.

Of note, despite the difference in pain and quality of life outcomes not being statistically significant between warm water exercise and land exercise participants, results of the meta-analysis consistently favoured warm water exercise over land based exercise for these outcomes.

Characteristics of effective warm water exercise programs

There was considerable variability between studies in key program characteristics such as duration of programs and the exercises included. Unfortunately, many studies did not provide adequate descriptions of the exercises included. However, when the characteristics of the programs and exercises of the highest quality effective programs were reviewed, some common characteristics were evident:

- Warm water exercise programs were commonly performed two or more times per week and were of 60 minutes in duration;
- Programs ran for at least 6 weeks (range: 6 to 52 weeks);
- Lower-limb strengthening exercises and equipment such as floats, weights, paddles or elastic tubing were often used to increase the load during strengthening exercises;
- Squats, step-ups or other exercises that focused on hip and knee extension were commonly included in programs; and
- Aerobic activities such as running and cycling were also commonly used with a target of >65% of maximum heart rate.

There is some evidence from a small number of studies that suggest that the inclusion of education and balance exercises may provide additional benefits, consistent with contemporary models of care for people living with chronic musculoskeletal health conditions.

Key learnings and insights

The key messages that emerged from this review are:

- The evidence suggests warm water exercise has beneficial effects on pain, physical function and quality of life in adults with musculoskeletal conditions. These benefits appear comparable to those achieved with land based exercise.
- Gaps remain in our understanding of the characteristics (e.g. frequency, duration, intensity and exercises) of warm water exercise programs that provide the most benefit. However, based on the current evidence, successful programs appear to include two sessions of 60 minute duration per week, run for at least 6 weeks, target strengthening of hip and knee extensors using resistance and weight-bearing exercises, and include moderate intensity aerobic exercise.

Considerations arising from a small number of studies or the broader musculoskeletal and preventative healthcare evidence base include:

- **The addition of an education component may add value to the Arthritis and Osteoporosis Victoria warm water exercise programs**

  Education could be provided by Arthritis and Osteoporosis Victoria staff in a once-off session for participants on enrolment to Waves classes and augmented by information leaflets and follow-up face-to-face sessions following enrolment. Education could include information on the benefits of exercise and behaviour change strategies such as goal setting within a self-management framework. Information leaflets that are developed could also be distributed by the peer support groups to their warm water exercise participants.

- **The inclusion of balance exercises in warm water exercise classes has potential to provide wider health benefits in terms of falls prevention to warm water exercise participants**

  A simple way to include balance exercises would be to integrate these into the walking and lower-limb exercises that are already performed in many sessions. Balance exercises require moving the body over a narrow base of support without hand support. Examples of balance exercises include toe, heel or heel-toe walking and hip ROM exercises performed without holding onto a rail or the side of the pool.

Summing it up

The academic literature should be considered an important input into overall service planning and improvement. This is the first meta-analysis that has assessed the effectiveness of warm water exercise programs across different musculoskeletal conditions. The evidence suggests warm water exercise has beneficial short-term effects on pain, physical function and quality of life in adults with arthritis and musculoskeletal conditions. Outcomes for adults with musculoskeletal conditions following warm water exercise appear comparable to land based exercise, suggesting that when people are unable to exercise on land, or find land based exercise difficult, warm water exercise programs provide an effective alternative strategy.

There is further need for high-quality, large scale studies of sufficient duration and an adequate follow-up period to validate the long-term effects of warm water exercise. To improve practice and decision making, further studies are needed that examine different modes, frequency and intensity of warm water exercise programs so the characteristics of programs that achieve maximum benefits are well understood. It is also not known whether warm water exercise improves the progression of conditions such as osteoarthritis or osteoporosis. Further studies should aim to investigate this and also to explore patient preferences for warm water exercise compared to land based exercise.

BACKGROUND

What evidence is there that warm water exercise is beneficial for people with musculoskeletal conditions? Can it reduce pain? Can it improve function and quality of life? Does it offer benefits above land based exercise programs? This review sought to answer these questions using rigorous review methods recommended by the National Health and Medical Research Council.

Purpose

The purpose of this occasional paper is to provide an overview of the research evidence on the effectiveness of warm water exercise for improving pain, function and quality of life in people who have musculoskeletal conditions such as arthritis, osteoporosis, fibromyalgia and low back pain. We also sought to identify the characteristics of warm water exercise programs that are most effective. This information can be used to inform the review of the warm water exercise programs provided by Arthritis and Osteoporosis Victoria.

The Arthritis and Osteoporosis Victoria warm water exercise programs

The Waves program provides gentle exercise in hydrotherapy pools for people with arthritis and related musculoskeletal conditions. The program was established in 1977 as an informal exercise class by members of the Ringwood Self-Help Group. The goals of the Waves program are to provide a service to its consumers that will facilitate self-help to people who share common chronic musculoskeletal health conditions. It aims to decrease the burden of musculoskeletal associated illness through physical activity and to support, promote and improve the well-being of participants. There are now more than 40 classes in over 20 locations across Melbourne. The Waves classes are peer-led and now have 450 participants and 120 leaders. Arthritis and Osteoporosis Victoria also has 16 peer support groups conducting warm water exercise classes in various locations around Victoria. The volunteer leaders of these classes are trained by Arthritis and Osteoporosis Victoria staff, so that the classes are conducted in a similar format to those within the Waves program.

Arthritis and musculoskeletal conditions

Musculoskeletal conditions are widespread and are among the world's leading causes of chronic pain, disability and reduced health-related quality of life[6]. A recent report on global burden of disease highlighted that they accounted for 7% of total disability adjusted life years with low back pain accounting for nearly half, and osteoarthritis accounting for almost 10% of this burden[7]. Musculoskeletal conditions are the most common causes for utilising healthcare resources[8]. This burden, reflected by endorsement of the Bone and Joint Decade 2000–2010 by the United Nations and World Health Organisation, is predicted to rise due to the ageing population. In Australia, total healthcare costs associated with treating musculoskeletal conditions was estimated to be nearly $10 billion for 2012, with the majority of these costs being attributed to back problems (53%) and osteoarthritis (41%)[9]. As such, identifying and promoting effective management strategies for these conditions has been flagged as a public health priority[10]. Further information on the rising cost of musculoskeletal conditions in Australia can be found in the Arthritis and Osteoporosis Victoria report, "A problem worth solving"[9].

Warm water exercise

In recent years, there has been increasing evidence regarding the positive benefits of warm water exercise for people with a variety of musculoskeletal conditions[2, 5, 11]. The benefits arise from the unique combination of the physiological effects of immersion and the hydrodynamic principles of exercise in the warm water exercise environment[12]. The effect of buoyancy decreases compressive weight-bearing stresses on joints and allows functional exercise with lessened gravitational load, improving both strength and range of movement[13]. Additionally, immersion in thermo neutral water (34 degrees Celsius) slows sympathetic nervous system conduction, which in combination with the compressive effects of hydrostatic

pressure can reduce swelling and the perception of pain in people with musculoskeletal conditions[12]. Finally, those with chronic musculoskeletal conditions are frequently deconditioned[14], and the warm water exercise environment allows higher-intensity exercise to be undertaken, with lower cardiovascular stress than is possible on land[15]. The social inclusion aspects of group-based hydrotherapy may also infer benefit to participants, given the psychosocial burden associated with chronic musculoskeletal health conditions.

What do we already know about the effectiveness of warm water exercise?

A number of studies have sought to establish the effectiveness of warm water exercise in the treatment of arthritis and other musculoskeletal conditions. Despite the increasing number of studies being undertaken, the most recent Cochrane Review published in 2007, and limited to osteoarthritis studies, concluded that there remains a lack of high-quality studies in this area[1]. The review included information from six studies and identified that warm water exercise had small-to-moderate short term effects on pain, function and quality of life compared to no intervention for patients with hip and/or knee osteoarthritis[1]. A more recent review published in 2011 focused only on functional mobility and pooled health outcomes in people with hip and/or knee osteoarthritis or rheumatoid arthritis[2]. This review included 10 studies and concluded that warm water exercise had comparable effects to land based exercise in this patient group. This review again highlighted the variability in the quality of included studies, hindering the identification of true differences between land and water based exercise. Reviews completed on the effects of warm water exercise for people with fibromyalgia[3, 4] and low-back pain[5] have also reported positive impacts but were cautious in their conclusions due to variable study quality.

How does this review build on those completed previously?

Additional studies have been published since these prior reviews highlighting that an update of the reviews is indicated. In addition to including new evidence, we also sought to extend on previously completed reviews by pooling information from studies across different types of musculoskeletal conditions and to provide more accurate estimates of effects by examining the effects when excluded low quality studies were removed from the analysis. We also aimed to identify the characteristics of effective warm water exercise programs to inform the review of the warm water exercise programs provided by Arthritis and Osteoporosis Victoria.

Review objectives

The objectives of this review were to compare the effectiveness of warm water exercise interventions in the treatment of musculoskeletal conditions to other land based exercise or non-active interventions (e.g. no exercise) or no intervention.

In addition, the characteristics of warm water exercise programs that appear most effective were described.

The following sections provide a brief overview of the methods, key findings, and suggested next steps following on from this review.

METHODS

About the literature review

We undertook a systematic review of studies on warm water exercise published in peer-reviewed journals from Australia and overseas. Robust research methods were applied to synthesise findings from the highest quality studies—randomised controlled trials (RCTs) and quasi-randomised controlled trials—about the effects of warm water exercise in people with arthritis or other musculoskeletal conditions.

The review explored the impacts of warm water exercise on pain, physical function and quality of life using meta-analysis—a statistical technique that combines results from different studies to identify consistent patterns among study results. The following sections describe the steps taken to identify, appraise and synthesise findings from the peer reviewed literature.

How studies were identified

A systematic search of literature was conducted up until May 2013. Ovid was used to search MEDLINE, CINAHL and EMBASE. The Cochrane Central Register of Controlled Trials was also searched. A sensitive search strategy was developed using medical subject heading search terms and keywords based on those used in previous published reviews (see Appendix 1), and was translated for each database as appropriate. We also checked the references of included studies for further relevant literature.

How studies were selected

Studies were selected for inclusion in this review based on a predefined criterion. The criteria were designed to ensure that the only the highest quality studies that were undertaken in populations similar to the Waves participants, and delivering exercise programs similar to Waves, were included in the review.

Two researchers independently screened and excluded studies based on title and abstracts. For articles not excluded by this process, full text was obtained and assessed independently by both researchers against the inclusion/exclusion criterion (see Appendix 2 for the list of studies excluded).

Types of studies and participants

Studies were included if they were conducted as a RCT[1] or a quasi-randomised controlled trial[2]. Participants had to be diagnosed with at least one musculoskeletal condition using accepted arthritis and musculoskeletal diagnostic criteria. Studies that included participants less than 18 years of age or who had recently had surgery (e.g. arthoplasty or spinal surgery) were excluded.

Interventions

Studies must have included one group that participated in warm water exercise and a comparison group that participated in land based exercise, no exercise or a non-active activity (e.g. education). Warm water exercise interventions were defined as any type of endurance, flexibility, strength, resistance or aerobic exercise conducted in a pool. Other hydrotherapy methods such as turbulent spa therapy and balneotherapy (immersion in mineralised water) were excluded because these approaches do not usually include an active exercise component. Trials where warm water exercise was performed in combination with other exercise

[1] Randomised controlled trials (RCTs), are considered to be the 'gold-standard' when it comes to types of research studies. They involve having two or more groups of patients; one group that receives the intervention being tested and the others either receives no intervention or a different intervention. Which patients end up in each group is determined by chance, like a lottery or a coin toss. RCTs are designed to reduce the risk of bias in the results of the trial.

[2] Quasi-randomised controlled trials, like RCTs involve having two or more groups of patients. However unlike a RCT, a quasi-randomised controlled trial does not randomly assign patients to the groups and instead uses some other criteria for patient allocation. This type of group allocation may introduce issues relating to selection bias.

interventions were excluded from the review as it was not possible to determine the independent effects of the warm water exercise intervention in these studies.

Types of outcome measures

Outcomes of interest were pain, physical function and quality of life. Outcome measures were also required to be responsive for measuring change in pain, physical function, quality of life and disability in people with arthritis[16] and other musculoskeletal conditions[17, 18], and be scored on a 0 to 100 scale or able to be accurately converted to this. When two outcome measures were available for the outcomes of interest, only one was included in the meta-analysis. Generic (non-disease or condition specific) outcome measure were prioritised for inclusion in the meta-analysis followed by disease specific measures based on priority lists defined by the prior Cochrane systematic review[1]. The list of outcome measures which met the inclusion criteria are listed in Box 1 in descending order of priority.

Box 1: Outcome measures eligible to be included in the meta-analysis

Pain
VAS-Pain (Visual Analogue Scale), HAQ-Pain (Health Assessment Questionnaire), SF-36-Pain (Short Form), SF-12-Pain, EQ-5D-Pain (European Quality of Life-5 Dimensions), BPI (Brief Pain Inventory), Functional Capacity Evaluation-Pain, WOMAC-Pain (Western Ontario and McMaster Universities Osteoarthritis Index), AIMS-Pain (Arthritis Impact Measurement Scale), KOOS-Pain (Knee Injury and Osteoarthritis Outcome Score), FIQ-Pain (Fibromyalgia Impact Questionnaire)
Physical function
HAQ-Function, DRI (Disability Rating Index), SF-36-Function, SF-12-Physical function, EQ-5D-Mobility, Functional Capacity Evaluation-ADLs, FAP-Score (Functional Ambulation Performance), SPFScale (Summary Physical Function), AAP (Adelaide Activities' Profile), WOMAC-Function, AIMS-2- Physical Activity, KOOS -ADLs , ASEQ-Function (Arthritis Self-Efficacy Questionnaire), OP functional disability questionnaire (functional abilities domain), FIQ-Function
Quality of life (QoL)
EQ-5D, SF-36 and SF-12 ("physical function"), AQoL, PQOL (Perceived Quality Of Life Scale), QWB (Quality of Well-Being Scale), GSI (Global Self-Rating Index), AIMS-2-Affect, OQoL and arthritis QoL scale total scores, KOOS-QoL,

Data extraction

Two reviewers independently extracted data for the included studies using a structured tool. Baseline demographic data (age, sex, and musculoskeletal condition), intervention characteristics (exercise components, duration, and frequency) and outcome data were extracted from included trials. Outcome data was extracted for one time point; the first follow-up post-intervention. To compare effectiveness of warm water exercise versus comparator interventions for each outcome of interest, point and variability estimates for differences in outcomes across groups were extracted. When necessary, the standard deviation [SD] was approximated by dividing the inter-quartile range by 1.35, and medians were used as best estimates of means.

Quality Assessment

All included studies were critically appraised using the Physiotherapy Evidence Database (PEDro)[19] scale to assess the methodological quality. This scale rates 11 aspects of methodological quality of RCTs as being either absent or present (Box 2). As the first item (eligibility criteria) is not scored, the total score ranges

from 0 to 10[19]. Studies that obtain a score of <6 points are considered as low quality, while those with a score ≥6 points are considered high quality[20]. All eligible studies were independently assessed by two researchers with the PEDro scale, with discrepancies resolved by a third.

Box 2: PEDro scale for assessing study methodological quality

1. Eligibility criteria *(does not contribute to total score)*
2. Random allocation
3. Concealed allocation
4. Baseline comparability
5. Blind subjects
6. Blind therapists
7. Blind assessors
8. Adequate follow-up
9. Intention-to-treat analysis
10. Between-group comparisons
11. Point estimates and variability

Statistical Analysis

A meta-analysis was conducted using pooled data and described as standardised mean differences [SMD] and 95% confidence intervals [CI] to assess intervention effects on the outcomes defined in Box 1. The SMD was the difference between two means normalised using either pooled or control group standard deviations (the former where no significant difference in control and intervention standard deviations was observed). This index is useful for comparing data collected using different scales[21]. Outcome data was excluded from the meta-analysis if there were significant difference in baseline scores of the outcome of interest to ensure SMD in post-intervention scores were not confounded by baseline differences. A SMD of less than 0.2 was considered a small effect, between 0.2 and 0.8 a moderate effect and greater than 0.8 a large effect[22]. Heterogeneity between studies was assessed using the I^2 statistic which shows the proportion of total variance that is explained by heterogeneity[23]. Statistical heterogeneity was considered substantial if I^2 was greater than 50%, and in this event a random effects model was applied; otherwise a fixed-effects model was used[21]. Scale directions were aligned by adding negative values where required. Meta-analysis was performed using Review Manager (RevMan5.2) software.

A separate meta-analysis was run for each outcome and comparator options (1. No exercise and 2. Land based exercise). For each meta-analysis, a secondary analysis was conducted that excluded studies of low methodological quality (PEDro score < 6) so that estimates of effect could be established that avoided distortion probable from inclusion of findings from low quality studies.

REVIEW FINDINGS

What types of studies were included in the review?

The electronic search identified 1199 potential studies for screening of eligibility after duplicate studies were removed. Of these, 1136 studies were excluded based on title and abstract. The full text was obtained for the remaining 63 studies. Based on the reviewer's decisions, 32 studies were excluded after full text review as they did not meet inclusion criteria and 30 studies were included in the review (Figure 1).

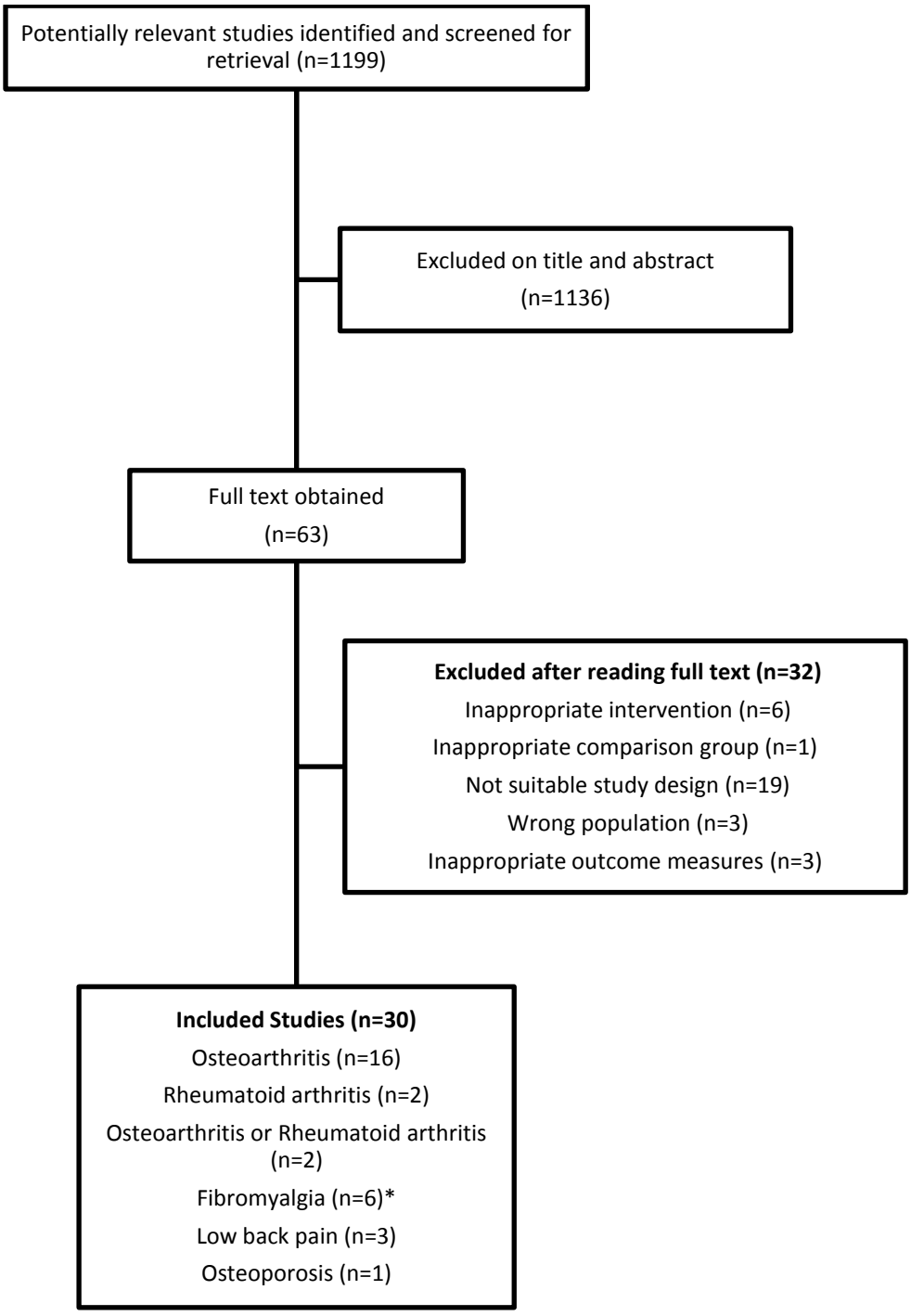

Figure 1: Flow chart of exclusion process

**Note: One study consisted of 2 publications reporting on different outcome measures and was recorded as one study in this review.*

Description of included studies

Study design and participants

The 30 included studies consisted of 28 RCTs and 2 quasi-randomised controlled trials. Of these studies, 16 were conducted in people with osteoarthritis, 2 in people with rheumatoid arthritis, 2 in people with osteoarthritis or rheumatoid arthritis, 6 in people with fibromyalgia, 3 in people with low back pain and 1 in people with osteoporosis. Twenty-two studies compared warm water exercise to a non-active control group, and 15 to some form of land based exercise (7 studies included both non-active and land based exercise comparisons). Participants were typically older with 18 of the 30 studies including participants with an average age older than 60 years. The majority of studies reported on pain and physical function outcomes. Table 2 provides a summary of these studies.

Methodological quality

Methodological quality of the included studies was variable. The median score for methodological quality using the PEDro scale was 6 of 10 (range: 3 to 8). However, 21 of the 30 studies were assessed as being high quality (PEDro score ≥6). Common methodological limitations identified across studies included omission of reporting if analysis was performed on an intention to treat basis and a lack of reporting of allocation concealment. None of the included studies blinded participants or therapists who administered the interventions; however this is often not possible in studies evaluating exercise interventions. Most of the included studies also only had a small number of participants which may also limit the rigor and generalisability of the study findings.

Warm water exercise program characteristics

Table 3 provides a summary of the warm water exercise program characteristics. There was much variability across the included studies in terms of the total intervention duration (3 to 52 weeks), frequency (1-7 times per week) and class duration (30 to 60 minutes). Variability was also observed for the types of exercises included in programs; however it was common for programs to include warm-up, strength, stretching, range of motion, aerobic and cool-down exercises.

Participation

Twelve of the included studies reported on participation outcomes expressed as a simple % or average number of warm water exercise sessions attended during the follow-up period (Table 1). Participation rates for the warm water exercise classes were high and for the included studies that reported on participation, participation in warm water exercise sessions was greater than land based exercise sessions. This highlights that warm water exercise is appealing to people with arthritis or other musculoskeletal conditions.

Table 1: Participation in warm water exercise and land based exercise sessions

	Warm water exercise participation (% or average number of sessions attended)	Land based exercise participation (% or average number of sessions attended)
Arnold et al. (2008)	69%	67%
Arnold et al. (2010)	Warm water exercise alone: 65% Warm water exercise +education:74%	-
Cochrane et al. (2005)	59%	-
Foley et al. (2003)	84%	75%
Fransen et al. (2007)	81%*	61%*
Gill et al. (2009)	10.5/12	9.8/12
Hale et al. (2012)	75%^	-
Hinman et al. (2006)	99%	-
Lund et al. (2008)	:92%	85%
Munguia-Izquierdo et al. (2008)	88%	-
Patrick et al. (2001)	29%†	-
Tomas-Carus et al. (2007)	100%‡	-

* % that attended 50% or more of the classes ^ % that attended 80% or more of the classes
† % that attended at least twice per week for at least 16 weeks ‡ % that attended more than 95% of the classes

Table 2: Study design and quality assessment

	Diagnosis	Comparator		Number of subjects randomised			Age, Mean (SD)			Outcomes assessed			Follow-up (weeks)	PEDro Score (0-10)
		LB	C	AE	LB	C	AE	LB	C	Pain	PF	QoL		
Arnold et al. (2008)	OP	✓	✓	21	20	27	68.6 (5.4)	69.1 (6.3)	67.7 (6.3)	×	✓	✓	20	6
Arnold et al. (2010)	OA hip		✓	27		27	74.4 (7.5)		75.8 (6.2)	×	✓	×	11	7
Belza et al. (2002)	OA		✓	125		124	65.98 (5.94)		66.09 (6.16)	✓	✓	✓	20	5
Cadmus et al. (2010)	OA hip/knee		✓	124		125	65.7 (5.9)		66.0 (6.1)	✓	✓	✓	20	4
Cochrane et al. (2005)	OA lower limbs		✓	153		159	69.86 (6.82)		69.63 (6.26)	✓	✓	✓	26	7
Dundar et al. (2009)	LBP	✓		32	33		35.3 (7.8)	34.8 (8.3)		✓	✓	✓	8	6
Evcik et al. (2008)	FM	✓		31	30		43.8 (7.7)	42.8 (7.6)		✓	✓	×	20	5
Eversden et al. (2007)	RA	✓		57	58		55.2 (13.3)	56.1 (11.9)		✓	✓	✓	12	7
Foley et al. (2003)	OA hip/ knee	✓	✓	35	35	35	73.0 (8.2)	69.8 (9.2)	69.8 (9.0)	✓	✓	✓	6	7
Fransen et al. (2007)	OA hip/ knee	✓	✓	55	56	41	70.0 (6.3)	70.8 (6.3)	69.6 (6.1)	✓	✓	✓	24	8
Gill et al. (2009)	OA & RA	✓		42	44		71.6 (8.9)	69.2 (10.5)		✓	✓	×	8	6
Gusi et al. (2006)	FM		✓	18		17	51 (10.0)		51 (9.0)	✓	✓	✓	12	6
Hale et al. (2012)	OA		✓	23		16	73.6 (1.5)		75.7 (1.1)	✓	✓	×	13	8
Hall et al. (1996)	RA	✓		35	34		55.8 (12.5)	59.5 (11.0)		✓	×	✓	12	6
Han et al. (2011)	LBP		✓	9		10	61.2 (3.3)		60.8 (5.0)	✓	×	×	10	5
Hinman et al. (2007)	OA hip/ knee		✓	36		35	63.3 (9.5)		61.5 (7.8)	✓	✓	✓	6	8
Lim et al. (2010)	Obesity/ OA knee	✓	✓	26	25	24	65.7 (8.9)	63.3 (5.3)	63.3 (5.3)	✓	✓	✓	8	7
Lund et al. (2008)	OA knee	✓	✓	27	25	27	65 (12.6)	68 (9.5)	70 (9.9)	✓	✓	✓	12	6
McIlveen et al. (1998)	LBP		✓	56		54	57.2 (15.2)		58.4 (15.0)	✓	✓	×	4	3
Munguia-Izquierdo et al. (2008)	FM		✓	35		25	50 (7)		46 (8)	✓	✓	×	52	8
Patrick et al. (2001)	OA hip/ knee		✓	125		124	65.7		66.1	✓	✓	✓	20	6
Silva et al. (2008)	OA knee	✓		32	32		59 (7.60)	59 (6.08)		✓	✓	×	18	7
Stener-Victorin et al. (2004)	OA hip		✓	15		15	70.3		65.5	✓	✓	✓	26	4
Suomi & Collier (2003)	OA & RA	✓	✓	11	11	10	68.0 (6.8)	64.2 (3.3)	68.3 (6.2)	✓	✓	×	8	4
Tomas-Carus et al. (2007)	FM		✓	18		17	51 (10)		51 (9)	✓	✓	✓	12	5
Tomas-Carus et al. (2008)	FM		✓	17		16	50.7 (10.6)		50.9 (6.7)	✓	✓	×	32	7
Vitorino et al. (2006)	FM	✓		25	25		48.9 (9.2)	46.6 (8.4)		✓	✓	✓	3	7
Wang et al. (2007)	OA hip/ knee		✓	21		21	69.3 (13.3)		62.7 (10.7)	✓	✓	×	12	6
Wang et al. (2011)	OA knee	✓	✓	28	28	28	66.7 (5.6)	68.3 (6.4)	67.9 (5.9)	✓	✓	✓	12	7
Wyatt et al. (2001)	OA knee	✓		23	23		-	-		✓	✓	×	6	6

LB=Land based exercise C=Non-active control AE=Warm water PF=Physical function QoL=Quality of life SD=Standard deviation

OA=Osteoarthritis RA=Rheumatoid arthritis FM=Fibromyalgia LBP=Low back pain OP=Osteoporosis

Table 3: Warm water exercise program overview

(High quality studies where warm water exercise was found to be effective at reducing pain or improving physical function or quality of life)

	Duration (weeks)	Sessions/ week	Exercises Components									Intensity
			WU	Strength	Stretch	Aerobic	ROM	Bal	Core	Relax	CD	
Arnold et al. (2008)	20	50 min x 3	✓	✓	-	-	✓	✓	✓	-	✓	Moderate (12-14/20 RPE)
Arnold et al. (2010)	11	45 min x 2	✓	✓	✓	-	✓	✓	✓	✓	✓	-
Belza et al. (2003)	20	60 min x 1-7	-	✓	✓	-	✓	-	-	-	-	-
Cadmus et al. (2010)	20	45-60 min x 2-5	-	✓	-	✓	✓	-	-	-	-	-
Cochrane et al.(2005)	52	60 min x 2	✓	✓	✓	✓	✓	✓	-	-	-	Low to moderate
Dundar et al. (2009)	4	60 min x 5	✓	✓	✓	✓	✓	-	-	✓	✓	-
Evcik et al. (2008)	5	60 min x 3	✓		✓	✓	✓	-	-	✓	✓	-
Eversden et al. (2007)	6	30 min x 1	✓	✓	✓	-	✓	-	-	-	✓	-
Foley et al. (2003)	6	30 min x 3	✓	✓	✓	✓	✓	-	-	-	-	Individualised
Fransen et al. (2007)	12	60 min x 2	✓	✓	-	✓	✓	✓	-	-	-	-
Gill et al. (2009)	6	60 min x 2	-	✓	✓	✓	✓	✓	-	-	-	Moderate (12-14/20 RPE)
Gusi et al. (2006)	12	60 min x 3	✓	✓	-	✓	✓	-	-	-	✓	65-75% of max HR
Hale et al. (2012)	12	60 min x 2	✓	✓	✓	✓	✓	✓	-	-	✓	Self-paced
Hall et al. (1996)	4	30 min x 2	-	✓	-	-	✓	-	-	-	-	Individualised
Han et al. (2011)	10	50 min x 5	✓	-	-	✓	✓	-	-	✓	✓	-
Hinman et al. (2006)	20	45-60 min x 2	✓	✓	-	✓	✓	✓	✓	-	✓	Individualised
Lim et al. (2009)	8	40 min x 3	✓	✓	-	✓	-	-	-	-	✓	>65% of maximum HR
Lund et al. (2008)	8	50 min x 2	✓	✓	✓	-	-	✓	✓	-	✓	-
McIlveen et al. (1998)	4	60 min x 2	✓	✓	✓	✓	-	-	-	-	-	-
Munguia-Izquierdo et al. (2008)	16	60 min x 3	✓	✓		✓				✓	✓	50-60% to 70-80% of max HR
Patrick et al. (2001)	20	45-60 min x 2-7	-	✓	✓	-	✓	-	-	-	-	-
Silva et al. (2008)	18	50 min x 3	-	✓	✓	-	-	-	-	-	-	
Stener et al. (2004)	5	30 min x 2	✓	✓	✓	-	✓	-	-	-	-	Below pain
Suomi & Collier (2003)	8	45 min x 2	-	✓	-	-	✓	-	-	-	-	-
Tomas-Carus et al. (2007)	12	60 min x 3	✓	✓	-	✓	✓	-	-	-	✓	65-75% of max HR
Tomas-Carus et al. (2008)	32	60 min x 3	✓	✓	-	✓	✓	-	-	-	✓	60-65% of max HR
Vitorino et al. (2005)	3	60 min x 3	✓	-	✓	✓	-	-	-	✓	✓	-
Wang et al. (2006)	12	60 min x 3	✓	✓	✓	✓	-	-	-	-	✓	2-3/10 RPE increasing to 4/10
Wang et al. (2011)	12	60 min x 3	✓	✓	✓	✓	-	-	-	-	✓	-
Wyatt et al. (2001)	6	NR x 3	-	✓	-	✓	✓	-	-	-	-	-

RPE=Rating of perceived exertion using Borg scale -= Not reported in the publication. This may have been included in the program however was not reported in the publication.
HR=Heart rate

Effects of warm water exercise on pain, physical function and quality of life

Of the 30 studies included in this review, 26 met the criteria for inclusion in the meta-analysis. The majority of studies were conducted in people with osteoarthritis (54%; 14 studies) and reported on pain and physical function outcomes (Table 4).

Table 4: Summary of studies included in the review

	Number of studies		Pain		Physical function		Quality of life	
	All	Meta-analysis	All	Meta-analysis	All	Meta-analysis	All	Meta-analysis
Osteoarthritis	16	14	15	14	16	11	11	9
Rheumatoid Arthritis	2	2	2	2	1	2	2	2
Osteoarthritis or Rheumatoid Arthritis	2	2	2	-	2	1	-	-
Fibromyalgia	6	5	6	3	6	4	3	-
Low Back Pain	3	2	3	2	2	1	1	-
Osteoporosis	1	1	0	-	1	1	1	1
	30	26	28	21	28	20	18	12

The following sections present the results of the meta-analysis. Results are presented under each of the studied outcomes of pain, physical function and quality of life including a forest plot for each analysis undertaken.

Forest plots of effects

A forest plot is a graphical display designed to illustrate the relative strength of treatment effects in multiple quantitative studies addressing the same question. Forest plots include the names of the studies listed on the left side along with information relating to the study effects (mean and standard deviation of the outcome score), and participant numbers for each comparator group. On the right side of each study text is a horizontal line for the measure of effect (standardised mean difference) for each study. The line includes a box for the estimate of effect with the lines either side of the box representing the confidence intervals for this estimate.

The meta-analysed measure of effect which combines the information from each of the effects reported for studies included in the analysis, is plotted as a diamond, the lateral points of which indicate confidence intervals for this estimate. The center of the forest plot has a vertical line representing no effect. If the confidence intervals for individual studies overlap with this line, it demonstrates that at the given level of confidence their effect sizes do not differ from no effect for the individual study. The same applies for the meta-analysed measure of effect—if the points of the diamond overlap the line of no effect the overall meta-analysed result cannot be said to differ from no effect at the given level of confidence.

In this meta-analysis two comparator groups were included—land based exercise and no exercise. The comparator included in the meta-analysis is listed at the bottom of the plot. The horizontal lines for the estimate of effect of each study and the diamond representing the meta-analysed measure of effect are positioned either side of, or crossing the vertical no-effect line. For physical function and quality of life outcomes, higher scores indicate improved health and studies which favour warm water exercise over the comparator for these outcomes are positioned on the right side of the no effect line. For pain outcomes, lower scores indicate improved health (i.e. a reduction in pain). Therefore, studies which favour warm water exercise over the comparator for pain are positioned on the left side of the no effect line.

Pain

Warm water exercise compared to no exercise (non-active control)

Fifteen studies were included in the meta-analysis of pain outcomes for warm water exercise compared to no exercise (non-active control). These included studies in osteoarthritis (11 studies), rheumatoid arthritis (1 study), fibromyalgia (2 studies) and low back pain (1 study) populations.

There was significant heterogeneity detected for studies reporting on pain outcomes that compared warm water exercise to non-active controls (I^2=53%). When a random-effects analysis was applied, compared to non-active controls, warm water exercise achieved a moderate reduction in pain (SMD -0.37, 95% CI -0.56 to -0.18) and effects were comparable across populations (test for sub-group differences P=0.07) (

Figure 2).

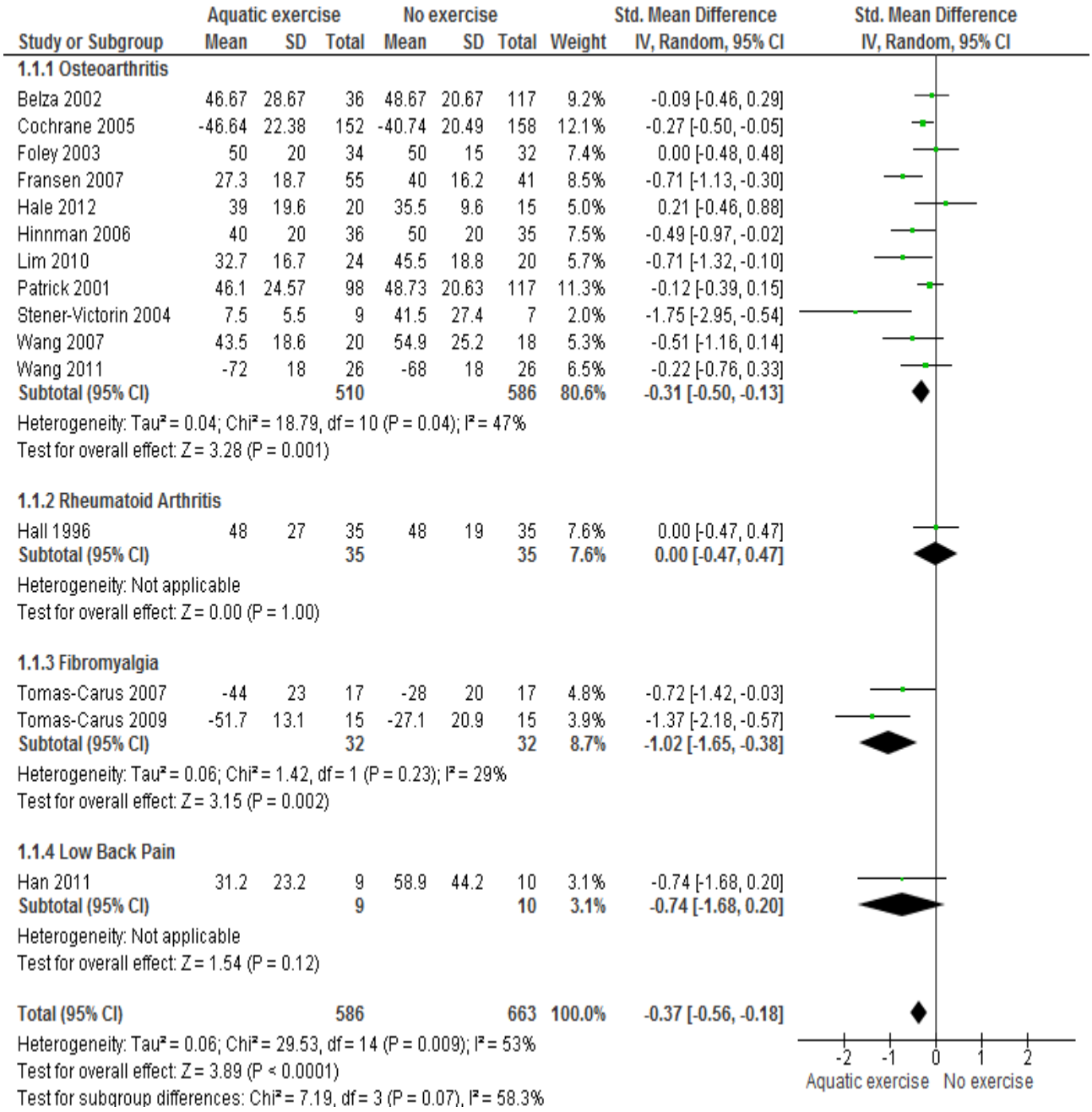

Figure 2: Meta-analysis of pain comparing warm water exercise to no exercise

When the meta-analysis was repeated excluding low methodological quality studies (4 studies with PEDro score < 6)[24-

[27] there was no appreciable difference in the effect on pain with a moderate reduction in pain persisting (SMD -0.33, 95% CI -0.53 to -0.13).

Warm water exercise compared to land based exercise

Ten studies were included in the meta-analysis of pain outcomes for warm water exercise compared to land based exercise. These included studies in osteoarthritis (6 studies), rheumatoid arthritis (2 studies), fibromyalgia (1 study) and low back pain (1 study) populations.

There was no significant heterogeneity detected for studies reporting on pain outcomes that compared warm water exercise to land based exercise (I^2=50%). When a fixed-effects analysis was applied, compared to land based exercise, warm water exercise achieved a small non-significant reduction in pain (SMD -0.11, 95% CI -0.27 to 0.04) and effects were comparable across osteoarthritis, rheumatoid arthritis, fibromyalgia and low back pain populations (test for sub-group differences P=0.18) (

Figure 3). Of note, a significant reduction in pain was observed for the fibromyalgia population (SMD -0.51 95% CI -1.02 to 0.00), however these results are from one study only.

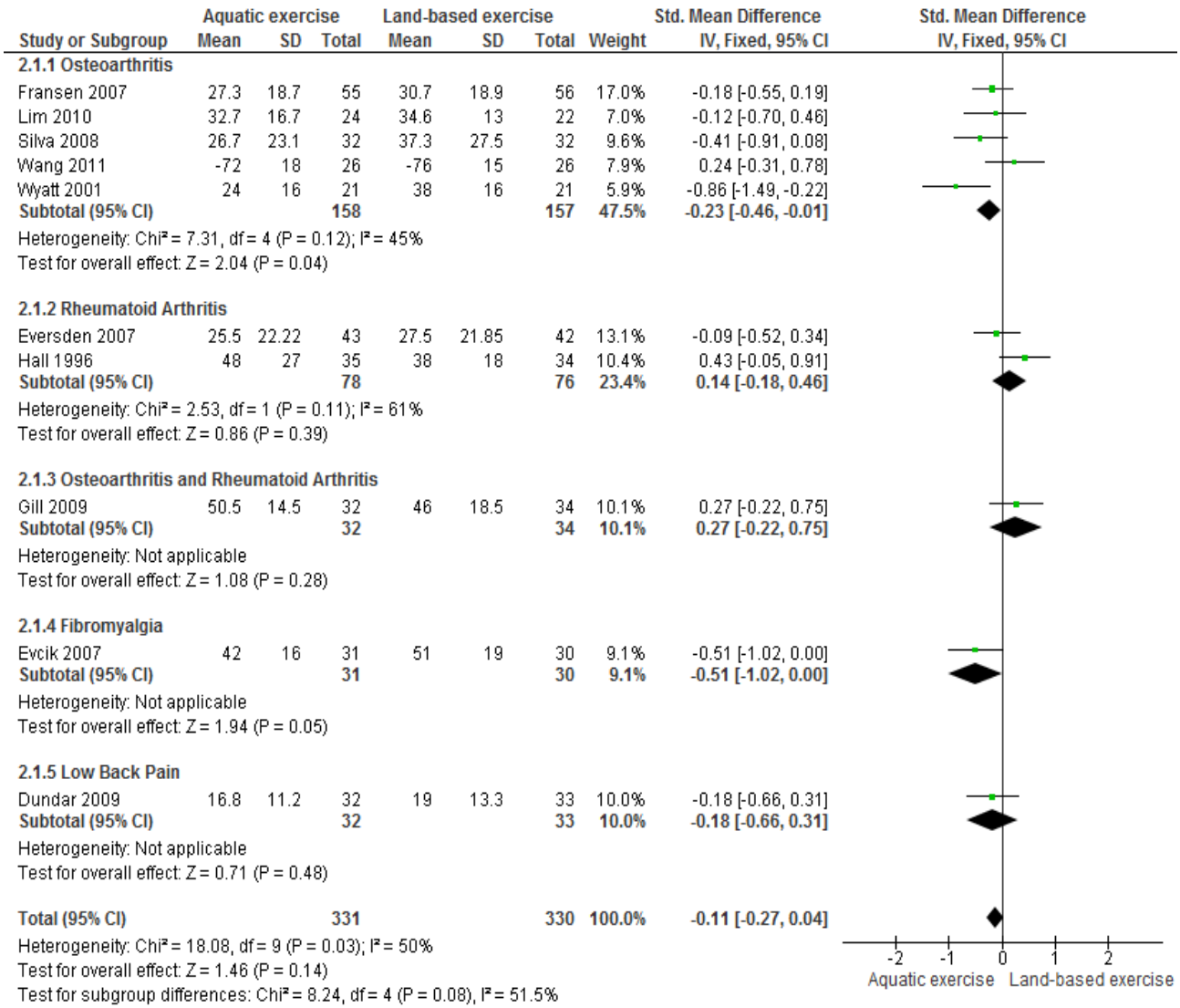

Figure 3: Meta-analysis of pain comparing warm water to land based exercise

When the meta-analysis was repeated excluding low methodological quality studies (1 study with PEDro score <6)[28], there was no appreciable difference in effects on pain in the warm water exercise group compared to the land based exercise group (SMD -0.08, 95% CI -0.24 to 0.09).

Physical function

Warm water exercise compared to no exercise (non-active control)

Fourteen studies were included in the meta-analysis of physical function outcomes for warm water exercise compared to no exercise (non-active control). These included studies in osteoarthritis (9 studies), rheumatoid arthritis (1 study), fibromyalgia (3 studies) and osteoporosis (1 study) populations.

There was significant heterogeneity detected for studies reporting on physical function outcomes that compared warm water exercise to non-active controls (I^2=53%). When a random-effects analysis was applied, compared to non-active controls, warm water exercise achieved a moderate improvement in physical function in favour of warm water exercise (SMD 0.32, 95% CI 0.13 to 0.51). There was some evidence of a difference of effects across the included condition types (test for sub-group differences P=0.02) with the one study conducted in people with osteoporosis favouring the non-active control (

Figure 4).

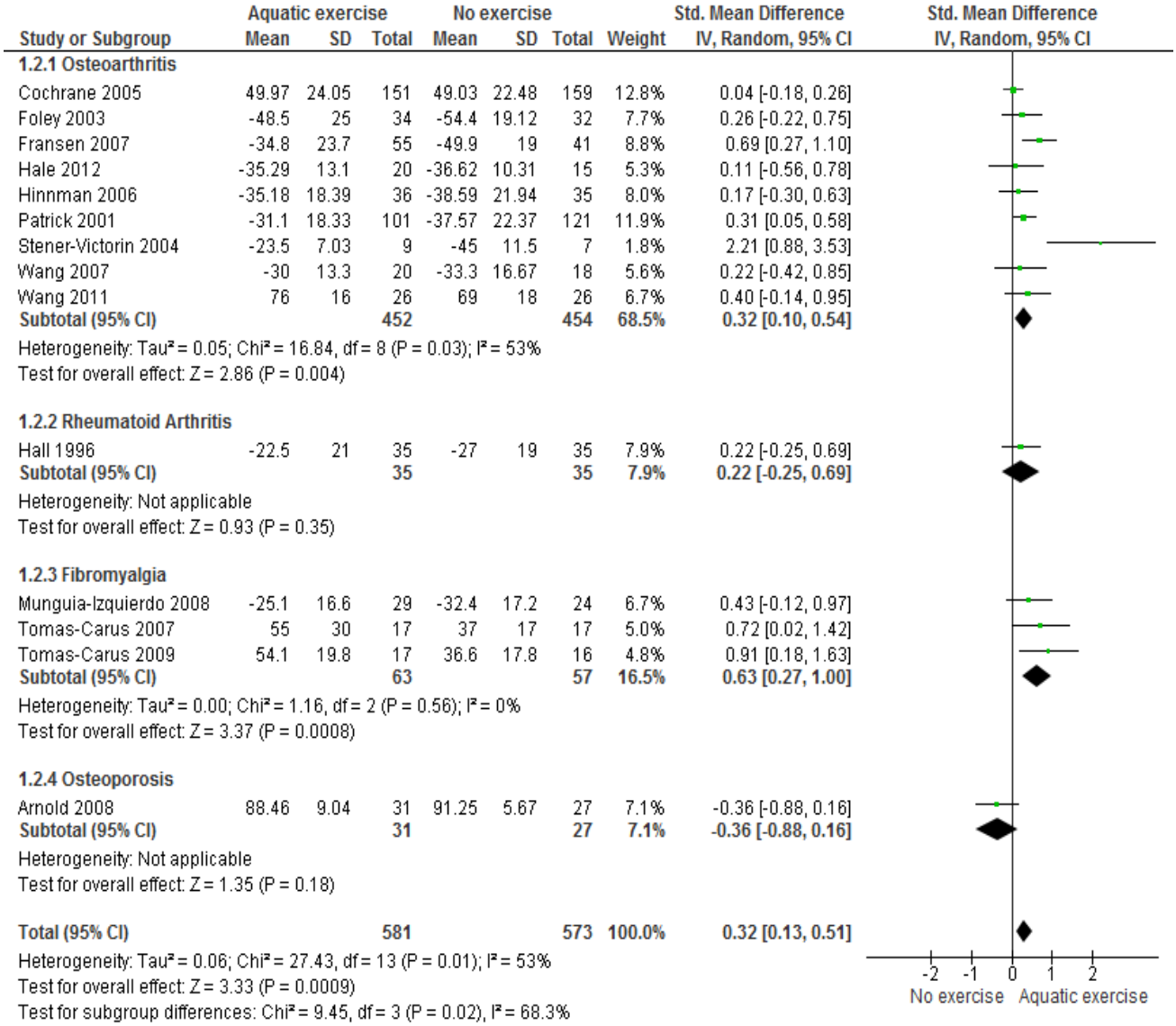

Figure 4: Meta-analysis of physical function comparing warm water exercise to no exercise

When the meta-analysis was repeated excluding low methodological quality studies (2 studies with PEDro score < 6)[25, 29] there was no appreciable difference in the effect on physical function with a finding of a moderate improvement in physical function persisting (SMD 0.23, 95% CI 0.11 to 0.35).

Warm water exercise compared to land based exercise

Ten studies were included in the meta-analysis of physical function outcomes for warm water exercise compared to land based exercise. These included studies in osteoarthritis (4 studies), rheumatoid arthritis (2 studies), osteoarthritis or rheumatoid arthritis (1 study), fibromyalgia (1 study), low back pain (1 study) and osteoporosis (1 study) populations. There was no significant heterogeneity detected for studies reporting on physical function outcomes that compared warm water exercise to land based exercise (I^2=38%). Applying a fixed-effects analysis, when compared to land based exercise, warm water exercise achieved comparable effects on physical function (SMD -0.03, 95% CI -0.19 to 0.12) and this effect was consistent across osteoarthritis, rheumatoid arthritis, fibromyalgia low back pain and osteoporosis populations (test for sub-group differences P=0.08) (

Figure 5). Of note, a significant effect was observed for physical function for the low back pain population (SMD 0.51 95% CI 0.02 to 1.01), however these results are from one study only.

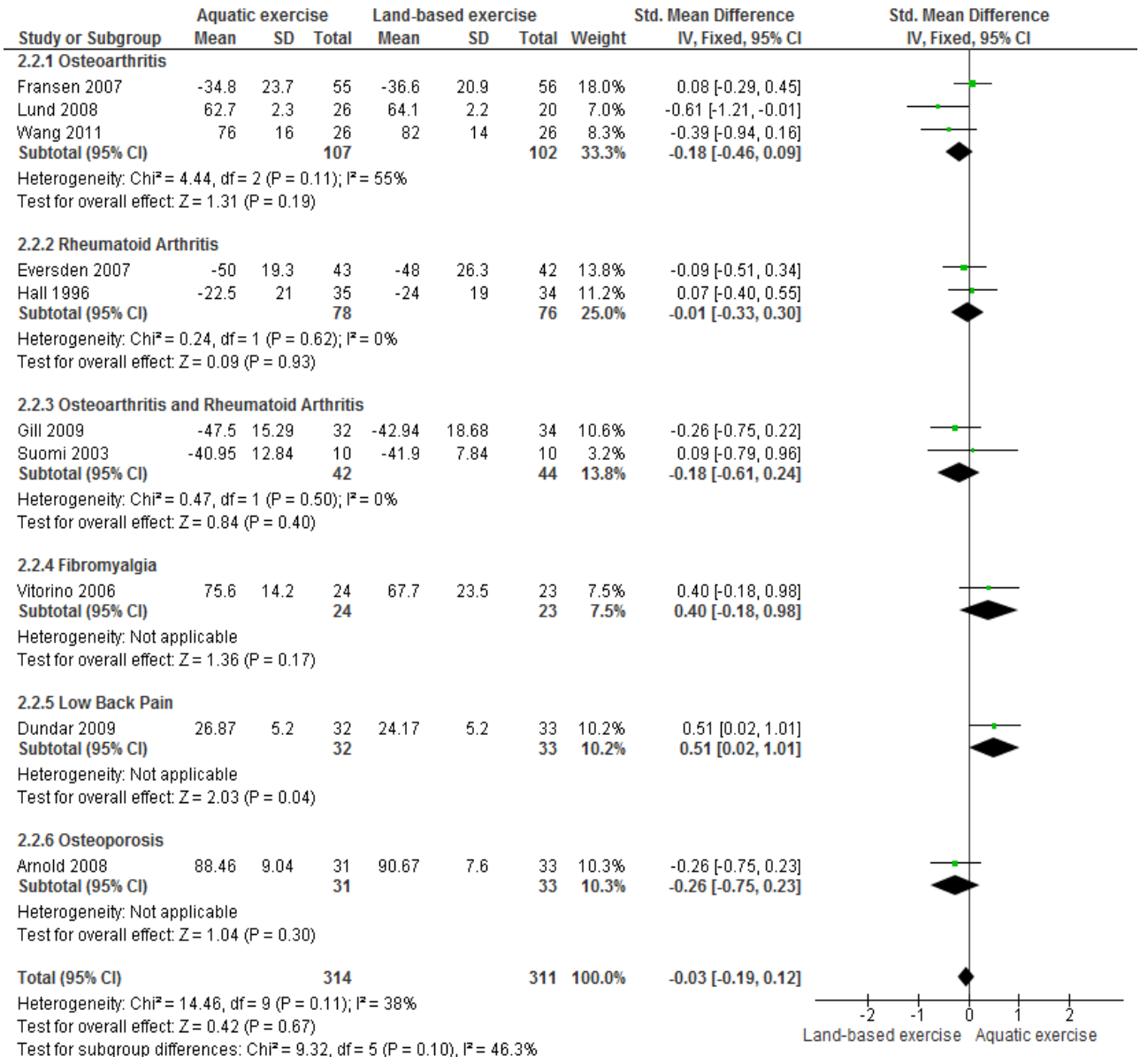

Figure 5: Meta-analysis of physical function comparing warm water to land based exercise

When the meta-analysis was repeated excluding low methodological quality studies (1 study with PEDro score < 6)[30] there was no appreciable difference in the effect on physical function with a finding of a comparable effect for warm

water and land based exercise persisting (SMD -0.04, 95% CI -0.20 to 0.12).

Quality of life

Warm water exercise compared to no exercise (non-active control)

Eleven studies were included in the meta-analysis of quality of life outcomes for warm water exercise compared to no exercise (non-active control). These included studies in osteoarthritis (9 studies), rheumatoid arthritis (1 study) and osteoporosis (1 study) populations.

There was significant heterogeneity detected for studies reporting on quality of life outcomes that compared warm water exercise to non-active controls (I^2=78%). When a random-effects analysis was applied, warm water exercise achieved moderate improvements in quality of life compared to non-active controls (SMD 0.39, 95% CI 0.06 to 0.73). There was some evidence of a difference of effects across the included condition types (test for sub-group differences P=0.02). Whilst a moderate improvement in quality of life was observed in studies conducted in osteoarthritis populations (SMD 0.53, 95% CI 0.17 to 0.88), no significant effect was observed in osteoporosis or rheumatoid arthritis populations however there was only one study included for each of these conditions (

Figure 6).

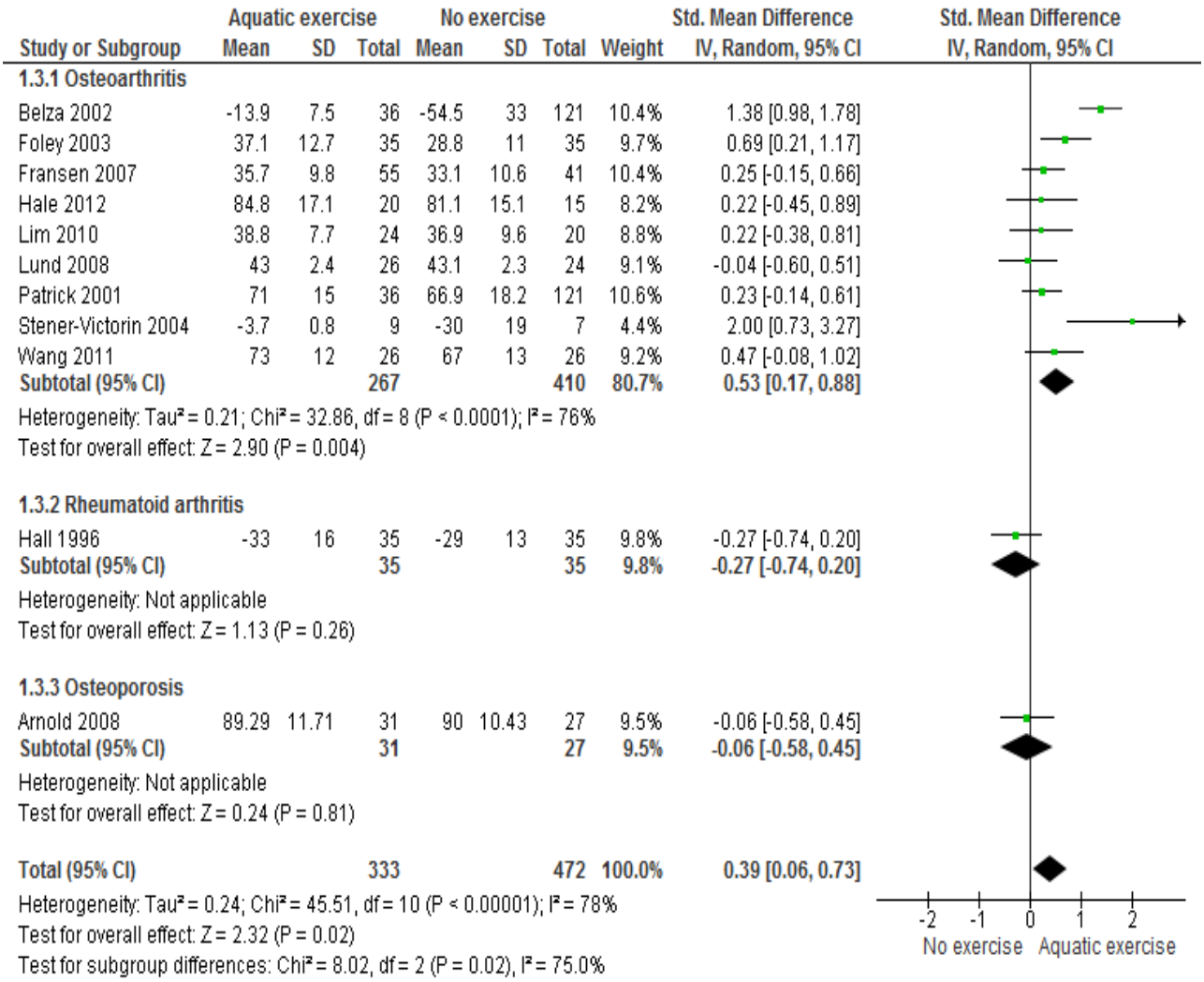

Figure 6: Meta-analysis of quality of life comparing warm water exercise to no exercise

When the meta-analysis was repeated excluding low methodological quality studies (2 studies with PEDro score < 6)[24, 25] there was no appreciable difference in the effect on quality of life with a finding of a smaller but consistent improvement persisting (SMD 0.19, 95% CI 0.03 to 0.36).

Warm water exercise compared to land based exercise

Seven studies were included in the meta-analysis of quality of life outcomes for warm water exercise compared to land based exercise. These included studies in osteoarthritis (4 studies), rheumatoid arthritis (2 studies) and osteoporosis (1 study) populations.

There was no significant heterogeneity detected for studies reporting on quality of life outcomes that compared warm water exercise to land based exercise (I^2=12%). When a fixed-effects model analysis was applied, compared to land based exercise, warm water exercise achieved comparable improvements in quality of life (SMD -0.10, 95% CI -0.29 to 0.09) (

Figure 7). These effects were consistent across osteoarthritis, rheumatoid arthritis and osteoporosis populations (test for sub-group differences P=0.47).

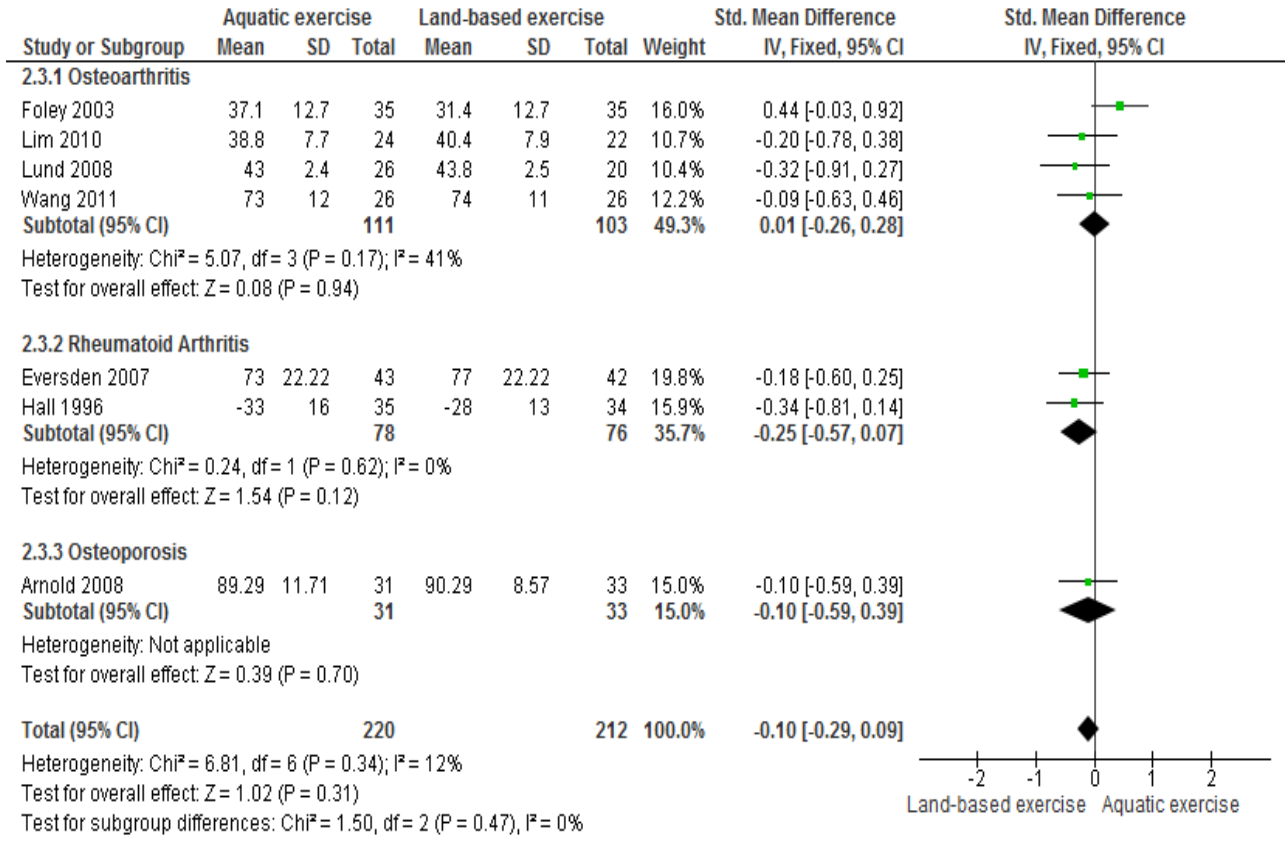

Figure 7: Meta-analysis of quality of life comparing warm water exercise to land based exercise

All studies reporting on quality of life were of high methodological quality (PEDro score ≥ 6).

Characteristics of effective warm water exercise programs

Table **3** summarises the characteristics of warm water programs tested in the studies included in this review. The high quality studies which found a positive effect with warm water exercise on pain, physical function or quality of life compared to no exercise or land based exercise are highlighted. Table 5 summarises the exercises included in the warm water programs of the high quality studies that reported a positive outcome. There was considerable variability between studies in key program characteristics such as duration of programs and the exercises included. Unfortunately, many studies did not provide adequate descriptions of the exercises included. However, when the characteristics of the programs and exercises of the highest quality effective programs were reviewed some common characteristics were evident:

- Warm water exercise classes were commonly performed two or more times per week and were of 60 minutes in duration;
- Programs ran for at least 6 weeks (range: 6 to 52 weeks);
- There was a focus on lower-limb strengthening exercises and equipment such as floats, weights, paddles or elastic tubing was often used to increase the load during strengthening exercises;
- Squats, step-ups or other exercises that focused on hip and knee extension were commonly included in programs; and
- Aerobic activities such as running and cycling were also commonly used with a target of >65% of maximum heart rate.

There is some evidence from a small number of studies that suggest that the inclusion of education[31] and balance exercises[32-34] may provide additional benefits.

Three studies included in this review included an education component. The details of the education components are summarised in Box 3. In the study by Arnold and colleagues, adding education and cognitive-behavioural activities such as goal setting appeared to increase participation in warm water exercise classes from 65% (warm water exercise only) to 74% (warm water exercise and education and goal setting activities)[31].

Box 3: Summary of education components included in studies of the effectiveness of warm water exercise for people with musculoskeletal conditions

Arnold et al (2010)[31]	30 minute session each week prior to warm water exercise class conducted by a physiotherapist. Sessions aimed to increase the transfer of exercises learned in the pool to the ability to perform activities of daily living and to increase knowledge of falls risk factors and fall prevention strategies. Participants were provided with a booklet that detailed the information provided in the sessions and were also encouraged to set exercise and falls prevention strategy goals. Sessions also included practice of functional tasks such as sit-to-stand, walking, dual-tasks and getting up and down from the floor. Sessions incorporated peer-support principles such as sharing goals and solutions.
Gill et al. (2009)[35]	60 minute session on the pathogenesis of advanced osteoarthritis and disability and the principles of healthy exercise at the start of the program. Participants also received a home visit and environmental assessment by an occupational therapist.
Stener-Victorin (2004)[25]	Two 120 minute sessions on hip anatomy and osteoarthritis. Information on activity and pain relief and hip arthoplasty surgery was provided.

Warm water exercise and falls prevention

It is widely acknowledged that falls in older people are a major concern in terms of frequency, disability, institutionalisation and mortality with an ever-growing socioeconomic burden[36]. An Australian study found

8% of women in their forties, 14% in their fifties, 25% in their sixties and 40% in their seventies had experienced a fall in the previous 12 months[37]. In older adults up to 30% of falls can result in moderate to severe injuries, such as lacerations, hip fractures and head trauma, resulting in an increased risk of early death[38]. A fall may lead to a fear of falling with avoidance of activities and social isolation resulting in a reduced quality of life and precipitate a move to residential care[39-41].

The link between exercise and decreased falls in older people living in the community can be considered well established[42]. A recent review[43] reported that specifically designed balance exercises can reduce falls by 38%. A simple way to include balance exercises in warm water exercise programs would be to integrate these into the walking and lower-limb exercises that are already performed in many sessions. Balance exercises require moving the body over a narrow base of support without hand support. Examples of balance exercises include toe, heel or heel-toe walking and hip ROM exercises performed without holding onto a rail or the side of the pool. Including balance exercises in warm water exercise classes would provide the added benefit of falls prevention which is advantageous considering these classes often include people at high risk of falling based on the age profile of participants.

Table 5: Types of exercises

	Strength										ROM			Stretches			Aerobic				
	Hip Flex/Ext	Hip Abd/Add	Knee Flex/Ext	Step-ups	Squats	Lunges	Calf raises	Upper limb	Lower limb other	Dosage Sets x Repetitions	Upper limb	Lower limb	Trunk	Upper limb	Lower limb	Dosage Repetitions x hold	Walking	Running	Jumping	Cycling	Other
Cochrane et al. (2005)								✓R	✓R	6-15 reps	✓				✓	1 -5 x 5-30 sec	✓				✓
Fransen et al. (2007)	✓R	✓R	✓R	✓	✓	✓	✓	✓		10-20 reps		✓	✓				✓R	✓		✓	
Hinman et al. (2006)		✓	✓	✓	✓	✓	✓			2 x 10 reps						-	✓				
Lim et al. (2009)	✓	✓			✓											-	✓	✓R		✓	
Tomas-Carus et al. (2009)			✓					✓R		4 sets of 10 reps	✓	✓		✓	✓		✓				✓
Wyatt et al. (2001)	✓	✓	✓		✓					-	✓					-	✓				

R=Resistance equipment used such as floats, weights, paddles or elastic tubing.

KEY LEARNINGS AND INSIGHTS

In summary the key messages that emerged from this review are:

- The evidence suggests warm water exercise has beneficial effects on pain, physical function and quality of life in adults with musculoskeletal conditions. These benefits appear comparable to those achieved with land based exercise.
- Gaps remain in our understanding of the characteristics (e.g. frequency, duration, intensity and exercises) of warm water exercise programs that provide the most benefit. However, based on the current evidence successful programs appear to include two sessions of 60 minute duration per week, run for at least 6 weeks, target strengthening of hip and knee extensors using resistance and weight-bearing exercises (e.g. squats) and include moderate intensity aerobic exercise.

Considerations arising from a small number of studies or the broader musculoskeletal and preventative healthcare evidence base include:

- **The addition of an education component may add value to the Arthritis and Osteoporosis Victoria warm water exercise programs**

  Education could be provided by Arthritis and Osteoporosis Victoria staff in a once-off session for participants on enrolment to Waves classes and augmented by information leaflets and follow-up face-to-face sessions following enrolment. Education could include information on the benefits of exercise and behaviour change strategies such as goal setting within a self-management framework. Information leaflets that are developed could also be distributed by the peer support groups to their warm water exercise participants.

- **The inclusion of balance exercises in warm water exercise classes has potential to provide wider health benefits in terms of falls prevention to warm water exercise participants**

  A simple way to include balance exercises would be to integrate these into the walking and lower-limb exercises that are already performed in many sessions. Balance exercises require moving the body over a narrow base of support without hand support. Examples of balance exercises include toe, heel or heel-toe walking and hip ROM exercises performed without holding onto a rail or the side of the pool.

SUMMING IT UP

The academic literature should be considered an important input into overall service planning and improvement. This is the first meta-analysis that has assessed the effectiveness of warm water exercise programs for musculoskeletal conditions. The evidence suggests warm water exercise has beneficial effects on pain, physical function and quality of life in adults with arthritis and musculoskeletal conditions. Importantly, these results persisted when low quality studies were removed from the analysis. Improvements in pain and physical function effects were also observed to be mostly consistent across the different musculoskeletal conditions included in studies that contributed to the meta-analysis.

Outcomes for adults with musculoskeletal conditions following warm water exercise appear comparable to land based exercise, therefore when people are unable to exercise on land, or find land based exercise difficult, warm water exercise programs provide an alternative strategy. The equivalent benefits observed with warm water and land based exercise also indicate that patients can choose the exercise mode that appeals most to them. This is an important finding as provision of patient choice in treatment interventions is known to improve patient outcomes[44] and participation which is a critical factor to intervention effectiveness.

There is some preliminary evidence to suggest that warm water exercise programs have the additional benefits of greater participation than land based programs. This attribute is appealing as acceptability of programs by consumers is a critical factor to program success and overall therapeutic benefits achieved. Participation is a critical measure of effectiveness as it represents acceptability of an intervention. Even if an intervention is effective, if it is not accepted by the target population it is of little benefit. A review of exercise adherence among people with osteoarthritis found that poor exercise participation is the most compelling explanation for the declining impact of the benefits of exercise over time[45]. Future studies should aim to explore patient preferences for warm water exercise compared to land-based exercise through the examination of barriers and enablers to access and acceptability of such programs.

All but one of the studies in this review tested a program where participants attended warm water exercise sessions two or more times a week. A recent RCT not included in this review studied the effects of an warm water exercise program with different frequencies (2 vs 3 times per week) in chronic low back pain patients[46]. A dose-response effect was observed in some outcomes, with greater improvements found in the participants attending the warm water exercise program three times per week compared with two[46]. Belza et al also observed that participants who attended the minimal amount of warm water exercise classes experienced smaller improvements in outcome measures compared to participants that attended classes more frequently[24]. Whilst these studies provide some insights into dose response relationship for warm water exercise and patient outcomes, more robust studies are required to more accurately determine the relative effects of different warm water frequencies.

Strengths of this review include a systematic search of more than 30 years of peer-reviewed literature with a rigorous approach to critical appraisal of study design, bias and contamination, outcome measures, methods of analysis and reporting. Despite this approach there remain limitations. Firstly, only RCTs published in English were included. Therefore, potentially relevant high quality studies with different designs or in other languages may have been excluded. In addition, searches were limited to published studies only. As there is a tendency for editors to publish studies with positive findings, this review may be subject to publication bias. Variability in study quality and exercise interventions (frequency and types of exercise) may also have contributed random error to outcomes. Of note, the aim of this literature review was to explore the benefits of warm water exercise in several different musculoskeletal clinical groups in the peer review literature. As such, this review was undertaken with a broad exploratory focus. This potential limitation needs to be acknowledged when considering the review findings. Future systematic review of the literature targeting specific clinical groups would be beneficial.

The studies included in this review demonstrate that warm water exercise can have positive short-term effects on pain, physical function and quality of life for people with musculoskeletal conditions. There is further need for high-quality, large scale studies of sufficient duration and an adequate follow-up period to validate the long-term effects of warm water exercise. To improve practice and decision making, further studies are needed that examine different modes, frequency, intensity and adherence of warm water exercise programs so the characteristics of programs that achieve maximum benefits are well understood. It is also not known whether warm water exercise improves the progression of conditions such as osteoarthritis or osteoporosis. Further studies should aim to investigate this and also to explore patient preferences for warm water exercise compared to land based exercise.

This review provides a comprehensive overview of the evidence for the effectiveness of warm water exercise and includes key recommendations for exercise prescription. On the basis of this evidence, it appears that the warm water exercise programs provided/supported by Arthritis and Osteoporosis Victoria are likely to decrease the burden of musculoskeletal associated illness through their beneficial effects on pain, physical function and quality of life in adults with arthritis and musculoskeletal conditions. Findings from this review can be used by Arthritis and Osteoporosis Victoria to refine the current programs and exercise repertoire to ensure they are reflective of the current evidence base.

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APPENDIX 1: SEARCH STRATEGY

In MEDLINE the following subject specific search strategy was applied:

#1: hydrotherapy

#2: aquatic therapy

#3: aquatic exercise

#4: arthritis

#5: arthritis, rheumatoid

#6: osteoarthritis

#7: fibromyalgia

#8: low back pain

#9: osteoporosis

#10: musculoskeletal diseases

#11: 1 or 2 or 3

#12: 4 or 5 or 6 or 7 or 8 or 9 or 10

#13: 11 and 12

APPENDIX 2: LIST OF EXCLUDED STUDIES

Study	Reason for exclusion
Ahern et al. (1995)	Not suitable study design
Altan et al. (2004)	Comparison group inappropriate
Ashina et al. (2010)	Outcome measures inappropriate
Baena-Beato et al. (2013)	Not suitable study design
Batterham et al. (2011)	Not suitable study design
Bartels et al. (2009)	Not suitable study design
Brosseau et al. (2002)	Not suitable study design
Brosseau et al. (2010)	Not suitable study design
Cuesta-Vargas et al. (2011)	Intervention was inappropriate
Cuesta-Vargas et al. (2011)	Intervention was inappropriate
Dagfinrud et al. (2009)	Not suitable study design
Escalante et al. (2010)	Not suitable study design
French et al. (2013)	Intervention was inappropriate
Giaquinto et al. (2010)	Wrong population (recovering after TKA)
Green et al. (1993)	Outcome measures inappropriate
Guillemin et al. (1994)	Intervention was inappropriate
Gusi et al. (2008)	Outcome measures inappropriate
Harmer et al. (2009)	Wrong population (recovering after total knee replacement)
Kelley et al. (2008)	Not suitable study design
Langhorst et al. (2009)	Not suitable study design
Lin et al. (2004)	Not suitable study design
Mannerkorpi et al. (2002)	Not suitable study design
Matsumoto et al. (2011)	Intervention was inappropriate
McVeigh et al. (2008)	Not suitable study design
Mobily et al. (2001)	Not suitable study design

Perraton et al. (2009)	Not suitable study design
Sjogren et al. (1997)	Not suitable study design
Tilden et al. (2010)	Not suitable study design
Van Tubergen et al. (2001)	Intervention was inappropriate
Verhagen et al. (2008)	Not suitable study design
Waller et al. (2009)	Not suitable study design
Yurtkuran et al. (2006)	Intervention was inappropriate

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