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ORIGINAL ARTICLE

Effects of water therapy on disease activity, functional capacity, spinal mobility and severity of pain in patients with ankylosing spondylitis: a systematic review and meta-analysis

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ABSTRACT

Purpose: To evaluate the efficacy of water therapy for disease activity, functional capacity, spinal mobility, and pain in patients with ankylosing spondylitis.

Methods: PubMed, Ovid, web of science, Cochrane library, Physiotherapy Evidence Database, CNKI, VIP, Wan Fang, and Open Grey were searched for randomized controlled trials that investigated the effects of water therapy on patients with ankylosing spondylitis. Two researchers independently screened the literature databases and then assessed methodological qualities using the Physiotherapy Evidence Database scale and extracted data. Outcomes included were disease activity, functional capacity, spinal mobility, and pain.

Results: A total of eight studies ($n = 383$) met the inclusion criteria. Analysis demonstrated that water therapy had a significant effect on disease activity and pain, but not on spinal mobility, or functional capacity in patients with ankylosing spondylitis.

Conclusion: Water therapy can benefit patients with ankylosing spondylitis by reducing disease activity and alleviating pain. More well-designed randomized controlled trials are needed to confirm the results.

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Water therapy; hydrotherapy; balneotherapy; aquatic exercise; ankylosing spondylitis; meta-analysis

➤ IMPLICATIONS FOR REHABILITATION

- Water therapy can reduce disease activity and pain in patients with ankylosing spondylitis, but cannot improve functional capacity or spinal mobility.
- Due to its analgesic effect both during and after treatment, water therapy remains an alternative for patients with ankylosing spondylitis when land-based therapy is not well tolerated.

Introduction

Ankylosing spondylitis (AS) is an inflammatory rheumatic disease that can affect the spine and sacroiliac joints, leading to back pain, joint stiffness, and a decrease in quality of life (QoL) [1]. The progression of AS is strongest in the first 10 years of the disease but it is also clear that the disease keeps on being active for further decades [2]. Men are more often affected than are women, with a ratio of roughly 2 to 1 [3].

Although AS is an incurable disease, there are a number of treatments available to relieve symptoms including medications, surgery, and physical therapy. Among the many types of physical therapy, water therapy, as an alternative medicine treatment, is widely used in the treatment of AS. Water therapy takes advantages of the physical properties of water, such as resistance, buoyancy, and temperature. It is generally recognized that with immersion, the patients may experience some physiologic changes induced by the properties of water [4]. Water offers resistance, which helps to strengthen the muscles, and leads to an increase in energy expenditure and a decrease in mechanical loads on lower extremity joints [5]. The buoyancy of water reduces pressure on the bones, joints, and muscles facilitating movement. The warmth and buoyancy of water may block nociception by acting on thermal receptors and mechanoreceptors, thus influencing spinal segmental mechanisms [6]. The beneficial effects of water therapy may result from the combined effect of water (e.g., resistance, buoyancy, and heat)

There are many forms of water therapy, mainly including hydrotherapy (HT) and balneotherapy (BT). In fact, both HT and BT involve the use of water in any form or at any temperature for therapeutic purposes. However, the definition of HT and BT is frequently confused, and the terms are used interchangeably. HT consists of the use of plain water (tap or very low mineralized water). On the other hand, BT employs generally natural thermal mineral water, as well as mud or gas, which is usually practiced in spas. Compared to HT, whose therapeutic effects may be mostly attributed to the physical properties of water, BT also provides thermal stimulus and chemical substances that are believed to be able to exert therapeutic effects. Thermal stimulus causes muscle relaxation, blocks pain perception at the dorsal horn level, and

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stimulates opioid secretion; minerals, salts, and gaseous compounds may modulate metabolism and immunology after they are absorbed through the skin and carried to the relevant body parts [7]; for instance, sulfur from BT was reported to have anti-inflammatory effect on diseases such as rheumatic arthritis and psoriatic arthritis [8,9]. Hydrokinesitherapy (HKT) is a type of therapeutic exercise performed in the water environment, whether in HT or in BT setting.

There are several randomized controlled trials (RCTs) on the effect of water therapy in patients with AS in the literature, but their results seem inconsistent with each other. In this study, we aim to summarize information about the results of these RCTs and to evaluate whether water therapy is effective in improving disease activity, functional capacity, spinal mobility, and severity of pain in patients with AS.

Materials and methods

This meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [10].

Search strategy

We searched in several electronic databases including PubMed, Ovid, web of science, Cochrane library, Physiotherapy Evidence Database (Pedro), CNKI, VIP, Wan Fang, Open Grey with the following search strategy: (ankylosing spondylitis) AND (balneotherapy OR hydrotherapy OR thalassotherapy OR spa therapy OR thermotherapy OR aquatic OR hydrogalvanic OR cryo OR pool exercise OR water-based OR pool-based OR Stanger OR mud OR thermal water OR bath OR peloid OR natural therapeutic gas OR radon). The search filter was used for RCTs. Hand search was also performed for articles included in previous systematic reviews. Studies published prior to April 2019 were searched. Two searchers independently reviewed titles and available abstracts to retrieve potentially relevant studies. Next, a third searcher identified the studies that need full-text reviews.

Selection criteria

Screening of titles and abstracts was conducted, followed by full-text reviews. Studies were included if they met the following criteria: (1) The study was an RCT; (2) participants were diagnosed with AS; (3) interventions were water therapy, including HT and BT; (4) the study provided at least one of the following clinical outcomes: disease activity, functional capacity, spinal mobility, and pain. Studies in languages other than English or Chinese were excluded. Two reviewers independently assessed the studies using the selection criteria described above. A third reviewer was involved if disagreement occurred.

Data extraction

From each study, we extracted general manuscript information (author, year of publication), demographic and clinical characteristics (the number of patients, baseline conditions), study characteristics (intervention and specific regimens performed in the experimental and control group), intervention protocols (session length, frequency, and total duration), and outcomes.

Methodological quality assessment

Methodological quality assessments were performed with the Pedro scale [11]. The scale contains 11 items. Item 1 reflects external validity and is not included in the total Pedro score. The other 10 items evaluate the internal validity of a clinical trial. One point was given for each satisfied criterion. Therefore, a score of 0–10 was allocated to each study (9–10: excellent; 6–8: good; 4–5: fair; and $\leq$3: poor).

Assessment of bias risk

According to the Cochrane system evaluation manual 5.1 edition of the risk assessment criteria for the bias, the included studies were assessed by two reviewers independently. If disagreement occurred, the decisions were made by discussions with a third reviewer. The assessment mainly includes the following contents: (1) random sequence generation; (2) allocation concealment; (3) blinding of participants and personnel; (4) blinding of outcome assessment; (5) incomplete outcome data; (6) selective reporting; and (7) other bias.

Outcome measures

Different scales such as the BASDAI (Bath Ankylosing Spondylitis Disease Activity Index), BASFI (Bath Ankylosing Spondylitis Functional Index), BASMI (Bath Ankylosing Spondylitis Metrology Index), and VAS/NHP-pain (Visual Analog Scale/Nottingham Health Profile-pain) were used as quantitative indicators of disease activity, functional capacity, spinal mobility, and pain.

Disease activity in AS is measured by BASDAI, a valid and appropriate composite index that evaluates fatigue, spinal pain, joint pain/swelling, areas of localized tenderness, morning stiffness. The self-administered instrument is made up of six questions regarding the patient's symptoms in the previous week, each to be answered on a VAS (0–10 cm). The mean of the two scores relating to morning stiffness is taken to give each symptom equal weighting. The resulting 0 to 50 is divided by 5 to give a final 0–10 BASDAI score. A higher BASDAI score means higher disease activity [12].

Functional capacity in AS was measured by BASFI, a scale containing 10 questions that can be answered on a VAS (0–10 cm). The mean of the ten scales gives the BASFI score, a value between 0 and 10. The higher the BASFI score, the more severe the patient's limitation of function due to their AS [13].

The BASMI is used to assess spinal mobility in AS. It is a metrological index that uses measurement to assess cervical rotation, tragus to wall distance, lumbar side flexion, lumbar flexion (modified Schober's test), and intermalleolar distance. The conversion of each measure uses a score of 0 to 10. The higher the BASMI score, the more severe the patient's limitation of movement due to AS [14].

Pain was measured by VAS or NHP-pain. A VAS is a 0–100 mm scale where 0 = no pain and 100 = unbearable pain. When VAS is not available, data were extracted from the NHP pain subscale. The patients were asked to give "yes" or "no" answers to the items in the questionnaire. Eight questions for pain were asked. The "weighted score" of the related question was given for each "yes" answer and 0 for each "no" answer. A score of 0–100 is calculated by summing the weighted score for each question. The higher the score, the more severe the patient's pain due to AS [15].

Statistical analysis

RevMan software, version 5.3, was used to analyze the data from the included studies. The mean difference (MD) was presented as the effect size, and its 95% confidence interval (CI) was computed. As quantitative measurement of inconsistency across studies, heterogeneity was tested using the I^2 statistic. If $I^2 < 50\%$, fixed-effect model was used; however, if $I^2 > 50\%$, random-effect model was used. Statistical significance was indicated by a p values < 0.05.

Results

Literature search

A total of 1467 references were identified, 293 of which were excluded for duplicated trials. Furthermore, a total of 1151 studies were excluded after screening the titles and abstracts. Another 15 studies were excluded for various reasons: (1) two studies did not have a control group [16,17]; (2) in four studies, all of the groups received water therapy [18–21]; (3) two study did not provide sufficient data [22,23]; (4) five articles were written in neither English nor Chinese [24–28]; (5) one study is in process and its results have not yet been published [29]; (6) One study is review [30]. Finally, eight trials [7,31–37] ($n = 383$) (six in English and two in Chinese) that met our eligibility criteria were selected for this study. Figure 1 shows the flow of information through the different phases of our systematic review. This flow figure followed the PRISMA guidance.

Methodological quality assessment and assessment of bias risk

The Pedro score of the included studies ranged from 4 to 7, with a median score of 5. Three studies were of good quality, while the other five were of fair quality. Four studies were open-label trials [31,33,34,36], while the rest were single assessor-blinded trials [7,32,35,37]. A detailed evaluation of the methodological quality is provided in Table 1. The results of the assessment of bias risk are shown in Figure 2.

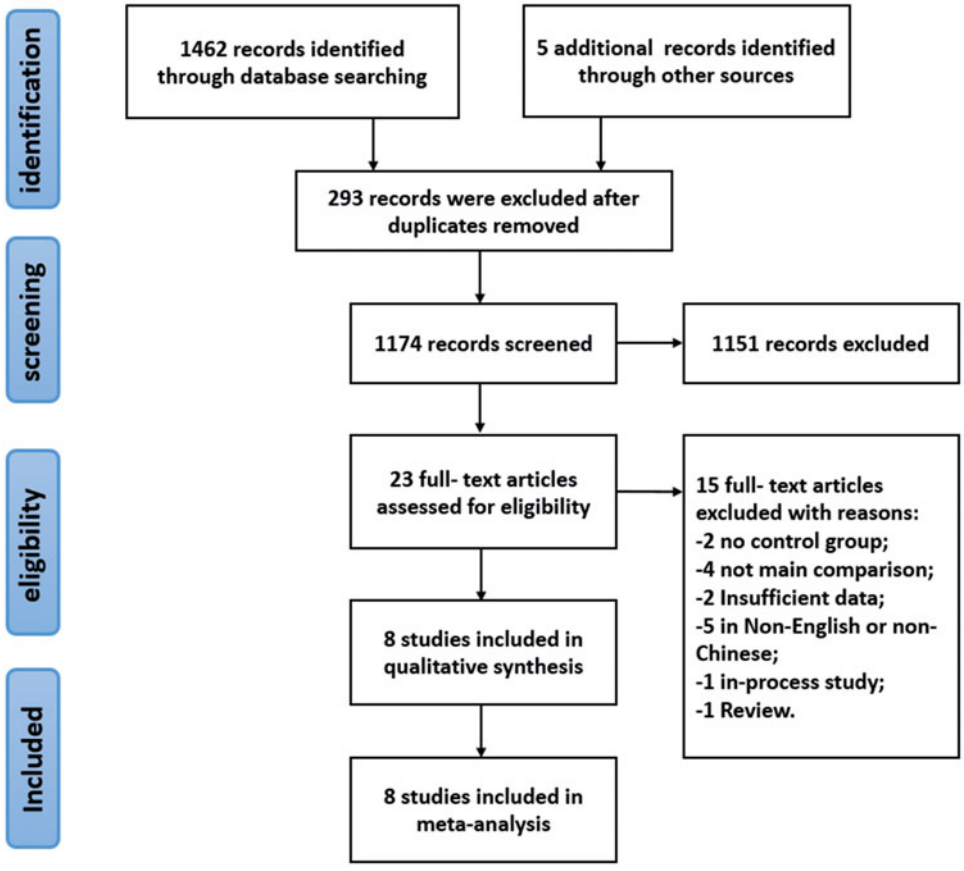

Figure 1. Flowchart of study selection.

Table 1. Methodological quality assessment of the included studies.

Study	Eligibility criteria	Random allocation	Concealed allocation	Baseline comparability	Blind subjects	Blind therapist	Blind assessors	Adequate follow-up	Intention-to-treat analysis	Between-group comparison	Points estimates and variability	Total score
Yurtkuran et al. [35]	Y	Y	N	Y	N	N	Y	Y	N	Y	Y	6
Altan et al. [7]	Y	Y	N	Y	N	N	Y	Y	N	Y	N	5
Wan et al. [36]	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5
Caprian et al. [33]	N	Y	N	Y	N	N	N	Y	N	N	Y	4
Dundar et al. [32]	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Gurcay et al. [37]	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Karapolat et al. [31]	Y	Y	Y	Y	N	N	N	N	N	Y	Y	5
Yu et al. [34]	Y	Y	N	Y	N	N	N	N	N	Y	Y	4

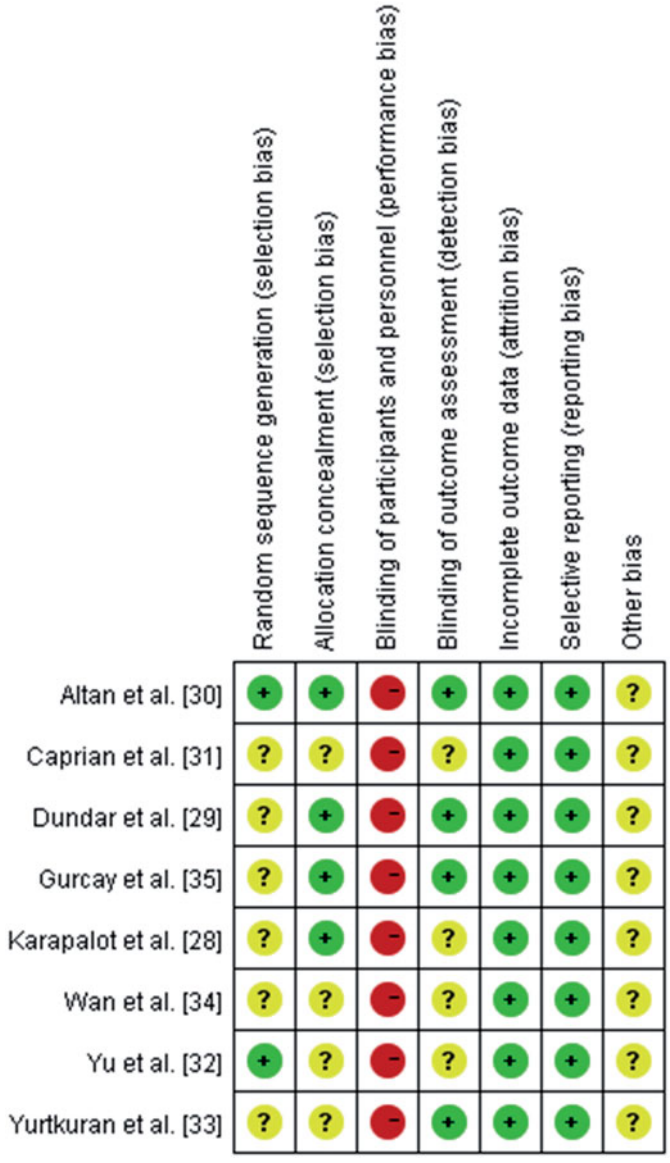

Figure 2. Assessment of bias risk.

Study characteristics

Descriptive data of the included trials in this systematic review are shown in Table 2. The included studies were published from 2005 to 2019. For the experimental groups, BT was used in four trials [7,33–35] in only one of which BT was combined with water-based exercise (HKT in BT) [33]. The other four trials [31,32,36,37] used HT as the intervention; among them, HKT was used in three trials [31,32,36] and Stanger therapy in only one trial [37]. For the control groups, the intervention included drugs and/or land-based exercise. The parameters of the interventions varied among studies, with a total treatment duration ranging from 2 weeks to 6 months, a frequency of 2, 3, 5, or 7 times a week, and a session duration ranging from 10 to 60 min. Furthermore, only four trials [7,32,33,35] had a 3-month or 6-month follow-up, while the other four did not provide follow-up data.

Outcomes

Disease activity

A total of six studies [7,31–34,37] assessed disease activity using BASDAI, with 292 subjects in total and 147 in the experimental group and 145 in the control group. The fixed-effect model was used in the analysis since the heterogeneity between studies is low ($I^2 < 50\%$). The aggregated result of these studies suggested that water therapy significantly reduced disease activity (MD −0.48, 95% CI: −0.77 to −0.18, $p = 0.001$. Figure 3).

Functional capacity

Functional capacity was assessed in five trials [7,31–33,37] using Bath Ankylosing Spondylitis Functional Index (BASFI). A total of 235 cases were analyzed, with 119 in the experimental group and 116 in the control group. The fixed-effect model was used ($I^2 = 0$). The aggregated results of these studies suggested that water therapy did not significantly improve functional capacity (MD −0.23, 95% CI: −0.53 to 0.07, $p = 0.13$. Figure 4).

Spinal mobility

Four trials involving 181 cases assessed spinal mobility using BASMI. The aggregated results of these studies suggested that water therapy did not significantly improve spinal mobility (MD −0.01, 95% CI: −0.75 to 0.73, $p = 0.98$. Figure 5).

Pain

Pain was assessed in six studies using Visual Analog Scale (VAS) [32–35] or Nottingham Health Profile (NHP) [7,31]. Therefore, the Standard Mean Difference (SMD) was employed given the heterogeneity of the assessment tool of pain. The meta-analysis demonstrated that water therapy significantly alleviated pain compared with control (SMD −0.33, 95% CI: −0.57 to −0.09, $p = 0.007$. Figure 6).

Discussion

The study aimed to assess the effectiveness of water therapy on patients with AS. Disease activity, functional capacity, spinal mobility, and severity of pain were assessed by using BASDAI, BASFI, BASMI, and VAS/NHP-pain, respectively. The meta-analysis suggested that water therapy reduced disease activity and severity of pain, but did not improve functional capacity or spinal mobility compared to usual care.

Water therapy provided an overall analgesic effect for AS patients, both during and after treatment. In fact, there are many difficulties for AS patients exercising on land. Land-based exercises may not attract a patient's interest, causing discontinuation of exercise. Movement in water is often less painful than the same movement on land [32]; the characteristic relaxing atmosphere of the spa promotes health and a sense of well-being, conditioning significant improvement of mood, depressive symptoms, and QoL [38]. Given all these, it is reasonable to assume that patients with AS show more willingness to take water therapy than land-based therapy. Therefore, water therapy remains an alternative for AS patients when land-based therapy is not well tolerated. Future studies that focus on patient satisfaction and compliance with water therapy are needed.

As a treatment for AS, water therapy consists of BT and HT. In this study, we have included both therapies because they are all practiced in the water environment. In contrast to HT, which usually employs tap water, BT may also take advantages of its mineral content and thermal effects. Therefore, the results of the meta-analysis should be carefully interpreted due to the heterogeneity of the type of intervention.

The effectiveness of exercise for AS patients has been well-established [39], so it is possible that HKT has similar effects to land-based exercise. We intended to conduct a subgroup analysis

Table 2. Descriptive data of the included study.

Study	Study design and sample (E/C)	Intervention group	Control group	Outcomes	Follow-up months
Yurtkuran et al. [35]	RCT (21/20/20)	Group 1: BT, 20 min once a day, 5 days a week for 3 weeks. Land-based exercises including respiratory and postural correction exercises for 20 min a day, 6 months. Group 2: BT and land-based exercises the same as group1, plus NSAID therapy	NSAID therapy and the same land-based exercises.	Pain, Morning stiffness, ESR, OWD, CE, FFD, Schober's test, functional index, global well-being.	6 months.
Altan et al. [7]	RCT (30/30)	BT, 30 min once a day for 3 weeks. Land-based exercise including respiration-postural exercises and dorsal/lumbar extension exercises, 30 min once a day and for 6 months.	The same exercise protocol but without BT.	Pain, Morning stiffness, BASDAI, BASFI, OWD, CE, QoL. Modified Schober's test, Dougados Functional Index Fingertip-fibula head distance, Patient's global evaluation, and the physician's global evaluation,	6 months.
Wan et al. [36]	RCT (25/25)	Aquatic exercises, including ROM, strengthening and respiratory exercise. 45 min a day, 5 days a week, and for 3 months.	Drugs.	CE, Schober's test, FFD, OWD, CCD,	N/A
Caprian et al. [33]	RCT (15/15)	Mud pack, aquatic exercises including spine mobilization, muscular spine strengthening and respiratory exercises. Ten sessions over a 2 weeks period.	Drugs.	BASFI, BASDAI, BASMI, Pain, QoL	6 months.
Dundar et al. [32]	RCT (35/34)	Aquatic exercises including aerobic exercise, active ROM, stretching, strengthening, postural, respiratory exercise and relaxation. For 60 min once a day, 5 days a week and for 4 weeks.	Land-based exercise including muscle relaxation, flexibility, ROM, stretching, postural, respiratory, and strengthening exercise. 60 min once a day and for 4 weeks.	Modified Schober's test, Lumbar active ROM, Pain, CE, BASFI, BASMI, BASDAI, QoL.	3 months.
Gurcay et al. [37]	RCT (30/28)	Stanger bath therapy (a combination of electrotherapy and hydrotherapy) for 20 min daily for 15 sessions over 3-week period. And home exercise program including ROM, strengthening, respiratory and postural exercises, for 30 min a day, 5 days a week, and for 3 weeks.	The same exercise program but no Stanger bath therapy.	BASMI, BASFI, BASDAI, QoL.	N/A.
Karapalot et al. [31]	RCT (13/12/12)	Group 1: CE comprising flexibility exercises, stretching exercises and respiratory exercises for 30 min, once a day for six days. Free-style swimming for 30 min, three times a week for 6 weeks.	Group 2: CE, and 30-min walking a day, three times a week for 6 weeks. Group 3: CE only.	PFT, pVO_2, 6MWT BASFI, BASDAI, BASMI NHP, BDI	N/A
Yu et al. [34]	RCT (28/29)	Hydrogen rich water baths for 10–15 min, twice a week for 8 weeks.	Drugs	BASDAI, VAS, ASDAS-CRP, BAS-G, ESR, CRP	N/A

E/C: experimental group/control group; BT: balneotherapy; NSAIDs: non-steroid anti-inflammatory drugs; ESR: erythrocyte sedimentation rate; OWD: occiput-wall distance; CE: chest expansion; FFD: finger-floor distance; BASDAI: Bath Ankylosing Spondylitis Disease Activity Index; BASFI: Bath Ankylosing Spondylitis Functional Index; BASMI: Bath Ankylosing Spondylitis Metrology Index; QoL: quality of life; ROM: range of motion; CCD: chin-chest distance; PFT: pulmonary function test; pVO_2: maximal oxygen uptake; 6MWT: 6-min walking test; NHP: Nottingham Health Profile; BDI: Beck Depression Inventory; ASDAS-CRP: the ankylosing spondylitis disease activity score; BAS-G: Bath Ankylosing Spondylitis Patient Global Score; CRP: C-reactive protein.

on the effect of HKT for AS patients but were hindered by the limited number of the included studies evaluating HKT (only four studies and even less for each outcome measured). More well-designed RCTs are needed to determine the role of HKT in the treatment of patients with AS.

Although the values of the I^2 are low, we should also notice there are other potential sources of heterogeneity. The interventions varied in the included studies. The frequency, intensity, time, and type of the interventions were very different. What's more, the temperature of water, as a key element that may have

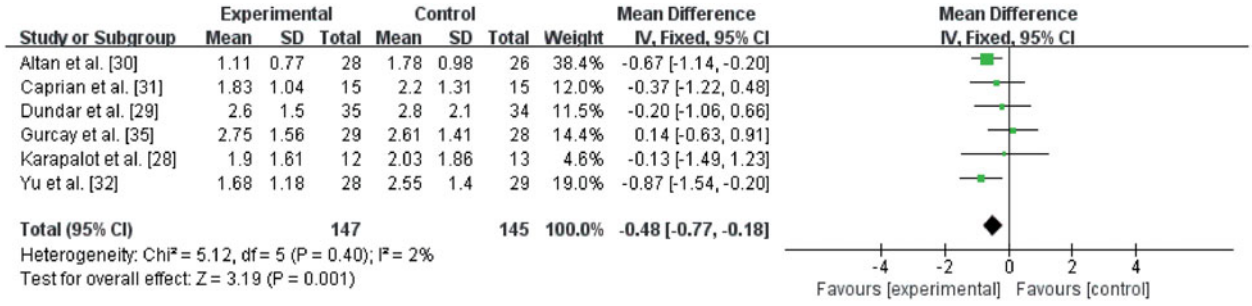

Figure 3. Forest plot of included studies comparing the effect of water therapy group and control group on disease activity.

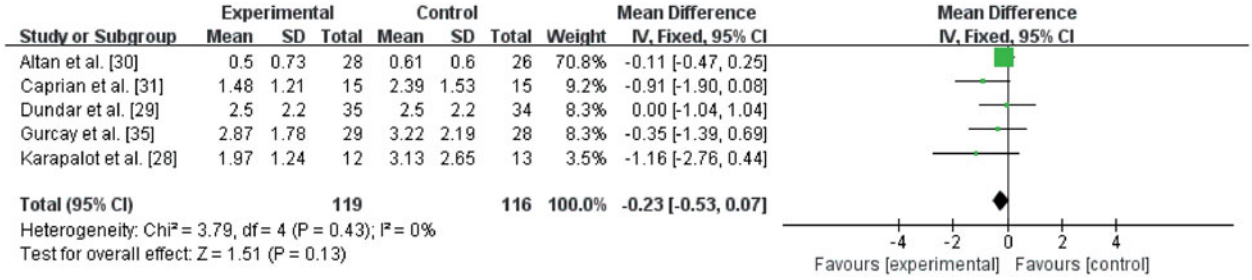

Figure 4. Forest plot of included studies comparing the effect of water therapy group and control group on functional capacity.

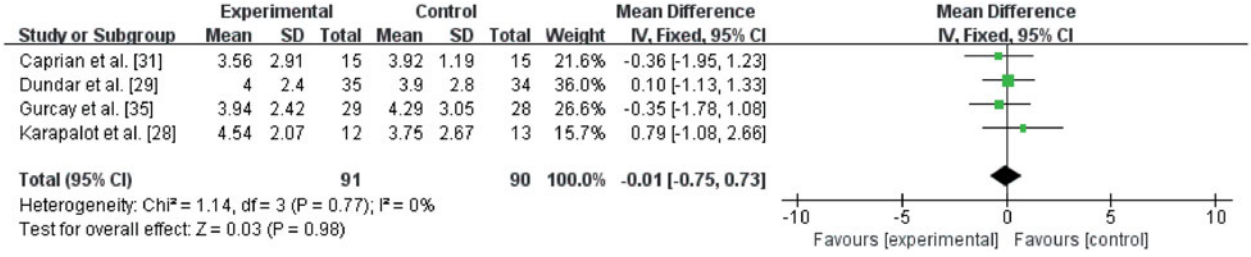

Figure 5. Forest plot of included studies comparing the effect of water therapy group and control group on spinal mobility.

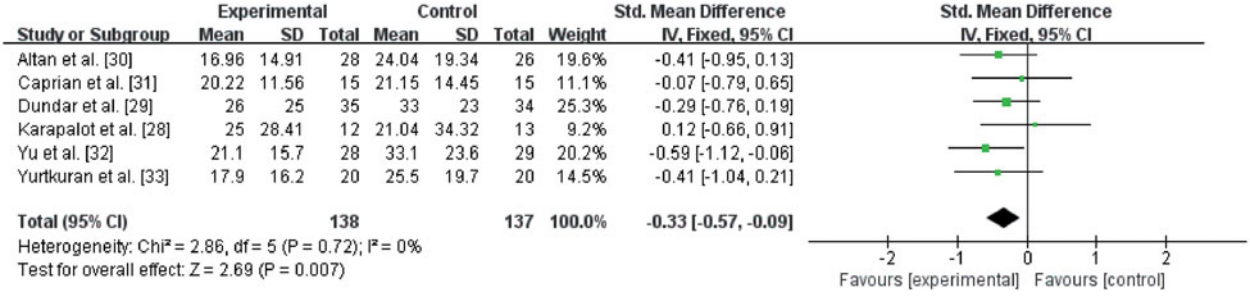

Figure 6. Forest plot of included studies comparing the effect of water therapy group and control group on pain.

a great influence on the effects of water therapy, varied among studies. Moreover, the patients enrolled in the studies were all diagnosed with AS, and in this meta-analysis, we considered them as a homogenous sample. However, we should take into consideration the stage of disease of each patient, as AS is a progressive disease, having different severity of signs and symptoms at different stages. These potential sources of heterogeneity may affect the reliability of the meta-analysis.

The present study has some limitations. The number of the included studies and patients was small and might not offer enough statistical power to support the results. Besides, the diversity of the interventions may affect the results. Additionally, given the limited linguistic capabilities of the research team, we excluded some non-English or non-Chinese studies. Therefore, it is necessary to include more high-quality studies to confirm the results.

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