

Aquatic versus Land-Based Exercise for Knee Osteoarthritis: An Updated Systematic Review and Meta-Analysis with Trial Sequential Analysis and GRADE Assessment

INPLASY202660035

doi: 10.37766/inplasy2026.6.0035

Received: 6 June 2026

Published: 6 June 2026

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ADMINISTRATIVE INFORMATION**Support** - None.**Review Stage at time of this submission** - Completed but not published.**Conflicts of interest** - None declared.**INPLASY registration number:** INPLASY202660035**Amendments** - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 6 June 2026 and was last updated on 6 June 2026.**INTRODUCTION**

Review question / Objective This review aims to determine whether aquatic exercise provides different clinical benefits from land-based exercise in adults with knee osteoarthritis. The main focus is on pain relief, symptom improvement, physical function, walking ability, mobility performance, and health-related quality of life. In addition, the reliability of the available evidence will be further examined using trial sequential analysis and the GRADE approach.

Condition being studied Knee osteoarthritis, a highly prevalent degenerative joint disorder that commonly causes pain, stiffness, impaired mobility, and reduced daily function. Exercise-based rehabilitation is widely used as an important conservative treatment strategy for this condition.

METHODS

Participant or population Adults with a diagnosis of knee osteoarthritis based on clinical

assessment, imaging findings, established diagnostic criteria, or a clear diagnosis described by the original investigators. No restrictions will be imposed on sex, body mass index, disease duration, or baseline functional status.

Intervention The intervention of interest is active aquatic exercise. Eligible programs may include water-based walking, aquatic aerobic training, resistance exercise in water, underwater treadmill training, hydrotherapy-based exercise, or combined aquatic rehabilitation programs.

Comparator The control intervention is active land-based exercise or land-based rehabilitation. This may include walking exercise, aerobic training, strengthening exercise, stretching, balance training, treadmill exercise, TRX-based training, or other structured rehabilitation programs performed on land.

Study designs to be included Randomized controlled trials.

Eligibility criteria Inclusion criteria:

- (1) Randomized controlled trials.
- (2) Participants were adults with knee osteoarthritis.
- (3) The study directly compared aquatic exercise with land-based exercise or land-based rehabilitation.
- (4) At least one relevant clinical outcome was reported, such as WOMAC score, VAS pain score, KOOS score, functional performance test, or SF-36 bodily pain score.

Exclusion criteria:

- (1) Observational studies, non-randomized trials, case reports, reviews, letters, conference abstracts, or study protocols.
- (2) Studies including patients without knee osteoarthritis, unless data for knee osteoarthritis could be extracted separately.
- (3) Studies using usual care, health education, waiting-list control, or no-exercise control as the only comparator.
- (4) Studies assessing passive water-based treatments, such as balneotherapy, spa therapy, mud therapy, simple immersion, or passive hydrotherapy, rather than active aquatic exercise.
- (5) Studies focusing on postoperative rehabilitation after knee arthroplasty.
- (6) Studies with insufficient numerical data for meta-analysis.
- (7) Duplicate reports from the same study population.

Information sources A comprehensive literature search was performed in PubMed, Embase, Web of Science, Cochrane Central Register of Controlled Trials, and ClinicalTrials.gov from database inception to May 28, 2026. The reference lists of relevant articles were also checked to identify additional eligible studies.

Main outcome(s) Primary outcomes: WOMAC total score, WOMAC function score, WOMAC pain score, and VAS pain score after intervention. Secondary outcomes: KOOS subscale scores, 6-minute walk test, timed up and go test, stair climbing test, and SF-36 bodily pain domain. WOMAC total score, WOMAC function score, WOMAC pain score, and VAS pain score after intervention.

Quality assessment / Risk of bias analysis The methodological quality of the included trials was evaluated using the Cochrane risk-of-bias assessment tool. The assessed domains included sequence generation, allocation concealment, blinding, incomplete outcome data, selective reporting, and other possible sources of bias.

Strategy of data synthesis Quantitative synthesis was performed using Review Manager 5.4. For continuous variables, pooled effects were calculated as mean differences or standardized mean differences with 95% confidence intervals, depending on whether the same measurement scale was used across studies. Statistical heterogeneity was examined using the Chi-square test and I^2 statistic. A fixed-effect model was used when heterogeneity was low, whereas a random-effects model was applied when substantial heterogeneity was present. Trial sequential analysis was conducted for major outcomes to judge whether the accumulated evidence was sufficient and to reduce the possibility of random error.

Subgroup analysis When substantial heterogeneity was detected, subgroup analysis was considered according to the type of land-based control intervention. The planned subgroup categories included comprehensive or strengthening-based land exercise and other types of land-based rehabilitation.

Sensitivity analysis Sensitivity analysis was performed by sequentially excluding each study from the pooled analysis. This approach was used to examine whether the overall results were affected by any single trial and to evaluate the stability of the meta-analysis findings.

Country(ies) involved China.

Keywords Knee osteoarthritis; Aquatic exercise; Land-based exercise; Randomized controlled trial; Meta-analysis.

Contributions of each author

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