



The efficacy and safety of hydrotherapy in patients with knee osteoarthritis: a meta-analysis of randomized controlled trials

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Background: Currently, there is poor evidence of the effect of hydrotherapy on patients with knee osteoarthritis (OA). The authors performed a meta-analysis from randomized controlled trials to determine the efficacy and safety of a hydrotherapy program on measures of pain and knee function in individuals living with knee OA.

Methods: A literature review included PubMed, EMBASE, Cochrane Library, Science Citation Index, ScienceDirect, and Ovid. Studies evaluating the efficacy of hydrotherapy for knee OA up to August 2023 were included. The research was reported based on the preferred reporting items for systematic reviews and meta-analysis guidelines to ensure the reliability and verity of results. Statistical analysis was performed using Stata/SE version 15.0.

Results: A total of six randomized controlled trials were included for data extraction and meta-analysis. The present study revealed that there were significant differences between the two groups regarding the pain intensity at 1 week (WMD = -0.429; 95% CI: -0.679 to -0.179; $P=0.001$), 4 week (WMD = -0.308; 95% CI: -0.587 to -0.030; $P=0.030$) and 8 week (WMD = -0.724; 95% CI: -1.099 to -0.348, $P<0.001$). Furthermore, hydrotherapy was associated with improved outcome of the Western Ontario and McMaster Universities Arthritis index at 1 week (WMD = -3.314; 95% CI: -6.484 to -0.145, $P=0.040$), 4 week (WMD = -3.630; 95% CI: -6.893 to -0.366, $P=0.029$) and 8 week (WMD = -3.775; 95% CI: -7.315 to -0.235; $P=0.037$). No serious adverse events were observed in all patients who received hydrotherapy.

Conclusion: Hydrotherapy is efficacious and safe for reducing pain and improving functional status in individuals with knee OA, without increasing the risk of adverse effects.

Keywords: hydrotherapy, knee osteoarthritis, meta-analysis, pain

Introduction

Osteoarthritis (OA), a leading cause of chronic joint pain and disability, has a seriously impact on the health of the individuals^[1]. Patients with moderate to severe OA often suffer from excruciating pain with chronic inflammation and reduced range of motion, especially in the knee. It is a slowly progressive, disabling joint disorder which affects quality of life. Radiographic changes of OA occur in the majority of people by age 65 and are

present in more than 80% of people over age 75^[2,3]. Conventional treatment of knee OA include nonpharmacologic therapies and pharmacologic therapies. Analgesics, low potency opioids, narcotic analgesics, and NSAIDs are commonly used in pharmacologic therapies^[4,5]. Although they have certain curative effect on relieving joint pain, several therapies are generally accompanied by poor tolerance or adverse drug reactions, including circulatory system disorders, upper renal impairment, gastrointestinal disorders, and risk of dependence or addiction.

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

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Individuals with NSAIDs intolerance or inadequate analgesia have fewer drugs available.

Hydrotherapy is recommended as a treatment option in the elderly population because it is performed in a safer environment with a lower risk of falls than land-based exercises^[6]. It has been reported to have positive outcomes on multiple body system functions, including cardiovascular, metabolic, and musculoskeletal functioning. Ellapen *et al.*^[7] reported that hydrotherapy improves patients with spinal cord injury underwater gait-kinematics, cardiorespiratory and thermoregulatory responses and reduces spasticity. Hydrotherapy was a cost-effective rehabilitation compared to land-based therapy for a population with musculoskeletal disorders. However, the benefit of hydrotherapy was not observed in patients with knee OA. Recently, more and more studies have suggest that hydrotherapy was associated with an improved outcomes for patients with OA. Therefore, we performed a meta-analysis from randomized controlled trials (RCTs) to determine the efficacy and safety of a hydrotherapy program on measures of pain and knee function in individuals living with knee OA.

Materials and methods

Study selection

The systematic review and meta-analysis were done according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)^[8] (Supplemental Digital Content 1, <http://links.lww.com/JS9/B508>) (Supplemental Digital Content 2, <http://links.lww.com/JS9/B509>) and AMSTAR (Assessing the methodological quality of systematic reviews) guidelines^[9] (Supplemental Digital Content 3, <http://links.lww.com/JS9/B510>). PubMed, EMBASE, Cochrane Library, Science Citation Index, ScienceDirect, and Ovid were searched exhaustively from inception to August 2023. The search was restricted to articles published in the English language. The search terms included 'hydrotherapy', 'knee', 'osteoarthritis', and 'randomized'. Manual search of bibliographies from reviews and selected studies was also performed for additional articles. Search strategy of PubMed was shown as supplementary (Supplemental Digital Content 4, <http://links.lww.com/JS9/B511>).

Selection criteria and eligibility criteria

Studies were included on the basis of the following criteria: (1) RCTs; (2) studies that compared hydrotherapy with placebo for the treatment of knee OA; (3) outcome measurements: pain intensity, The Western Ontario and McMaster Universities Arthritis (WOMAC) index, short form 12 health survey, and adverse effects. Exclusion criteria included (1) case reports, crossover studies, letters, editorials, review articles, meta-analysis, and retrospective studies; (2) studies involved in animal experiments; (3) studies with deficiency data, or data cannot be extracted.

Two independent reviewers screened all titles and abstracts of the trials identified by the search strategy to determine whether they met the inclusion criteria. The full-text for each potentially eligible study was retrieved and assessed against the eligibility criteria. In cases of disagreement, a third reviewer was consulted.

HIGHLIGHTS

- Hydrotherapy is efficacious and safe for reducing pain.
- Hydrotherapy is associated with an improved knee joint function.
- No significant difference in terms of adverse events was found in two groups

Data extraction

Data were extracted by two independent authors. By discussion or by involving a third author, disagreements were addressed. The general data collected were first author, publication year, country, study type, sample size, patient age, sex ratio, length of the follow-up period, and relevant clinical outcomes. The primary outcomes were pain intensity, WOMAC index and short form 12 health survey. The secondary outcome were adverse effects. The corresponding author was consult to request missing data.

Quality assessment

Two authors independently evaluated the quality of the RCTs according to the Cochrane Handbook for Systematic Reviews of Interventions version. The content of evaluation involved sequence generation, allocation concealment, blinding of participants, blinding of outcome assessor, incomplete outcome data, reporting bias and other bias. Each part of the evaluation contain a low risk of bias, a high risk of bias, or an unclear risk of bias.

According to the Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodology^[10], the quality of the evidence for all outcomes was assessed independently by two investigators. In this assessment, five indicators, which including risk of bias, inconsistency, indirectness, imprecision, and other considerations bias was applied to assess each outcome. Each indicator was classified as high, moderate, low, or very low. GRADE Pro, version 3.6 was applied to accomplish summary tables.

Statistical analysis

The meta-analysis of comparable data was performed using Review Manager 5.3 (The Nordic Cochrane Centre) and Stata/SE version 15.0 (StataCorp LLC) software. Dichotomous outcomes were pooled and reported as risk difference (RDs), while continuous outcomes were pooled and reported as weighted mean differences (WMDs). All outcomes were calculated at 95% CI. Inconsistency was quantified using the I^2 statistic and an I^2 of > 50% indicated substantial heterogeneity. A random-effects model or the fixed-effect model was used depending on the heterogeneity of the studies included. A random-effects model was used for heterogeneous data. Otherwise, a fixed-effect model was used. For any variable presenting with high heterogeneity, sensitivity analysis or subgroup analysis was used to investigate the potential origin. Publication bias will be performed if there is sufficient included studies.

Results

Literature screening process

There were 139 relevant studies included according to the search strategy. After the titles and abstracts were reviewed, 53 of them

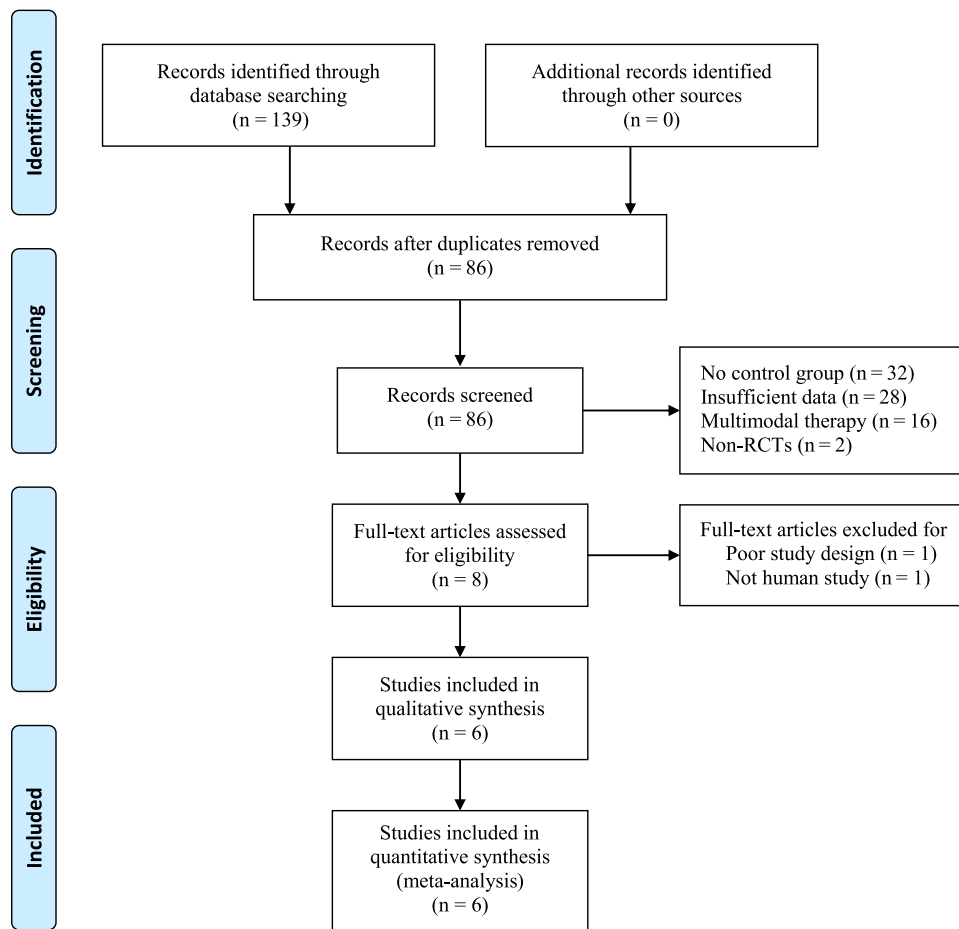


Figure 1. Flow diagram of study selection.

were removed. A full-text review was performed for the 86 records that were maintained, and 80 of them were excluded because they did not meet the inclusion criteria. Finally, six studies representing 351 patients were included in the present meta-analysis. The process and results of literature screening were shown in Figure 1.

Characteristics of included RCTs

We included six RCTs^[11-16] published from 2003 to 2019. In total, three studies were conducted in Australia, others were performed in Brazil, South Africa, and Germany. Experimental groups (n=183) received hydrotherapy classes and control groups (n=168) received physiotherapy. Average age ranged from 57 to 77 years old and follow-up period ranged from 4 to 18 weeks. Details of the included studies were presented in Table 1.

Risk of bias

The details of the risk of bias assessment can be obtained for all studies in Figure 2. All studies stated the specific way of random allocation. The allocation concealment of one article was not adequately illustrated. Only Schencking *et al.*^[14] reported double blinding to the participants and personnel. Incomplete outcome data were low risk of bias. Each risk of the bias item was expressed

in terms of the percentage across all the included articles, which indicated the proportion of risk levels for each item bias (Fig. 3).

Effects of interventions

Pain intensity at 1 week

A total of five RCTs provided the data on pain intensity at 1 week. There was no significant heterogeneity and a fixed-effect model was applied ($I^2 = 0\%$, $P = 0.446$). Our studies indicated that there was significant difference between the two groups regarding to pain intensity at 1 week (WMD = -0.429; 95% CI: -0.679 to -0.179; $P = 0.001$; Fig. 4).

Pain intensity at 4 week

Pain intensity at 4 week was available in five studies. Based on the available data, the pooled results exhibited no significant heterogeneity ($I^2 = 0\%$, $P = 0.967$), and a fixed-effect model was utilized. The present meta-analysis indicated that hydrotherapy was associated with an improved pain relief at 4 week (WMD = -0.308; 95% CI: -0.587 to -0.030; $P = 0.030$; Fig. 5).

Pain intensity at 8 week

A total of three trials provided data on pain intensity at 8 week. There was no significant heterogeneity ($I^2 = 25.8\%$, $P = 0.260$),

Table 1**Characteristics of the included studies.**

First author (Year)	Design	Mean age (years)		Sample size (n)		Gender (Female, n)		Intervention	Drugs	Physical therapies	Follow-up
		Hydrotherapy	Control	Hydrotherapy	Control	Hydrotherapy	Control				
Foley ^[11]	RCT	73	70	30	28	15	20	Hydrotherapy group: walking forwards, sideways, and backwards through the water; knee flexion and extension, and knee cycling. Control group: physiotherapy	Celecoxib	None	6 weeks
Fransen ^[12]	RCT	70	71	55	41	40	34	Hydrotherapy group: walking, bar work, seated, deep water noodle; abducted leg flexed Control group: without hydrotherapy	Nimesulide	Infrared ray	12 weeks
Silva ^[13]	RCT	59	59	32	32	37	40	Hydrotherapy group: gait training: forward walking with alternated movement of the upper and lower extremities; walk raising the knee; lateral walking; backward walking Control group: without hydrotherapy	Celecoxib	Massage	18 weeks
Schencking ^[14]	RCT	77	72	10	10	10	7	Hydrotherapy group: isometric strengthening; isotonic strengthening; stretching Control group: joint-specific physiotherapy (30 min, components were joint-related stretching elements, muscle strengthening of weak muscles and resistance exercises)	Diclofenac sodium	None	10 weeks
Dias ^[15]	RCT	71	71	33	32	20	21	Hydrotherapy group: anterior muscle exercises, posterior muscle exercises, abduction and adduction exercises, plantar flexion exercises, closed kinetic chain exercises, multidirectional walk Control group: educational protocol and weekly advice via telephone about controlling knee loading during daily activities	Ibuprofen	Thermal therapy	6 weeks
Sekome ^[16]	RCT	58	57	18	18	12	13	Hydrotherapy group: double-leg squats, double-leg calf raises, single-leg squats, single-leg calf raises, step-ups and -downs Control group: without hydrotherapy	Celecoxib	None	4 weeks

RCT, randomized controlled trial.

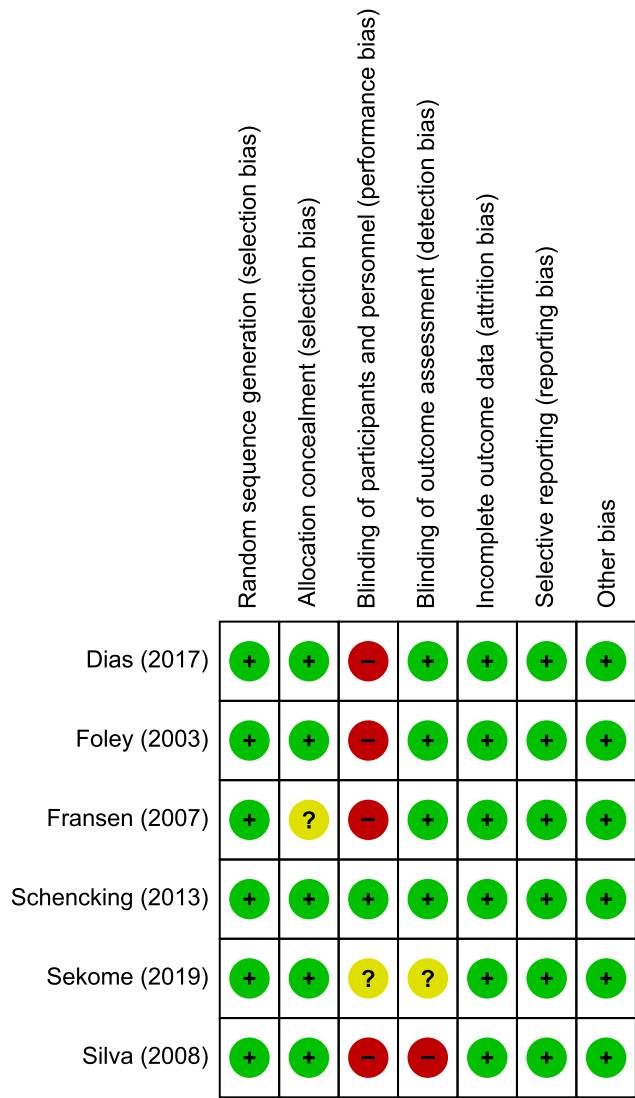


Figure 2. Risk of bias summary.

and a fixed-effect model was used. The pooled results showed significant difference between the two groups (WMD = -0.724; 95% CI: -1.099 to -0.348, $P < 0.001$; Fig. 6).

WOMAC index at 1 week

Data from four studies reported the outcome of WOMAC index at 1 week. Pooled results indicated that WOMAC index in hydrotherapy groups were significantly superior to which in control groups (WMD = -3.314; 95% CI: -6.484 to -0.145, $P = 0.040$; Fig. 7).

WOMAC index at 4 week

Four included studies evaluated WOMAC index at 4 week. There were significant differences between the hydrotherapy groups and the control groups (WMD = -3.630; 95% CI: -6.893 to -0.366, $P = 0.029$; Fig. 8). A fixed-effect model was used due to no statistical heterogeneity through the meta-analysis ($I^2 = 0\%$, $P = 0.781$).

WOMAC index at 8 week

A total of three RCTs provided the data on WOMAC index at 8 week. There was no significant heterogeneity and a fixed-effect model was applied ($I^2 = 0\%$, $P = 0.974$). Our studies indicated that there was significant difference between the two groups regarding to WOMAC index at 8 week (WMD = -3.775; 95% CI: -7.315 to -0.235; $P = 0.037$; Fig. 9).

Short form 12 health survey

Short form 12 health survey was available in three studies. Based on the available data, the pooled results exhibited no significant heterogeneity ($I^2 = 0\%$, $P = 0.667$), and a fixed-effect model was utilized. The present meta-analysis indicated that hydrotherapy was associated with an improved short form 12 health survey (WMD = 3.466; 95% CI: 0.298-6.635; $P = 0.032$; Fig. 10).

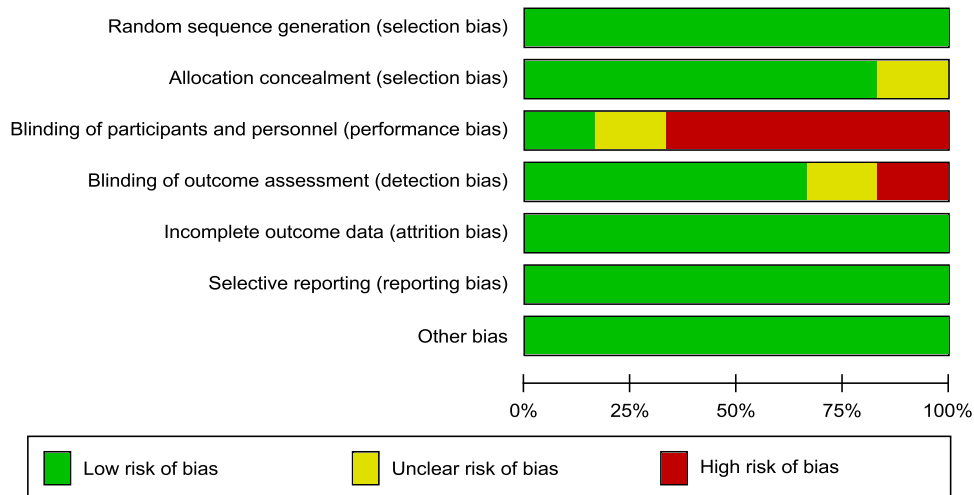


Figure 3. Risk of bias graph.

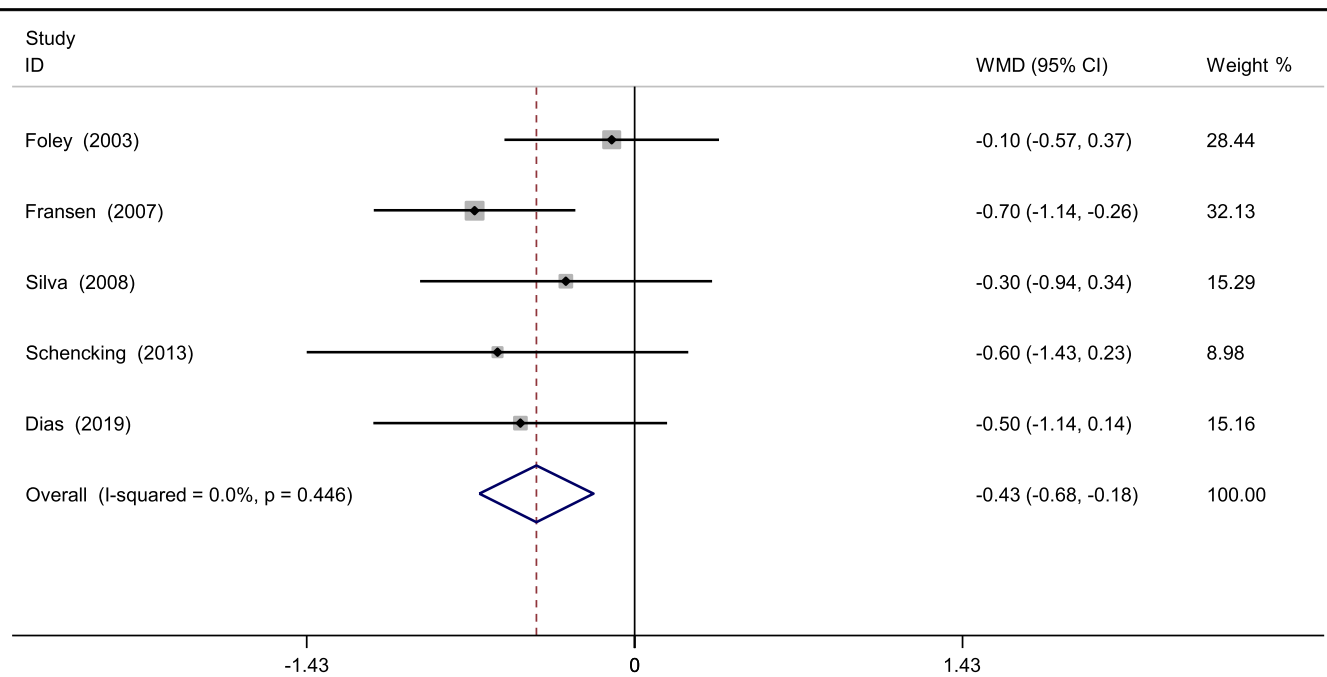


Figure 4. Meta-analysis of pain intensity at 1 week.

Adverse events

Four studies reported the adverse events after treatment. There was no significant heterogeneity among studies ($I^2 = 0\%$, $P = 0.805$) and a fixed-effect model was adopted. No significant difference in terms of adverse events was found in two groups (WMD = 0.003; 95% CI: -0.031-0.037; $P = 0.870$; Fig. 11).

Quality of the evidence and recommendation strengths

A summary of the quality of the evidence based on the GRADE approach was listed in Table 2. The evidence quality for each outcome was moderate to low. Therefore, we agree that the overall evidence quality was low, which indicates that further research is very likely to have an important impact on confidence in the estimate of effect and is likely to change the estimate.

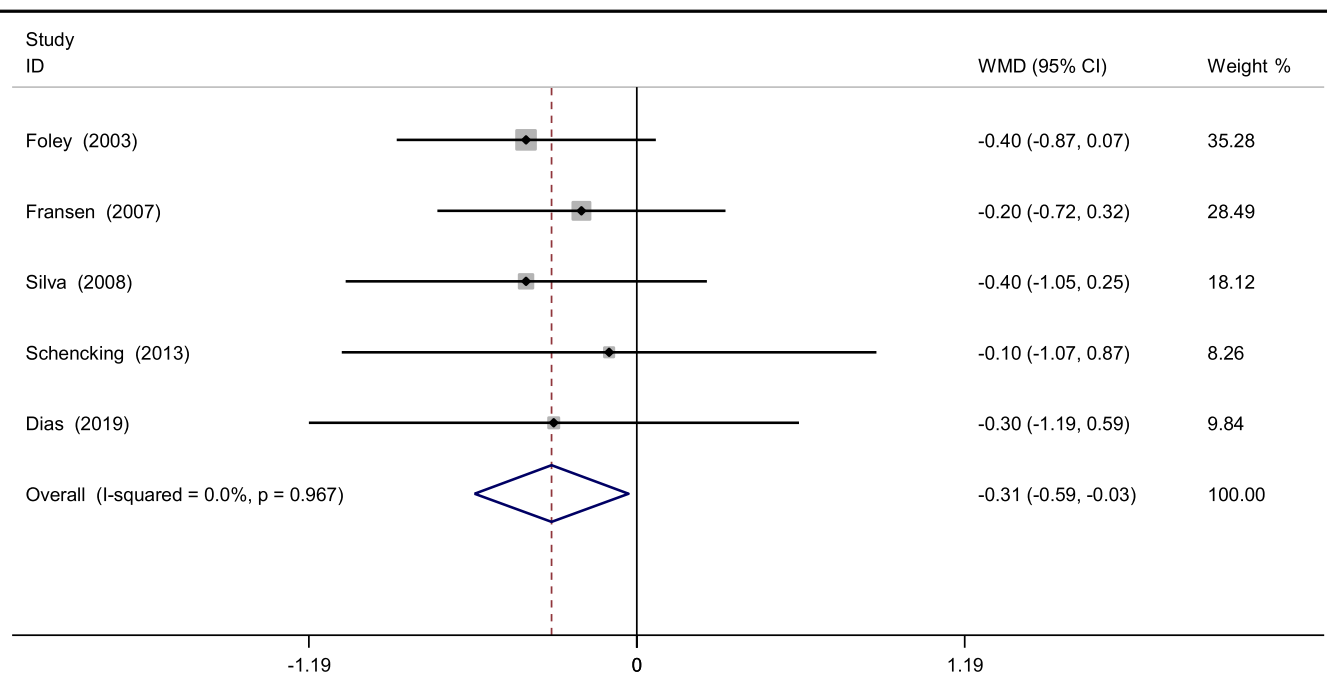


Figure 5. Meta-analysis of pain intensity at 4 week.

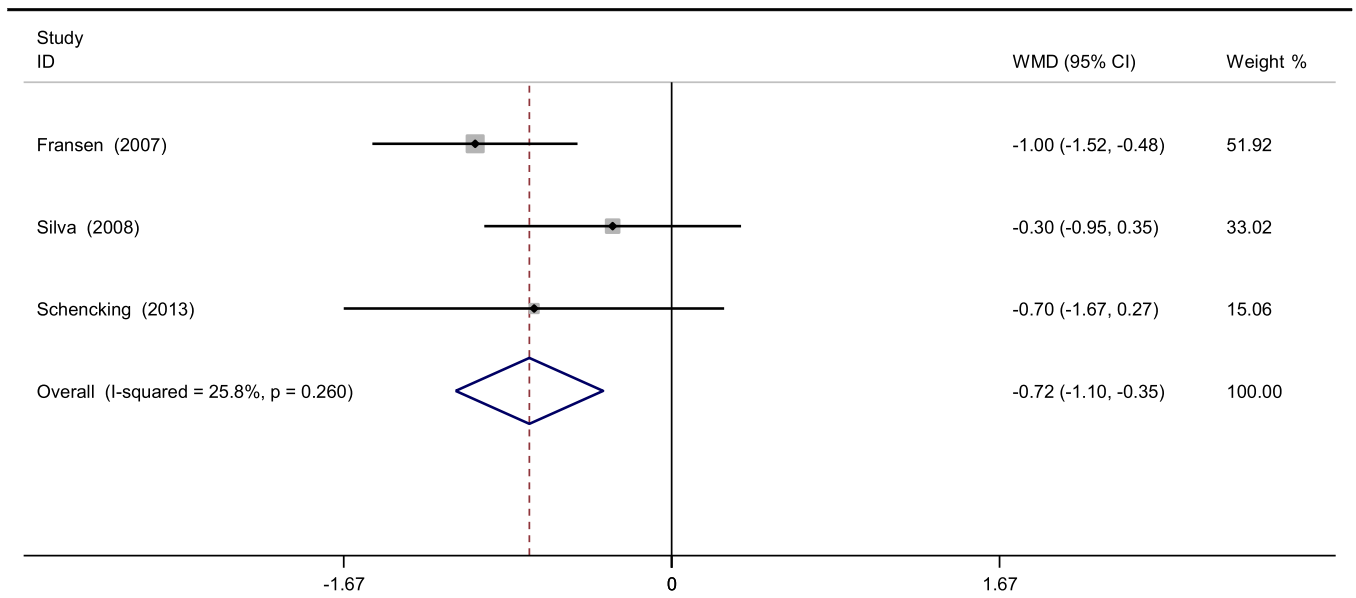


Figure 6. Meta-analysis of pain intensity at 8 week.

Subgroup analysis

Subgroup analysis was performed based on the treatment of control groups (hydrotherapy or rest). Similarly, pooled results indicated that pain intensity in hydrotherapy groups were significantly superior to which in control groups (Fig. 12).

Discussion

This study is the first systematic review and meta-analysis of the clinical efficacy and safety of hydrotherapy for reducing pain and

improving joint function in patients with knee OA. The main findings of this meta-analysis are that the hydrotherapy is associated with improved pain relief and WOMAC index. There are significant differences between groups regarding the short form 12 health survey. Furthermore, no serious adverse events are observed in all patients who received hydrotherapy.

OA of the knee is a major cause of pain and locomotor disability worldwide and chronic pain that restricts function of knee joints. Age is a major risk factor for knee OA^[17]. Given the increasing prevalence and incidence of OA, it is now considered a major public health problem not only in the United States but also worldwide. By 2030, it is predicted that 67 million people in the

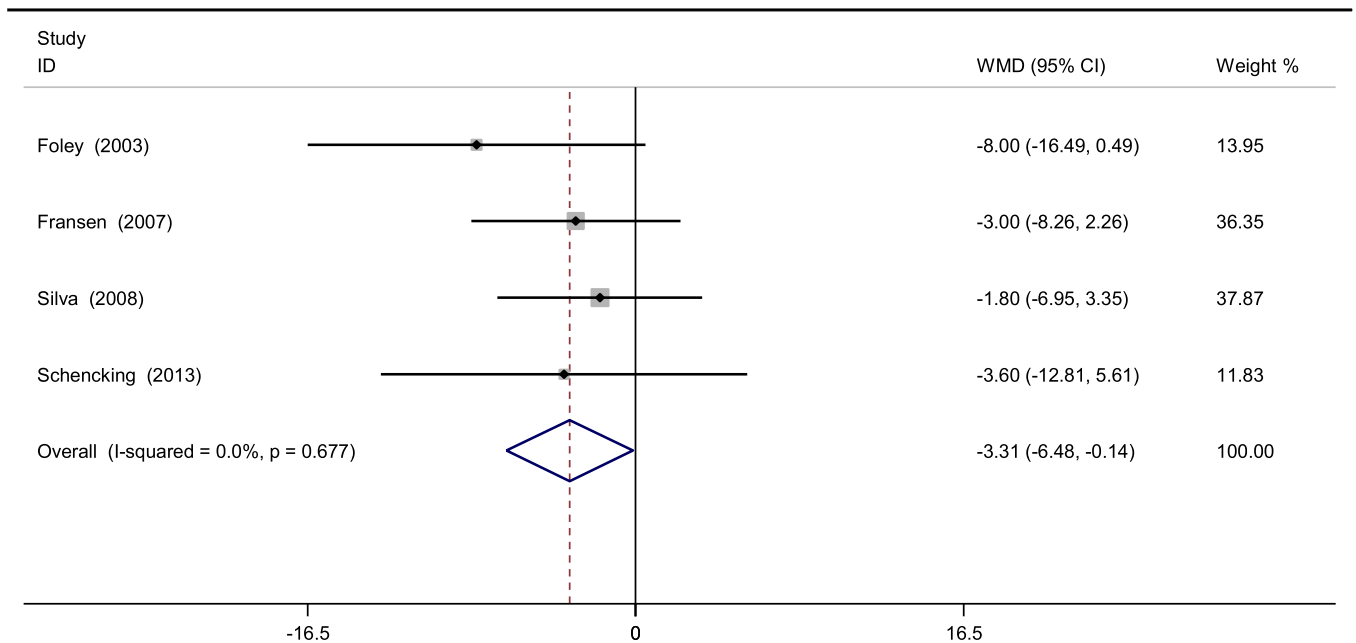


Figure 7. Meta-analysis of WOMAC index at 1 week. WOMAC, Western Ontario and McMaster Universities Arthritis.

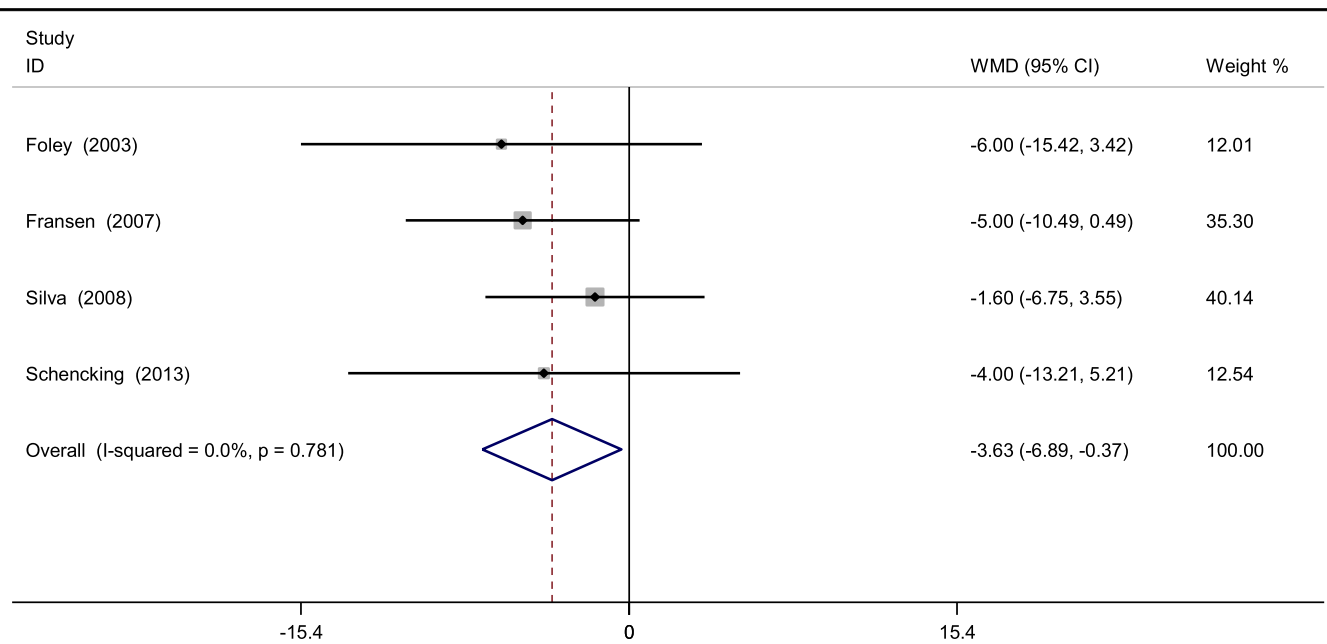


Figure 8. Meta-analysis of WOMAC index at 4 week.

United States will be diagnosed with OA^[18]. The weight-bearing joints are most frequently affected, such as knees and hips. Effective pain management plays a vital role in the treatment for OA, as well as improving the prognosis. Conservative treatment is the first choice for early-stage knee OA including physical therapy, intra-articular injections (platelet rich plasma, glucocorticoids, glucosamine, and hyaluronic acid) and oral anti-inflammatory drugs^[19-21].

Hydrotherapy has been shown to have positive outcomes on multiple body system functions, including cardiovascular, pulmonary, metabolic and musculoskeletal functioning^[22]. For knee OA, hydrotherapy can provide physiological and

biomechanical benefits compared to traditional exercises, which contributes to better clinical outcomes. Aquatic buoyancy potentially decreases weight-bearing stresses on knee, and muscles. Chae *et al.*^[23] reported that stroke patients showed improvement in postural balance and paretic knee extensor strength with hydrotherapy. Hydrotherapy exhibited significant effects on improving postural balance in chronic patients than in subacute patients. Pinto *et al.*^[24] concluded that hydrotherapy, combined or not with other therapies, may improve balance and functional mobility of patients with Parkinson disease when compared to land-based therapy alone or usual care. However, few study has determined whether

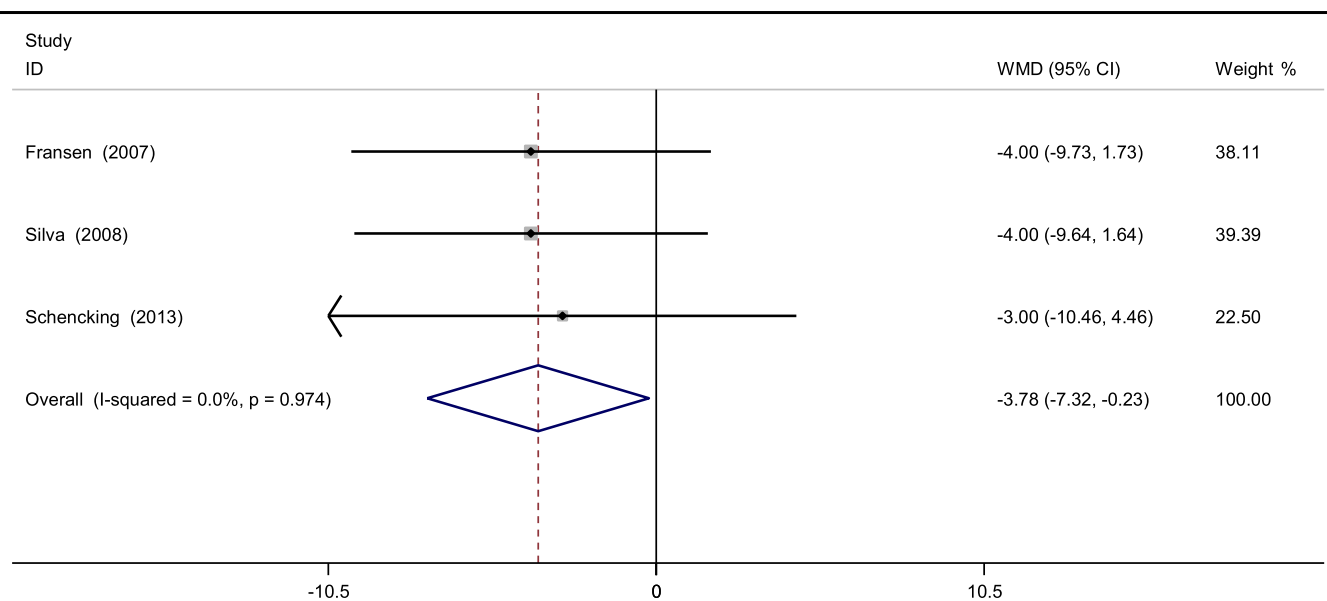


Figure 9. Meta-analysis of WOMAC index at 8 week.

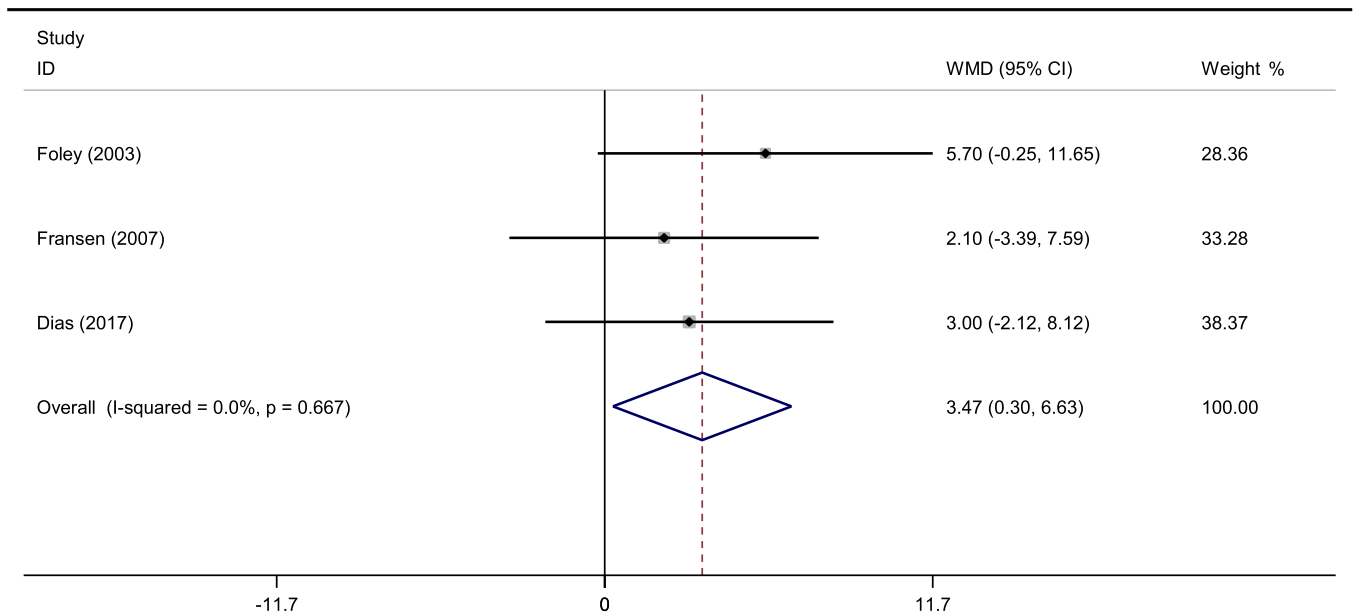


Figure 10. Meta-analysis of short form 12 health survey.

hydrotherapy can relieve knee OA pain. Our meta-analysis revealed that the hydrotherapy was associated with improved pain relief within 8 week. Due to the limited number of the

included studies, this evidence does not clarify the effectiveness of different types of hydrotherapy program and further research is required.

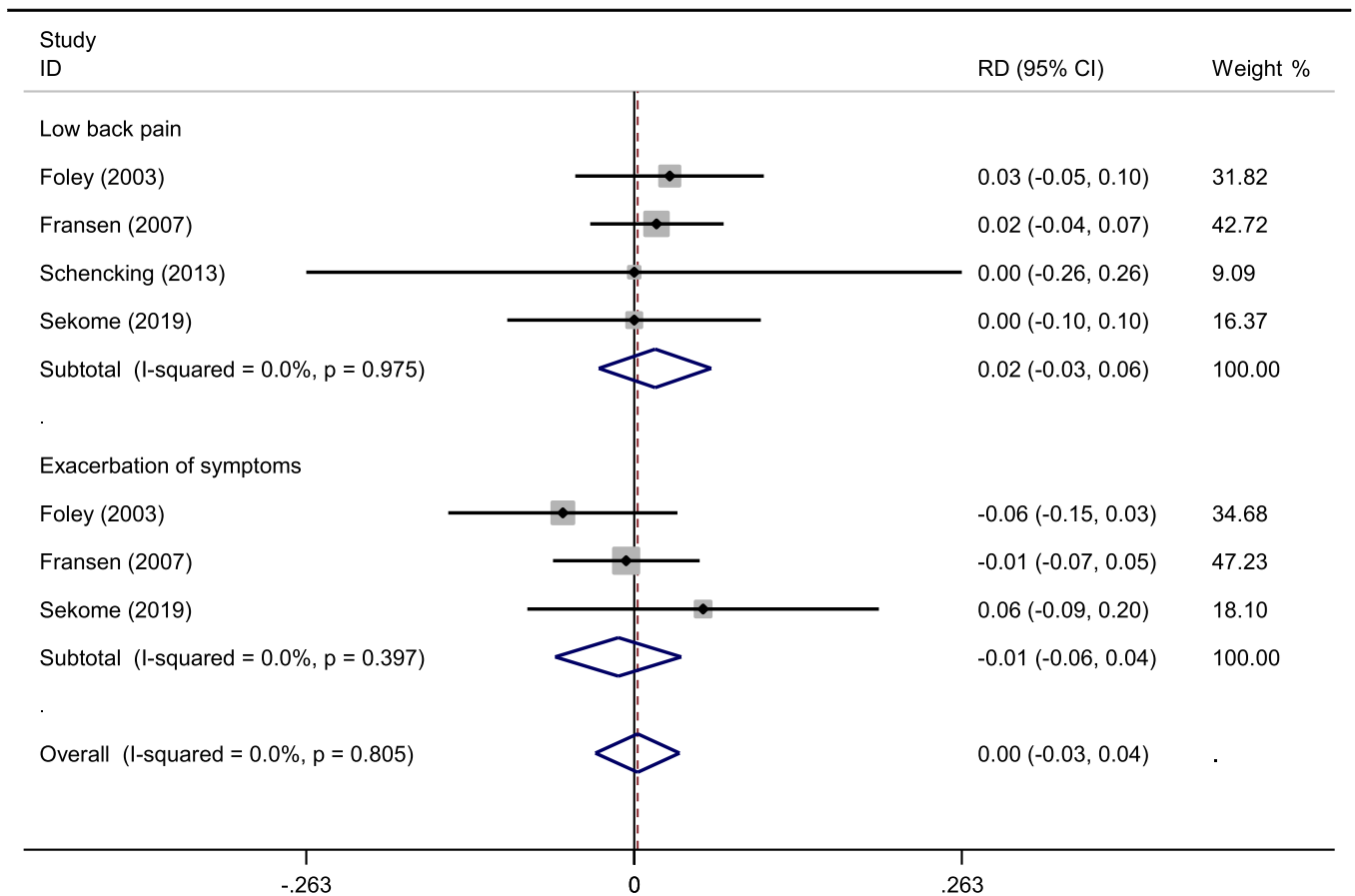


Figure 11. Meta-analysis of adverse effects.

Table 2
Quality of the evidence and recommendation strengths.

Number of RCT	Quality assessment					Outcome measures	Quality	Importance
	Limitations	Inconsistency	Indirectness	Imprecision				
Pain intensity at 1 week 5	Serious limitations	No serious inconsistency	No serious indirectness	No serious indirectness	WMD = -0.429; 95% CI: -0.679 to -0.179	Moderate	Critical	
Pain intensity at 4 week 4	Serious limitations	No serious inconsistency	No serious indirectness	No serious indirectness	WMD = -0.308; 95% CI: -0.587 to -0.030	Moderate	Critical	
Pain intensity at 8 week 3	Serious limitations	No serious inconsistency	No serious indirectness	No serious indirectness	WMD = -0.724; 95% CI: -1.099 to -0.348	Moderate	Critical	
WOMAC index at 1 week 4	Serious limitations	No serious inconsistency	No serious indirectness	No serious indirectness	WMD = -3.314; 95% CI: -6.484 to -0.145	Moderate	Critical	
WOMAC index at 4 week 4	Serious limitations	No serious inconsistency	No serious indirectness	No serious indirectness	WMD = -3.630; 95% CI: -6.893 to -0.366	Moderate	Critical	
WOMAC index at 8 week 3	Serious limitations	No serious inconsistency	No serious indirectness	No serious indirectness	WMD = -3.775; 95% CI: -7.315 to -0.235	Moderate	Critical	
Short form 12 health survey 3	Serious limitations	No serious inconsistency	No serious indirectness	No serious indirectness	WMD = 3.466; 95% CI: 0.298-6.635	Moderate	Critical	
Adverse effects 4	Serious limitations	Serious inconsistency	No serious indirectness	No serious indirectness	WMD = 0.003; 95% CI: -0.031 to 0.037	Low	Critical	

WOMAC, Western Ontario and McMaster Universities Arthritis.

The destruction of the articular cartilage renders it less capable to distribute large loads, more susceptible to stress, and less capable to reduce friction within the joint space^[25]. As a consequence, knee range of motion is limited. Although intra-articular injection of sodium hyaluronate has been widely used for several decades, the long-term benefit and cost-effectiveness are still under debate. Previous articles have suggest that intra-articular injection may accelerate the degeneration of articular cartilage, which leads to the surgical treatment. Water pressure and temperature could also lead to an increased sensory input and further help in blood circulation^[26]. Therefore, hydrotherapy is usually recommended for patients with degenerative joint disorder as water provides a range of benefits, including the reduction of edema, and reduces loading on damaged arthritic joints. As outcome measures, WOMAC index was used for evaluating the functional restoration. Foley *et al.*^[11] suggest that hydrotherapy was associated with superior outcome of WOMAC index compared to controls. However, Fransen *et al.*^[12] reported that there was no statistically significant difference in WOMAC index. A total of four RCTs provided the data on WOMAC index and our study revealed that hydrotherapy could significantly improve WOMAC index. Although the outcome of hydrotherapy is so far satisfactory, there are potential concerns, including low back pain and exacerbation of symptoms. Therefore, hydrotherapy will hold less clinical value if there was a higher risk of adverse effects. Four RCTs reported the adverse events and no significant difference in terms of adverse events was found in both groups. All adverse effects were mild and no further treatment was required. In addition, hydrotherapy achieved significant improvements in the short form 12 health survey. Long-term of follow is still

required to determine the efficacy and safety of hydrotherapy for knee OA.

Several methodological weakness of the included RCTs should be considered. The allocation concealment of study by Fransen *et al.*^[12] was not adequately illustrated. Only Schencking *et al.*^[14] reported double blinding to the participants and personnel, which may cause performance bias. Drug intervention were differed from each other. Foley *et al.*^[11], Silva *et al.*^[13], and Sekome *et al.*^[16] used Celecoxib, the other three used Nimesulide, Diclofenac sodium, and Ibuprofen. Fransen *et al.*^[12], Silva *et al.*^[13], and Dias *et al.*^[15] received physical therapies. These should be considered when analyzing the results. The overall evidence quality was low, which indicated that further research is likely to significantly alter confidence in the effect estimate and to change the estimate.

There are some limitations should be noted. First, some studies with a small sample size may lead to unreliable results during meta-analysis. Second, only published

articles in English were included in this meta-analysis, resulting in possible publication and language biases on the outcomes. Third, although subgroup analyses were used, the pooled results of some variables were still reported with high heterogeneity, which should be interpreted with caution. Last, the overall evidence quality is low. Further research into hydrotherapy should investigate the long-term effects of this form of exercise in patients with OA, and should also aim at measuring the effect of hydrotherapy on cardiovascular fitness.

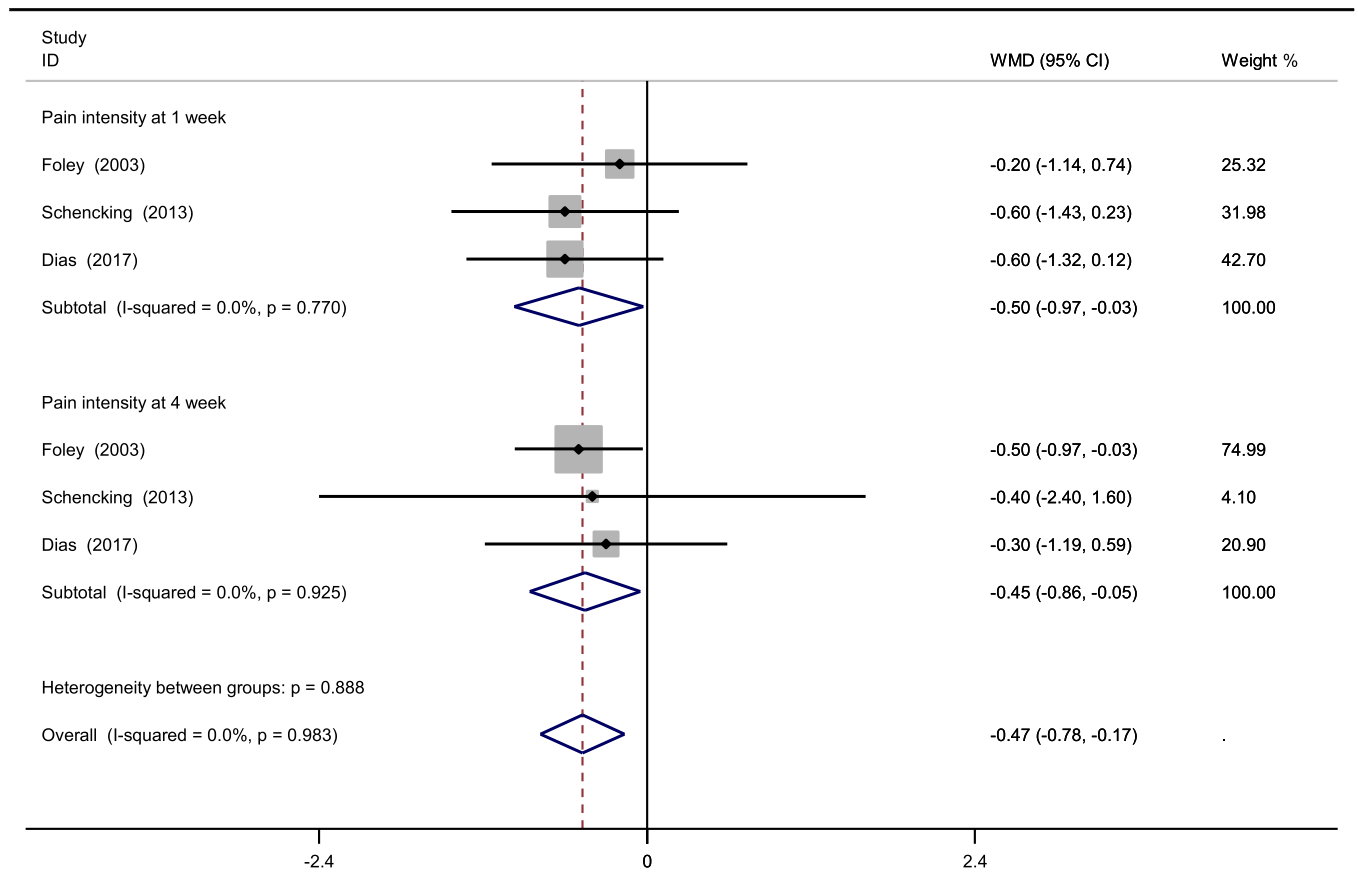


Figure 12. Subgroup analysis.

Conclusion

Hydrotherapy is efficacious and safe for reducing pain and improving functional status in individuals with knee OA, without increasing the risk of adverse effects.

Ethical approval

Not needed.

Sources of funding

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Author contribution

C.L., H.C., and S.Z.: original draft; Q.P.: data collections; J.X.: data analysis; Y.L. and Y.L.: review and editing.

Conflicts of interest disclosure

The authors declare that they have no financial conflict of interest with regard to the content of this report.

Research registration unique identifying number (UIN)

Reviewregistry1728.

Guarantor

Changjiang Lei.

Data availability statement

Data has been listed below each figure and table.

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