Available online at : http://journal.unj.ac.id/unj/index.php/gjik
Gladi : Jurnal Ilmu Keolahragaan, 17 (04) 2026, 555-568
Permalink/DOI: https://doi.org/10.21009/GJIK.174.03

Effectiveness of aquatic and land-based exercise in knee osteoarthritis: a systematic review (2020–2026)

Wiyonna Gusvominesia[1*], Anton Komaini[1], Roma Irawan[1]

[1] Faculty of Sports Sciences, Universitas Negeri Padang, Jl. Prof. Dr. Hamka, Air Tawar Barat, Kec. Padang Utara, Kota Padang, Sumatera Barat 25131, Indonesia

*Corresponding author: Wiyonna19@gmail.com

(Submission Track: Received: 23-09-2026, Final Revision: 19-10-2026, Available Online: 11-13-2026)

Abstract. Knee osteoarthritis (OA) is a leading cause of pain and disability in adults and older people, and exercise is first-line therapy. This review maps the 2020–2026 evidence on aquatic exercise and other exercise modalities for knee OA. The Scopus database was searched with a Boolean strategy combining *aquatic exercise*, *hydrotherapy*, *exercise* and *knee osteoarthritis* terms. Of 188 records, 80 passed the language, document-type and publication-period filters, and 59 passed title–abstract screening and were synthesised thematically following PRISMA 2020. Study quality was appraised with the FICO framework (Focus, Information, Context, Outcome). Thematic synthesis, organised around three research questions, covered: (1) effectiveness of aquatic exercise versus no exercise; (2) water versus land environments and the ranking of exercise modalities; (3) dose, intensity and novel combinations of aquatic exercise; (4) perioperative aquatic exercise around total knee arthroplasty (TKA); and (5) mechanisms, measurement and clinical implementation. The included meta-analyses show that aquatic exercise reduces pain (SMD −0.36 to −0.58) and improves physical function (SMD −0.33 to −0.64) compared with no exercise. However, its effects generally do not exceed those of land-based exercise, and only the effect on pain persists to three months. Two to three sessions per week over at least eight weeks was the most frequently tested schedule and was associated with more consistent improvements, but no included study compared doses directly, so an optimal dose could not be identified. Aquatic exercise may be a useful starting point for patients who do not tolerate land-based exercise, although this sequence has not been tested. Future research should use standardised aquatic outcome measures, direct dose comparisons, long-term follow-up and trials at low risk of bias.

Keywords: knee osteoarthritis; aquatic exercise; hydrotherapy; exercise therapy; rehabilitation

Copyright © 2026 Wiyonna Gusvominesia, Anton Komaini, Roma Irawan
This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

INTRODUCTION

Knee osteoarthritis is a degenerative joint disease involving cartilage breakdown, subchondral bone changes, synovitis and neuromuscular dysfunction (Heijink et al., 2012; Zeng et al., 2021). It causes pain, stiffness, muscle weakness and gait impairment that reduce independence and quality of life (Zeng et al., 2021). Pharmacological therapy has only a modest effect on disease progression, and surgery is reserved for end-stage OA. Exercise, education and weight management are therefore positioned as core treatments, and physical activity is recommended for all people with hip or knee OA (Rausch Osthoff et al., 2018; Zeng et al., 2021). Aquatic exercise uses the buoyancy, resistance and hydrostatic pressure of water to reduce joint loading while providing training resistance (Tedeschi et al., 2024; Zeng et al., 2021). These properties may make water-based exercise more tolerable for patients who find land exercise difficult because of pain and stiffness (Kim et al., 2021; Tedeschi et al., 2024). Patients with obesity and older adults, who carry a large share of the knee OA burden, are frequent targets of this modality (J. Xu et al., 2025; Zhou et al., 2026). At the same time, exercise options for knee OA have diversified, ranging from aerobic, strengthening and neuromuscular training to yoga and Tai Chi (Du et al., 2024; Mo et al., 2023).

Despite the growing evidence, several gaps remain. First, head-to-head comparisons of water- and land-based exercise give inconsistent results (Slouma et al., 2025; Z. Xu et al., 2023). Second, dose parameters (intensity, frequency, session length and programme duration) are not standardised, which makes practical guidance hard to formulate (Goikoetxea-Sotelo & van Hedel, 2023). Third, most trials are small, do not blind participants and use short follow-up. Fourth, functional measures validated specifically for the aquatic environment are still scarce. Publication volume has surged since 2025, with 31 of the 59 selected studies published in 2025–2026. This surge is not covered by earlier reviews, so an up-to-date synthesis is needed. The aim of this review is to identify, appraise and integrate the 2020–2026 evidence on the effectiveness of aquatic and other exercise in knee OA, and the factors that modify its outcomes. Three research questions (RQs) were formulated:

1. **RQ1:** How effective is aquatic exercise in reducing pain and improving physical function in knee OA, and how does it compare with land-based exercise and other modalities?
2. **RQ2:** Which dose, intensity and combined-intervention parameters give the most consistent benefits, including in the perioperative TKA setting?

3. **RQ3:** Which mechanisms, outcome measures and implementation factors determine the uptake of aquatic exercise in clinical practice?

METHOD

This study is a systematic literature review (SLR). Reporting follows PRISMA 2020 (Page et al., 2021), which includes guidance on evidence mapping, risk-of-bias assessment and documentation of the synthesis. Narrative and scoping reviews were not chosen because they are less replicable and more prone to selection bias. The search was run in Scopus on the TITLE-ABS-KEY field. The search string combined three blocks of terms: population (*knee osteoarthritis*, *gonarthrosis*), intervention (*aquatic exercise*, *hydrotherapy*, *water-based exercise*, *exercise therapy*) and outcomes (*pain*, *physical function*, *quality of life*). Scopus (Elsevier) was chosen for its broad interdisciplinary coverage, consistent indexing of rehabilitation and sports medicine journals, and support for advanced Boolean syntax. The export returned 188 records published between 1996 and 2026. No additional databases were searched.

Eligibility criteria

Studies were retained only if they met all inclusion criteria in Table 1 simultaneously.

Table 1. Inclusion and exclusion criteria

Criterion	Inclusion	Exclusion
Language	English	Non-English
Document type	Article, Review	Editorial, book chapter, conference paper, letter, short survey
Publication period	2020–2026	Before 2020
Population	Humans with knee OA or lower-limb OA, including after TKA	Animal models, healthy people, ligament or meniscal injury without OA
Intervention	Aquatic exercise or active exercise/rehabilitation	Surgery, injections, stem cells, purely passive modalities
Availability	Abstract available; full text accessible	No abstract

Selection followed three stages. Stage 1 filtered the 188 records by period, language and document type using Scopus metadata. Stage 2 screened titles and abstracts against the population and intervention criteria. Stage 3 checked full texts. All decisions and their reasons were logged so that the review can be audited. Study quality was appraised with the FICO

framework: Focus (clarity of the question and aims), Information (adequacy of design, sample and instruments), Context (realism of the setting and representativeness of the sample) and Outcome (validity and reliability of outcomes). Each criterion was scored 0 (absent), 1 (partial) or 2 (full), giving a maximum total of 8. Studies scoring ≥ 5 were considered eligible. A standardised template recorded: (a) first author, year and country; (b) study design; (c) participant characteristics (number, age, sex, OA grade); (d) type, dose and duration of the intervention; (e) primary and secondary outcomes; (f) main findings and statistical summaries; (g) DOI. All data were cross-checked against the Scopus CSV file. The descriptive bibliometric analysis covered annual publication frequency, the most productive journals, contributing countries and author keywords. Keyword co-occurrence can be analysed with VOSviewer (minimum threshold of three occurrences).

Thematic synthesis followed three stages (Thomas & Harden, 2008): line-by-line coding of study findings, development of descriptive themes and formulation of analytical themes. The final themes were aligned with the three RQs. Where quantitative data were sufficient, effect sizes (SMD, MD, 95% CI) from the included meta-analyses were reported descriptively. The flow diagram records 188 records identified with no duplicates. Metadata filtering excluded 108 records: 102 published before 2020, 1 not in English and 5 of an ineligible document type. Title–abstract screening of 80 records excluded a further 21, leaving 59 studies.

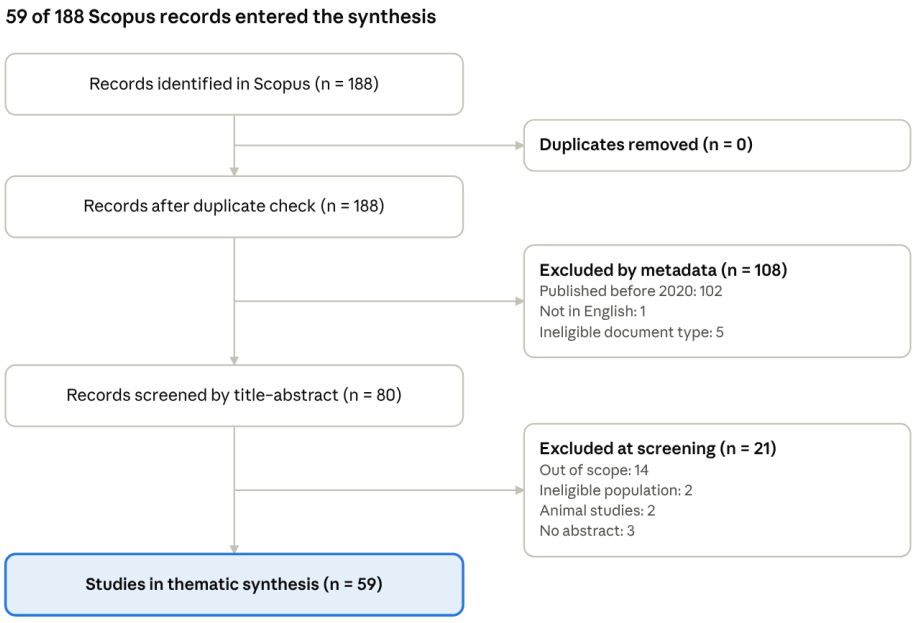


Figure 1. PRISMA 2020 flow diagram

The publication-period filter removed the largest share of records (102 of 188), so the final corpus reflects post-2020 evidence

RESULT AND DISCUSSION

Result

The Scopus search returned 188 records, and no duplicates were found after checking DOIs and titles. Metadata filtering excluded 108 records: 102 published before 2020, 1 in Chinese and 5 of an ineligible document type (editorial n = 3, book chapter n = 1, conference paper n = 1). Title–abstract screening of 80 records excluded 21: 14 out of scope (for example ACL reconstruction, stem-cell injection, cartilage tissue engineering, patient education and cost models), 2 with an ineligible population (healthy people and older adults without OA), 2 animal studies and 3 without an abstract. A total of 59 studies were carried forward to thematic synthesis.

Descriptive Characteristics

The 59 studies comprise 38 empirical articles and 21 reviews, with 880 Scopus citations in total. Table 2 presents 10 example studies to illustrate the range of designs, populations and interventions. These examples are not the analytical basis of the review; all 59 studies were integrated through thematic synthesis.

Table 2. Summary of included studies (selected sample, n = 10)

Title (abridged)	Authors	Year	Country	Method	Key findings
Efficacy and safety of aquatic exercise in knee OA	Xu et al.	2023	China	SR & meta-analysis (22 RCTs, n = 1,394)	Versus no exercise: pain SMD −0.58, stiffness −0.57, function −0.35; only the pain effect persisted to 3 months
Effectiveness of aquatic exercise in lower limb OA	Duan et al.	2022	China	Meta-analysis (19 RCTs, n = 1,592)	Short-term pain SMD −0.54, function −0.64, stiffness −0.40
Aquatic rehabilitation in knee joint dysfunction	Jiang & Peng	2026	China	Meta-analysis (29 trials, n = 1,984)	Symptoms SMD −0.55, function +0.50; quality of life not significant; programmes ≥ 8 weeks more effective
Exercise therapy for knee OA: network MA	Mo et al.	2023	China	Network MA (39 studies, n = 2,646)	Cycling, resistance training, Tai Chi and yoga beat control on WOMAC pain; aquatic exercise did not

Title (abridged)	Authors	Year	Country	Method	Key findings
Aquatic cycling in knee OA	Rewald et al.	2020	Netherlands	RCT (n = 111), 12 weeks	Pain (ES 0.50) and physical function (ES 0.43) improved versus usual care
Aquatic vs land-based exercise for knee OA	Slouma et al.	2025	Tunisia	RCT (n = 60), 8 weeks	WOMAC pain response ≥ 20% in 93% of the water group vs 33% of the land group
AquaHigh trial	Bunæs-Næss et al.	2025	Norway	RCT (n = 89), 12 weeks	Aquatic HIIT raised VO_2peak by 1.9 $mL \cdot kg^{-1} \cdot min^{-1}$ vs moderate intensity; not maintained at 6 months
Lower body positive pressure walking	Jayabalan et al.	2026	USA	Pilot RCT (n = 49), 8 weeks	KOOS-Pain improved 15.3 points with LBPP treadmill; pool walking not significant (0.9)
Aquatic prehabilitation before TKA	Kim et al.	2021	USA	Pilot study (n = 43), 4–8 weeks	Aquatic prehabilitation improved WOMAC, chair-stand, depression and cognition after TKA
Hydrotherapy after knee arthroplasty	Alrashedi et al.	2026	Saudi Arabia	SR & meta-analysis of RCTs	Pain no different from land rehabilitation; moderate gain in lower-limb muscle strength

The number of selected studies held at 6–7 per year in 2020–2023, fell to 2 in 2024, then surged to 18 in 2025 and 13 in 2026.

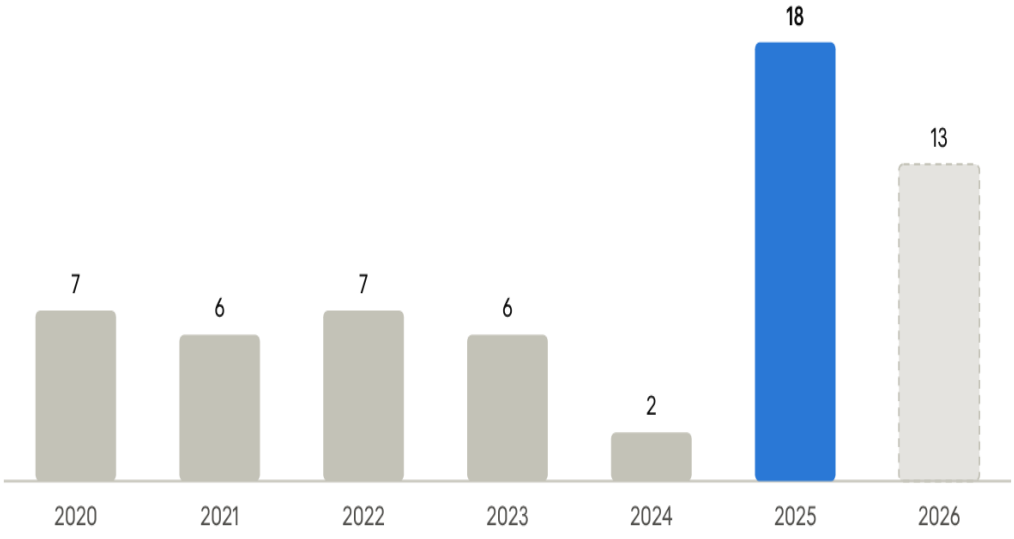


Figure 2. Selected studies per year · Scopus export, 59 studies

Based on author affiliations, the largest contributors were China (11 studies), Iran (10), the United States (6), Australia (4) and Italy (4). A study may involve more than one country. The concentration in Iran reflects many small RCTs of aquatic exercise in older women, while China dominates the meta-analyses.

Thematic synthesis

Findings for RQ1: Effectiveness of aquatic exercise and its position among exercise modalities

Four meta-analyses consistently showed that aquatic exercise was better than no exercise or usual care (Duan et al., 2022; Jiang & Peng, 2026; Z. Xu et al., 2023; Zhou et al., 2026). Pooled effects on pain ranged from SMD −0.36 to −0.58 and on physical function from SMD −0.33 to −0.64. These effects are small to moderate, and their confidence intervals do not rule out values below the minimal clinically important difference (Maltenfort & Díaz-Ledezma, 2017; Willigenburg & Poolman, 2023; Z. Xu et al., 2023). In the knee-specific meta-analysis of 22 RCTs, only the effect on pain persisted to three months, and aquatic exercise did not differ significantly from land-based exercise for pain, stiffness or physical function (Z. Xu et al., 2023). Quality of life did not improve significantly in the pooled analysis of aquatic rehabilitation (Jiang & Peng, 2026). In patients with overweight and obesity, aquatic exercise remained effective with low heterogeneity (I^2 0–18%), with numerically larger effects in the obese subgroup (Zhou et al., 2026). Individual RCTs are consistent with these pooled results: 12 weeks of aquatic cycling improved pain and function compared with usual care (Rewald et al., 2020), and 8 weeks of aquatic exercise or aquatic cycling improved static and dynamic balance and step length in older adults (Azizi et al., 2020; Rezasoltani et al., 2020). In obese patients, aquatic and Thera-band exercise both reduced pain, but only the water group improved endurance (Krishnan et al., 2022). Head-to-head trials were less consistent. One 8-week RCT reported a larger pain response with aquatic than with land-based exercise (Slouma et al., 2025), whereas in a three-arm pilot RCT, pool walking did not significantly improve KOOS-Pain, unlike lower-body positive-pressure treadmill walking (Jayabalan et al., 2026). In a network meta-analysis, cycling, resistance training, Tai Chi and yoga outperformed control on WOMAC pain, whereas aquatic exercise did not (Mo et al., 2023). Hydrotherapy reviews also report gains in the 6MWT, TUG, sit-to-stand tests and gait parameters (Minea et al., 2026; Tedeschi et al., 2024).

Findings for RQ2: Dose, intensity, combined interventions and the perioperative setting

The most frequently reported aquatic exercise schedule in the included studies was two to three sessions per week, with each session lasting 45–60 minutes. This describes the schedule most often tested, not a schedule shown to be optimal. The review did not identify direct comparisons showing that this frequency or session length produced greater improvements in pain or physical function than alternative schedules. A meta-analysis of aquatic rehabilitation reported larger improvements in programmes lasting at least eight weeks (Jiang & Peng, 2026), and a similar pattern was reported for land-based resistance and mind–body exercise (Mo et al., 2023). However, the aquatic meta-analysis included a broader population with knee joint dysfunction, and programme duration varied alongside exercise type, intensity and supervision. These findings therefore identify the most frequently used dosage, not the dosage proven to be most effective, and do not establish eight weeks as either the minimum effective or the optimal duration of aquatic exercise for knee OA.

For exercise intensity, the AquaHigh trial provides a direct comparison, although its participants had a range of rheumatic and musculoskeletal diseases. At programme completion, aquatic high-intensity interval training produced a 1.9 $mL \cdot kg^{-1} \cdot min^{-1}$ greater improvement in VO_2peak than moderate-intensity aquatic training, with no serious adverse events. The difference was no longer evident at six months, and the trial found no corresponding advantage in patient-reported outcomes or quality-adjusted life years (Bunæs-Næss et al., 2025). This finding supports a short-term aerobic fitness benefit in the population studied, but it does not establish that high intensity is preferable for reducing knee OA pain or improving daily function. Other intensity-related evidence is indirect: a Bayesian analysis of two RCTs in women with mild knee OA estimated a 55–71% probability of benefit from aquatic resistance training (Heikkinen et al., 2022), and 16 weeks of high-speed aquatic strength training increased knee extensor strength and power in older women without a knee OA diagnosis (Juesas et al., 2025). Across land and water settings, aerobic exercise improved cardiorespiratory fitness in knee OA (Su et al., 2025).

For combined interventions, the evidence comes from single small trials. In a double-blind RCT of 44 women with knee OA, adding anodal transcranial direct current stimulation (tDCS) to six weeks of aquatic neuromuscular training accelerated session-by-session pain relief, but pain did not differ between groups at six weeks; the combined group showed greater improvements in knee instability and WOMAC function (Kaboodi et al., 2025). Aquatic resistance training with blood flow restriction in postmenopausal women with knee OA was

associated with improvements in heart rate variability, functional capacity and pain (Baniasadi et al., 2025). In 66 patients treated at a health resort, adding two weeks of aquatic exercise to balneotherapy produced greater short-term pain relief than balneotherapy alone (Regazzo et al., 2026). The relevant dosing question for each combination is whether the added component produces a clinically meaningful benefit beyond aquatic exercise performed at a comparable frequency, intensity and duration. The available evidence does not establish an optimal prescription for any of these combinations.

In the perioperative setting, a pilot RCT evaluated four to eight weeks of aquatic prehabilitation, delivered as 60-minute sessions three times per week, in 43 older adults awaiting total knee arthroplasty (Kim et al., 2021). The intervention was associated with better WOMAC scores, chair-stand performance, depression and cognition, but the trial detected no difference in postoperative complications, unscheduled emergency visits or discharge to a rehabilitation or nursing facility. The four-to-eight-week period was the intervention window determined by the surgical schedule; the study did not compare programme lengths and therefore cannot determine the most effective duration of prehabilitation. After arthroplasty, a meta-analysis of RCTs found that hydrotherapy did not reduce pain more than land-based exercise or usual care, but it produced a moderate gain in lower-limb muscle strength (Alrashedi et al., 2026).

Findings for RQ3: Mechanisms, measurement and implementation

Evidence on implementation was limited. The benefits of exercise therapy for hip and knee OA tend not to persist long after supervised programmes end, although booster sessions help to maintain them (Pisters et al., 2007). Similarly, a 12-week unsupervised online yoga programme improved physical function, but participation declined once the programme became optional and the benefits were not maintained at 24 weeks (Bennell et al., 2022). For aquatic exercise specifically, pool access, travel time and cost were rarely measured in the included trials, and no functional outcome measure validated for the aquatic environment was identified. Biomarker and biomechanical outcomes were reported only in small trials (Jayabalan et al., 2026), so the included evidence does not establish the mechanisms through which aquatic exercise exerts its effects; proposed mechanisms, such as reduced joint loading and anti-inflammatory effects, are derived mainly from broader exercise research (Zeng et al., 2021). Current physical-activity recommendations advise that exercise prescriptions be adapted to

individual needs and national health systems (Rausch Osthoff et al., 2018), which is particularly relevant where pool access is limited.

Interpretation and clinical implications

The findings above are those directly supported by the included studies; this subsection separates them from our interpretation. Compared with no exercise, aquatic exercise reduced pain and improved physical function in the short term. Direct comparisons with land-based exercise showed no clear advantage for either modality on these outcomes. Programmes lasting eight weeks or longer were associated with more consistent improvements. Because programme duration varied alongside frequency, intensity and supervision, this pattern does not establish an eight-week threshold or a dose–response relationship. Some benefits diminished during follow-up, but the studies did not establish whether changes in exercise participation after programme completion explained this decline.

From a clinical perspective, buoyancy may make exercise more tolerable for patients who experience pain during weight-bearing activities, including some people with obesity. Whether this translates into better attendance or a higher exercise dose remains uncertain. We therefore propose, as an interpretation rather than an evidence-based finding, aquatic exercise as a possible starting point for patients who have difficulty exercising on land. Land-based strengthening or aerobic activity could then be introduced according to the patient's tolerance and functional goals. The included studies did not establish whether this sequence produces better outcomes than either approach alone. Similarly, the additional benefits of combining aquatic exercise with tDCS or blood flow restriction remain questions for adequately powered controlled trials.

Research priorities and limitations of this review

Three research priorities follow from these limitations. First, small samples and short follow-up periods limit conclusions about the durability of benefits. Adequately powered multicentre trials with at least 12 months of follow-up would allow researchers to examine whether improvements in pain and function persist. Second, consistent reporting of exercise frequency, intensity, session duration and attendance, together with validated functional measures and trials that compare dosing parameters directly, would make programmes easier to compare. Third, broader recruitment of men, adults younger than 60 years and participants in low-income settings would clarify how widely the findings apply. Measuring pool access,

travel costs and cost-effectiveness alongside clinical outcomes would also help determine where aquatic rehabilitation is feasible in routine practice.

This review also has limitations. Only Scopus was searched, so relevant trials indexed elsewhere may have been missed. The FICO framework is not a validated risk-of-bias tool, and no new meta-analysis was performed: effect sizes were taken from the included meta-analyses, which overlap in their primary trials, so their agreement should not be read as independent confirmation. Several included studies enrolled mixed populations (for example, lower-limb OA, knee joint dysfunction or rheumatic and musculoskeletal diseases), which limits the specificity of conclusions for knee OA.

CONCLUSION

This systematic review, following PRISMA 2020, synthesised 59 studies published in 2020–2026 on aquatic and other exercise in knee OA. For RQ1, aquatic exercise reduced pain and improved physical function compared with no exercise, with small-to-moderate effects (SMD approximately −0.33 to −0.64), but it did not consistently outperform land-based exercise. For RQ2, two to three sessions per week of 45–60 minutes was the most frequently tested schedule, and programmes of eight weeks or longer were associated with more consistent improvements; however, no included study compared doses directly, so an optimal dose cannot yet be defined. High-intensity aquatic training was safe and improved aerobic capacity in the short term, while combinations with tDCS, blood flow restriction, balneotherapy and prehabilitation before TKA remain preliminary. For RQ3, the durability of benefits appears to depend on continued participation, uptake is limited by access, cost and the lack of standardised aquatic outcome measures, and the mechanisms of benefit were not established by the included studies.

Clinically, we propose, as an interpretation rather than a tested finding, that aquatic exercise may serve as an entry point for patients who cannot tolerate land-based exercise, with progression to land-based strengthening and aerobic training as tolerated. Because the search used only Scopus and the included studies are highly heterogeneous, these conclusions are tentative until confirmed by a multi-database search. Future research should use adequately powered multicentre trials, long-term follow-up, direct comparisons of dosing parameters, standardised aquatic outcome measures and more diverse populations.

REFERENCES

Alrashedi, S. N., Fahmy, E. K., Eladl, H. M., Alshammari, M. A., Esmaeel, S. E., Shukry, M.,

Ali, O. I., & Emam, M. A. (2026). The role of hydrotherapy in enhancing recovery after knee arthroplasty: A systematic review and meta-analysis of randomized controlled trials. *Healthcare*, *14*(13), 2005. https://doi.org/10.3390/healthcare14132005

Azizi, S., Dadarkhah, A., Rezasoltani, Z., Raeissadat, S. A., Mofrad, R. K., & Najafi, S. (2020). Randomized controlled trial of aquatic exercise for treatment of knee osteoarthritis in elderly people. *Interventional Medicine and Applied Science*, *11*(3), 161–167. https://doi.org/10.1556/1646.11.2019.19

Baniasadi, S., Mohammadnia Ahmadi, M., Ilbeigi, S., Yousefi, M., & Saremi, Z. (2025). Effect of resistance training in water with blood flow restriction on heart rate variability, functional capacity, and pain in postmenopausal women with knee osteoarthritis. *Journal of Kerman University of Medical Sciences*, *32*(1), 4170. https://doi.org/10.34172/jkmu.4170

Bennell, K. L., Schwartz, S., Teo, P. L., Hawkins, S., Mackenzie, D., McManus, F., Lamb, K. E., Kimp, A. J., Metcalf, B., Hunter, D. J., & Hinman, R. S. (2022). Effectiveness of an unsupervised online yoga program on pain and function in people with knee osteoarthritis: A randomized clinical trial. *Annals of Internal Medicine*, *175*(10), 1345–1355. https://doi.org/10.7326/M22-1761

Bunæs-Næss, H., Heywood, S. E., Kvæl, L. A. H., Heiberg, K. E., & Nilsson, B. B. (2025). Effects of aquatic high-intensity interval training on aerobic capacity in adults with rheumatic and musculoskeletal diseases: The AquaHigh randomised controlled trial. *BMJ Open*, *15*(3), 1–11. https://doi.org/10.1136/bmjopen-2024-090612

Du, X., Fan, R., & Kong, J. (2024). What improvements do general exercise training and traditional Chinese exercises have on knee osteoarthritis? A narrative review based on biological mechanisms and clinical efficacy. *Frontiers in Medicine*, *11*, 1395375. https://doi.org/10.3389/fmed.2024.1395375

Duan, X., Wei, W., Zhou, P., Liu, X., Yu, J., Xu, Y., Huang, L., & Yang, S. (2022). Effectiveness of aquatic exercise in lower limb osteoarthritis: A meta-analysis of randomized controlled trials. *International Journal of Rehabilitation Research*, *45*(2), 126–136.

Goikoetxea-Sotelo, G., & van Hedel, H. J. A. (2023). Defining, quantifying, and reporting intensity, dose, and dosage of neurorehabilitative interventions focusing on motor outcomes. *Frontiers in Rehabilitation Sciences*, *4*, 1139251. https://doi.org/10.3389/fresc.2023.1139251

Heijink, A., Gomoll, A. H., Madry, H., Drobnič, M., Filardo, G., Espregueira-Mendes, J., & van Dijk, C. N. (2012). Biomechanical considerations in the pathogenesis of osteoarthritis of the knee. *Knee Surgery, Sports Traumatology, Arthroscopy*, *20*(3), 423–435. https://doi.org/10.1007/s00167-011-1818-0

Heikkinen, R., Waller, B., Munukka, M., Multanen, J., Heinonen, A., & Karvanen, J. (2022). Impact or no impact for women with mild knee osteoarthritis: A Bayesian meta-analysis of two randomized controlled trials with contrasting interventions. *Arthritis Care & Research*, *74*(7), 1133–1141. https://doi.org/10.1002/acr.24553

Jayabalan, P., Merenzon, Y., Lazar, A., Sen, S., Darbhe, V., Gray, E., Schnitzer, T., & Welty, L. (2026). Lower positive body pressure walking significantly improves pain and function in individuals with knee osteoarthritis: A pilot randomized clinical trial. *American Journal of Physical Medicine & Rehabilitation*, *105*(11), 1030–1038. https://doi.org/10.1097/PHM.0000000000003007

Jiang, Y., & Peng, Y. (2026). Effects of aquatic rehabilitation on symptoms, physical function,

and quality of life in individuals with knee joint dysfunction: A meta-analysis. *Frontiers in Physiology*, *17*, 1804926. https://doi.org/10.3389/fphys.2026.1804926

Juesas, A., Babiloni-Lopez, C., Gene-Morales, J., Jiménez-Martínez, P., Ramirez-Campillo, R., & Colado, J. C. (2025). Impact of a novel aquatic-based strength program on body composition, strength, and quality of life in older women: A 16-week randomized controlled trial. *Journal of Science in Sport and Exercise*. https://doi.org/10.1007/s42978-025-00330-2

Kaboodi, A. T., Gandomi, F., Soufivand, P., & Assar, S. (2025). The impacts of transcranial direct current stimulation combined with aquatic neuromuscular training on pain, function, kinesiophobia, knee instability, and quality of life in knee osteoarthritis: A double-blind randomized trial. *Journal of NeuroEngineering and Rehabilitation*, *22*(1), 151. https://doi.org/10.1186/s12984-025-01670-4

Kim, S., Hsu, F.-C., Groban, L., Williamson, J., & Messier, S. (2021). A pilot study of aquatic prehabilitation in adults with knee osteoarthritis undergoing total knee arthroplasty – short term outcome. *BMC Musculoskeletal Disorders*, *22*(1), 388. https://doi.org/10.1186/s12891-021-04253-1

Krishnan, K., Abadi, F. H., Choo, L. A., Zainudin, F. F., & Motevalli, S. (2022). Comparison between aquatic and Thera-Band exercises on pain intensity and endurance among obese individuals with knee osteoarthritis. *International Journal of Human Movement and Sports Sciences*, *10*(4), 1–9. https://doi.org/10.13189/saj.2022.101301

Maltenfort, M., & Díaz-Ledezma, C. (2017). Statistics in brief: Minimum clinically important difference—Availability of reliable estimates. *Clinical Orthopaedics and Related Research*, *475*(4), 933–946. https://doi.org/10.1007/s11999-016-5204-6

Minea, M., Lupu, A. A., Nedelcu, A. D., Ciortea, V. M., Irsay, L., & Iliescu, M. G. (2026). Hydrotherapy in the rehabilitation of functional performance and gait in knee osteoarthritis: A systematic review of randomized controlled trials. *Medicina*, *62*(5), 994. https://doi.org/10.3390/medicina62050994

Mo, L., Jiang, B., Mei, T., & Zhou, D. (2023). Exercise therapy for knee osteoarthritis: A systematic review and network meta-analysis. *Orthopaedic Journal of Sports Medicine*, *11*(5), 1–10. https://doi.org/10.1177/23259671231172773

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. https://doi.org/10.1136/bmj.n71

Pisters, M. F., Veenhof, C., van Meeteren, N. L. U., Ostelo, R. W., de Bakker, D. H., Schellevis, F. G., & Dekker, J. (2007). Long-term effectiveness of exercise therapy in patients with osteoarthritis of the hip or knee: A systematic review. *Arthritis & Rheumatism*, *57*(7), 1245–1253. https://doi.org/10.1002/art.23009

Rausch Osthoff, A.-K., Niedermann, K., Braun, J., Adams, J., Brodin, N., Dagfinrud, H., Duruoz, T., Esbensen, B. A., Günther, K.-P., Hurkmans, E., Juhl, C. B., Kennedy, N., Kiltz, U., Knittle, K., Nurmohamed, M., Pais, S., Severijns, G., Swinnen, T. W., Pitsillidou, I. A., … Vliet Vlieland, T. P. M. (2018). 2018 EULAR recommendations for physical activity in people with inflammatory arthritis and osteoarthritis. *Annals of the Rheumatic Diseases*, *77*(9), 1251–1260. https://doi.org/10.1136/annrheumdis-2018-213585

Regazzo, G., Contessa, P., Forcato, B., Fornasiero, M., Gaiofatto, M., Gibellini, M., Massimo,

F., Venturini, E., Scanu, A., & Masiero, S. (2026). Intensive combined balneotherapy and aquatic exercise for knee osteoarthritis: Short-term clinical and functional outcomes. *Frontiers in Medicine*, *13*, 1790566. https://doi.org/10.3389/fmed.2026.1790566

Rewald, S., Lenssen, A. F. T., Emans, P. J., de Bie, R. A., van Breukelen, G., & Mesters, I. (2020). Aquatic cycling improves knee pain and physical functioning in patients with knee osteoarthritis: A randomized controlled trial. *Archives of Physical Medicine and Rehabilitation*, *101*(8), 1288–1295. https://doi.org/10.1016/j.apmr.2019.12.023

Rezasoltani, Z., Sanati, E., Kazempour Mofrad, R., Azizi, S., Dadarkhah, A., & Najafi, S. (2020). Randomized controlled trial of aquatic cycling for treatment of knee osteoarthritis in elderly people. *Topics in Geriatric Rehabilitation*, *36*(2), 103–109. https://doi.org/10.1097/TGR.0000000000000264

Slouma, M., Abbes, M., Kharrat, L., Dhahri, R., Maaoui, R., Mouhli, N., Hfaidh, M., Zrida, S., Ksibi, I., Rahali, H., Hedia, B., & Gharsallah, I. (2025). Aquatic versus land-based exercise for knee osteoarthritis: A randomized controlled trial. *Korean Journal of Family Medicine*, *46*(5), 341–348. https://doi.org/10.4082/kjfm.23.0102

Su, S., Yu, C. C. W., Zhou, E. F. M., Liu, J. Y., & Fu, S. N. (2025). Effect of aerobic exercise on cardiopulmonary fitness among people with knee osteoarthritis: A systematic review and meta-analysis. *BMC Musculoskeletal Disorders*, *26*(1), 1–12. https://doi.org/10.1186/s12891-025-08746-1

Tedeschi, R., Giorgi, F., & Donati, D. (2024). Harnessing the power of water: A scoping review of hydrokinesiotherapy as a game-changer in knee osteoarthritis management. *Journal of Clinical Medicine*, *13*(19), 5811. https://doi.org/10.3390/jcm13195811

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology*, *8*, 45. https://doi.org/10.1186/1471-2288-8-45

Willigenburg, N. W., & Poolman, R. W. (2023). The difference between statistical significance and clinical relevance. The case of minimal important change, non-inferiority trials, and smallest worthwhile effect. *Injury*, *54*(S5), 110764. https://doi.org/10.1016/j.injury.2023.04.051

Xu, J., Lei, M., & Xu, D. (2025). Global, regional, and national burden of knee osteoarthritis attributable to high BMI: A systematic analysis from 1990 to 2021 and projections to 2050. *Frontiers in Public Health*, *13*, 1668257. https://doi.org/10.3389/fpubh.2025.1668257

Xu, Z., Wang, Y., Zhang, Y., Lu, Y., & Wen, Y. (2023). Efficacy and safety of aquatic exercise in knee osteoarthritis: A systematic review and meta-analysis of randomized controlled trials. *Clinical Rehabilitation*, *37*(3), 330–347. https://doi.org/10.1177/02692155221134240

Zeng, C. Y., Zhang, Z. R., Tang, Z. M., & Hua, F. Z. (2021). Benefits and mechanisms of exercise training for knee osteoarthritis. *Frontiers in Physiology*, *12*, 794062. https://doi.org/10.3389/fphys.2021.794062

Zhou, W., Yan, Y., Zhou, H., Zhang, Z., & Yan, J. (2026). Effects of aquatic exercise on pain and physical function in overweight/obese patients with lower limb osteoarthritis: A systematic review and meta-analysis. *Frontiers in Physiology*, *17*, 1864401. https://doi.org/10.3389/fphys.2026.1864401