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Clinical efficacy of hydrotherapy in the rehabilitation of patients with rheumatoid arthritis: a systematic review and meta-analysis

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Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 23 August 2026 and was last updated on 23 August 2026.

INTRODUCTION

Review question / Objective What is the clinical efficacy and safety of hydrotherapy (including thermal water balneotherapy, peloidotherapy, and radon spa therapy) as an adjunctive rehabilitation modality in improving disease activity, pain relief, and functional status among adult patients with rheumatoid arthritis?

Rationale Rheumatoid arthritis (RA) is a chronic systemic autoimmune disorder causing persistent synovial inflammation, progressive joint damage, and severe physical disability. Although disease-modifying anti-rheumatic drugs (DMARDs) form the cornerstone of management, long-term pharmacological therapy is often associated with adverse drug events and limited non-pharmacological relief. Hydrotherapy and balneotherapy have been widely utilized as non-invasive rehabilitation interventions to alleviate pain, ease joint stiffness, and enhance mobility. However, current clinical trial results show heterogeneity, and an updated quantitative synthesis evaluating standardized clinical outcomes (DAS28, VAS, HAQ-DI) and modality-specific responses is needed to guide clinical practice.

Condition being studied Rheumatoid arthritis (RA) is a chronic, progressive systemic autoimmune inflammatory disorder primarily affecting synovial joints. It is pathologically characterized by persistent synovial inflammation (synovitis), joint swelling, tenderness, morning stiffness, and the proliferation of inflammatory pannus, which progressively leads to articular cartilage degradation, subchondral bone erosion, and joint deformities. Clinically, patients with RA suffer from severe chronic joint pain, fatigue, limited range of motion, and physical disability, substantially impairing their daily functioning and overall health-related quality of life. Although pharmacological interventions such as disease-modifying anti-rheumatic drugs (DMARDs) and biologic agents represent the cornerstone of treatment to suppress

systemic inflammation, patients frequently endure residual pain, joint stiffness, and physical limitations. Consequently, structured non-pharmacological rehabilitation modalities, including hydrotherapy and balneotherapy, are widely sought as complementary strategies to relieve mechanical stress on joints, alleviate pain, reduce muscle spasms, and restore musculoskeletal function.

METHODS

Search strategy Electronic databases including PubMed, Embase, and Web of Science were systematically searched for eligible studies published between January 1, 2005, and May 24, 2025. A combination of MeSH terms and free-text keywords was used, including: ("Rheumatoid arthritis" OR "RA") AND ("Hydrotherapy" OR "Balneotherapy" OR "Spa therapy" OR "Peloidotherapy" OR "Mud therapy" OR "Mineral bath" OR "Radon bath" OR "Rehabilitation"). In addition, citation lists of relevant reviews and eligible trial reports were screened manually.

Participant or population Adult patients (aged ≥18 years) with a confirmed clinical diagnosis of rheumatoid arthritis according to recognized criteria (e.g., ACR 1987 or ACR/EULAR 2010 classification criteria).

Intervention Adult patients (aged ≥18 years) with a confirmed clinical diagnosis of rheumatoid arthritis according to recognized criteria (e.g., ACR 1987 or ACR/EULAR 2010 classification criteria).

Comparator Conventional pharmacological therapy alone, sham or attenuated mineral baths, untreated controls, or alternative non-pharmacological rehabilitation (e.g., land-based physical exercise).

Study designs to be included Randomized controlled trials (RCTs) and controlled clinical trials.

Eligibility criteria Additional Inclusion Criteria:
1. Publication format: Full-text, peer-reviewed original research articles published in academic journals.
2. Publication timeframe: Studies published between January 1, 2005, and May 24, 2025.
3. Data availability: Studies providing sufficient quantitative data (mean, standard deviation/error, and sample size) at baseline and post-intervention/follow-up, or studies where extractable data could be obtained.
4. Multi-arm trials: For multi-arm trials, only trial arms meeting the specified hydrotherapy intervention and eligible comparator criteria were included for pairwise comparisons.

Additional Exclusion Criteria:
1. Publication types: Conference abstracts, poster presentations, book chapters, editorials, commentaries, study protocols without published results, narrative reviews, and non-peer-reviewed preprints.
2. Duplicate or overlapping data: Duplicate publications, multiple reports of the same trial cohort (the study with the most comprehensive data or longest follow-up was retained), or studies with unverifiable data integrity.
3. Inaccessible data: Studies with incomplete outcome reporting where quantitative effect sizes could not be calculated or imputed, even after attempting to contact the corresponding authors.
4. Severe methodological attrition: Studies with excessive loss to follow-up (>20% attrition rate) lacking appropriate missing data handling (such as intention-to-treat [ITT] analysis).

Information sources Electronic databases: PubMed, Embase, and Web of Science (WOS). Additional manual searches included reference lists of retrieved articles and relevant systematic reviews.

Main outcome(s) 1. Disease Activity Score in 28 joints (DAS28)
2. Pain intensity assessed by Visual Analogue Scale (VAS)
3. Physical function and disability assessed by Health Assessment Questionnaire Disability Index (HAQ-DI)
(Assessed immediately post-treatment and at 3-month follow-up).

Additional outcome(s) Longer-term clinical outcomes (follow-up ≥3 months), oxidative stress and inflammatory biomarkers (ROS, MDA, SOD, GPx, cytokines), medication reduction, and adverse events.

Data management Two investigators independently screened titles and abstracts against the eligibility criteria, followed by full-text evaluation. Discrepancies were resolved by consensus or consultation with a third reviewer. Data were extracted independently using standardized extraction forms, including study characteristics (authors, publication year, country, study design), patient demographics (sample size, age, gender, disease duration, baseline severity), intervention details (modality, water temperature/composition, frequency, duration), control details, and quantitative outcome measurements (DAS28,

VAS, HAQ-DI at baseline, post-intervention, and follow-up).

Quality assessment / Risk of bias analysis Risk of bias for included studies was assessed independently by two reviewers using the Cochrane Risk of Bias tool, covering random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other sources of bias. Any disagreement was resolved by consensus. The certainty of evidence across outcomes was evaluated using the GRADE framework.

Strategy of data synthesis Meta-analyses were performed using STATA (version 17.0). For continuous outcomes (DAS28, VAS, HAQ-DI), effect sizes were expressed as weighted mean differences (WMD) or standardized mean differences (SMD) with 95% confidence intervals (CI). Categorical variables were synthesized as relative risks (RR). Heterogeneity across studies was assessed using Cochran's Q test and the I^2 statistic ($I^2 > 50\%$ indicating substantial heterogeneity). Fixed-effects models were applied when heterogeneity was low ($I^2 \leq 50\%$), and random-effects models were used in cases of significant heterogeneity. Publication bias was evaluated by funnel plot inspection and Egger's/Begg's regression tests.

Subgroup analysis Subgroup analyses were conducted based on:
1. Specific hydrotherapy modality (thermal water balneotherapy vs. peloidotherapy/mud therapy vs. radon baths).
2. Timing of outcome assessment (immediate post-treatment vs. 3-month follow-up).
3. Baseline disease severity and duration of intervention.

Sensitivity analysis Sensitivity analysis was performed by sequentially omitting individual studies (leave-one-out method) to test the stability and robustness of the pooled effect sizes.

Language restriction No language restriction was applied during literature retrieval.English.

Country(ies) involved China.

Keywords Rheumatoid arthritis, Hydrotherapy, Balneotherapy, Peloidotherapy, Rehabilitation, Meta-analysis.

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