

Aquatic exercise and therapeutic swimming for musculoskeletal disorders: A systematic review of functional outcomes and quality of life

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Abstract

Musculoskeletal disorders not only cause pain and physical limitations but may also restrict daily activities and reduce quality of life, highlighting the need for effective and tolerable rehabilitation approaches. This study aimed to synthesize randomized controlled trial evidence on the effectiveness of swimming and structured aquatic exercise for clinical and functional outcomes in musculoskeletal disorders. A systematic review following PRISMA 2020 searched PubMed, Cochrane Library, Wiley Online Library, Taylor & Francis, and Google Scholar for publications from 2015 to 2026. Of 412 records identified, eight RCTs met the eligibility criteria. The findings indicate that aquatic exercise primarily benefits pain and disability, while its superiority over land-based exercise depends on the clinical condition and outcome assessed, with some benefits diminishing during long-term follow-up. This review contributes by mapping effectiveness according to clinical condition, comparator, outcomes, safety, and durability, thereby supporting more appropriate rehabilitation strategies for community populations.

Keywords: Aquatic exercise; Therapeutic swimming; Musculoskeletal disorders; Quality of life; Physical function.

Abstrak

Gangguan muskuloskeletal tidak hanya menyebabkan nyeri dan keterbatasan fisik, tetapi juga dapat menghambat aktivitas sehari-hari dan menurunkan kualitas hidup, sehingga diperlukan pendekatan rehabilitasi yang efektif dan dapat ditoleransi. Penelitian ini bertujuan untuk mensintesis bukti *randomized controlled trials* mengenai efektivitas renang dan latihan akuatik terstruktur terhadap luaran klinis dan fungsional pada gangguan muskuloskeletal. *Systematic review* ini mengikuti PRISMA 2020 melalui pencarian PubMed, Cochrane Library, Wiley Online Library, Taylor & Francis, dan Google Scholar untuk publikasi tahun 2015–2026. Dari 412 *records* yang diidentifikasi, delapan RCT memenuhi kriteria inklusi. Hasil menunjukkan bahwa latihan akuatik terutama memberikan manfaat terhadap nyeri dan disabilitas, tetapi keunggulannya dibandingkan latihan berbasis darat bergantung pada kondisi dan luaran yang dinilai, sementara sebagian manfaat menurun pada tindak lanjut jangka panjang. Review ini berkontribusi dengan memetakan efektivitas berdasarkan kondisi, pembandingan, luaran, keamanan, dan keberlanjutan efek untuk mendukung strategi rehabilitasi yang lebih tepat bagi masyarakat.

Kata Kunci: Latihan akuatik; Renang terapeutik; Gangguan muskuloskeletal; Kualitas hidup; Fungsi fisik.

Introduction

Musculoskeletal disorders comprise a group of conditions affecting the muscles, bones, joints, and related tissues that may cause pain, restricted movement, and impaired physical function. Conditions such as low back pain, osteoarthritis, fibromyalgia, and ankylosing spondylitis often require rehabilitation approaches that focus not only on symptom reduction but also on restoring functional capacity. One emerging approach is aquatic exercise, including swimming and therapeutic pool-based exercise. Wang et al. (2023), through a meta-analysis of 32 RCTs involving 2,200 participants, demonstrated that aquatic exercise has beneficial effects on pain, physical function, and quality of life in chronic musculoskeletal disorders. These findings indicate that water-based exercise has emerged as an empirically supported rehabilitation intervention relevant to a range of musculoskeletal conditions.

The use of the aquatic environment in rehabilitation has specific clinical rationales. The buoyancy of water can reduce body loading during movement, while water resistance continues to provide stimuli for muscle activity and motor control. This environment allows exercise to be performed with more controlled loading when land-based exercise is difficult to tolerate. In fibromyalgia, Galvão-Moreira et al. (2021) found that pool-based exercise reduced pain scores and the *Fibromyalgia Impact Questionnaire* compared with the control group. In ankylosing spondylitis, Liang et al. (2021) found that water therapy improved disease activity and pain but did not produce significant improvements in functional capacity or spinal mobility. Salm et al. (2019) also demonstrated that aquatic exercise combined with *Far Infrared* therapy improved pain and IL-6 levels. These findings indicate that the benefits of aquatic exercise need to be understood according to specific conditions and outcomes.

The effectiveness of aquatic exercise depends not only on the aquatic environment but also on the form, dose, and comparator of the intervention. Alikhajeh et al. (2020), in an RCT involving 36 women with *chronic nonspecific low back pain*, showed that six weeks of aquatic exercise provided a relevant approach for comparison with *Kinesio taping* in addressing pain and functional limitations. Carvalho et al. (2020) subsequently showed that adding *deep-water running* to an exercise program produced greater short-term reductions in pain but did not provide an advantage in disability or functional capacity. In fibromyalgia, de Sousa et al. (2024) found that adding *pain neuroscience education* to aquatic exercise therapy improved quality of life. Thus, the effectiveness of aquatic exercise should be evaluated according to program characteristics, exercise dose, intervention combinations, and the targeted clinical outcomes.

Research on aquatic exercise has yielded promising findings, but it has not produced consistent conclusions regarding its superiority over land-based exercise. Kim et al. (2020) found that aquatic and land-based exercise produced comparable

improvements in several measures of dynamic balance among older adults. Martínez-Carbonell Guillamón et al. (2019) also demonstrated the potential of aquatic exercise to improve fall-related risk factors, particularly strength, balance, and flexibility. However, Carvalho et al. (2020) found that adding *deep-water running* to exercise provided benefits primarily for pain rather than disability or functional capacity. Murray et al. (2025) also showed that research on musculoskeletal disorders of the upper extremities continues to face variation in intervention characteristics and reporting. Therefore, the available evidence requires a more focused synthesis.

Based on this gap, this study aimed to synthesize evidence from *randomized controlled trials* on the effectiveness of swimming and structured aquatic exercise among individuals with musculoskeletal disorders. The synthesis focused on pain, disability, physical function, quality of life, psychological outcomes, safety, and the durability of intervention effects. This focus is important because previous evidence has encompassed different clinical conditions, exercise modalities, intensities, comparator groups, and follow-up periods. In addition, some previous reviews have combined various forms of aquatic exercise and therefore have not specifically distinguished between swimming and therapeutic pool-based exercise. This *systematic review* was therefore conducted to integrate RCT evidence in a more focused manner, identify patterns of benefits according to condition and outcome, and assess the position of aquatic exercise as an alternative or complement to land-based exercise in musculoskeletal rehabilitation.

Method

This study was a *systematic review* conducted in 2026 to identify and synthesize evidence from *randomized controlled trials* (RCTs) on the effectiveness of swimming and structured aquatic exercise among individuals with musculoskeletal disorders. The reporting process followed the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) 2020 guidelines, which emphasize transparency in reporting the identification, selection, eligibility assessment, and inclusion of studies (Page et al., 2021). The literature search was conducted in PubMed, Cochrane Library, Wiley Online Library, and Taylor & Francis, supplemented by Google Scholar. The search covered publications from 2015 to 2026 using combinations of terms related to swimming and aquatic exercise, musculoskeletal disorders, and clinical outcomes such as pain, disability, and physical function.

The search strategy combined the terms "*swimming*," "*aquatic exercise*," "*aquatic therapy*," "*hydrotherapy*," "*water-based exercise*," and "*pool-based exercise*" with "*musculoskeletal diseases*," "*low back pain*," "*osteoarthritis*," "*fibromyalgia*," "*ankylosing spondylitis*," "*spondyloarthritis*," "*myalgia*," and "*chronic musculoskeletal pain*." Related terms, including "*exercise therapy*," "*rehabilitation*," "*physical therapy modalities*," "*pain*," and "*disability*," were also used to broaden the search scope. The search yielded 412

records, comprising 84 records from PubMed, 63 from Cochrane Library, 96 from Wiley Online Library, 41 from Taylor & Francis, and 128 from Google Scholar. After 57 duplicate records were removed, 355 records remained for the initial screening stage. The inclusion criteria comprised full-text journal articles published in English between 2015 and 2026, using an RCT design, involving individuals with defined musculoskeletal disorders, and evaluating active and structured swimming or aquatic exercise with quantitative clinical outcomes.

The study selection process followed the PRISMA 2020 stages and is summarized in Figure 1. During the initial screening, 311 records were excluded, leaving 44 reports for which full-text retrieval was sought. Six reports could not be retrieved, leaving 38 reports for full-text eligibility assessment. At this stage, 30 reports were excluded because the intervention did not involve swimming or pool-based aquatic exercise ($n = 9$), the population did not have a defined musculoskeletal disorder ($n = 6$), no quantitative clinical outcomes were reported ($n = 5$), the report was a research protocol or conference abstract ($n = 4$), the study design was not an RCT or quasi-experimental study ($n = 4$), or the study represented a *duplicate cohort* ($n = 2$). Thus, 8 RCTs met all eligibility criteria and were included in the final synthesis. This process transparently illustrates the changes in the number of studies from identification through inclusion.

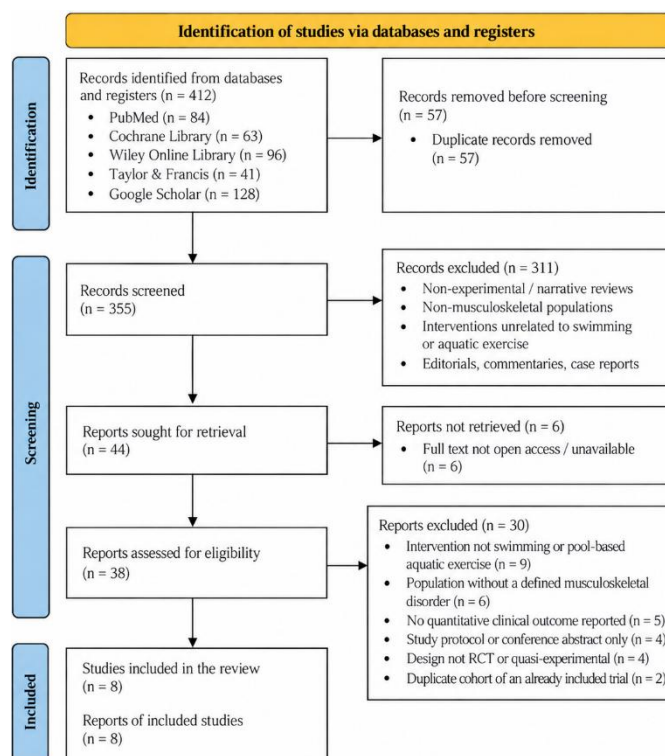


Figure 1. PRISMA flow diagram illustrating the identification, screening, eligibility assessment, and inclusion of studies.

Source: Adapted from Page et al. (2021).

Data from the eight eligible studies were systematically extracted based on author and publication year, study country, research design, participant characteristics, sample

size, musculoskeletal condition, intervention characteristics, comparator group, intervention duration and frequency, outcome measures, assessment time points, and reported key findings and effect estimates. The risk of bias in each study was assessed using the *Cochrane Risk of Bias 2* (RoB 2), which comprises five domains: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in outcome measurement, and bias in the selection of reported results. The extracted data and risk-of-bias assessments were presented in tables and synthesized narratively because of differences across studies in musculoskeletal conditions, intervention characteristics, comparator groups, measurement instruments, and follow-up periods.

Results and Discussion

Study Characteristics and Overall Effects of Swimming and Aquatic Exercise

The eight *randomized controlled trials* (RCTs) analyzed involved a total of 457 participants, with sample sizes ranging from 29 to 113 participants per study. The studies were conducted in eight countries: China, Canada, Australia, Tunisia, Iran, Brazil, Spain, and South Africa. The study populations included four musculoskeletal conditions: *chronic non-specific low back pain*, *knee osteoarthritis*, *fibromyalgia*, and *ankylosing spondylitis*. *Chronic low back pain* was the most frequently studied condition, appearing in three studies, while *knee osteoarthritis* and *fibromyalgia* were each examined in two studies. One study addressed *ankylosing spondylitis*. Participants were predominantly women in five studies, with a mean age of approximately 31 years in some *chronic low back pain* groups and approximately 50 years or older among participants with *fibromyalgia* and *osteoarthritis*.

The intervention characteristics indicate that the terms *swimming* and *aquatic exercise* in this review encompass different forms of exercise. Two studies specifically used *swimming*, namely *front-crawl swimming* and an individualized *swimming* program supported by *telehealth*. One study combined *swimming* with land-based *stretching*, *strengthening*, and *breathing exercises*, whereas five studies used structured *aquatic exercise*, such as *trunk-pelvic stabilization* and *closed kinetic chain exercise*. Program durations generally ranged from 8 to 12 weeks, with sessions lasting 50–60 minutes and conducted two to three times per week, while one study used a six-month program without direct supervision. Comparator groups included passive physiotherapy modalities, education, *standard care*, and land-based exercise. The characteristics of these studies are summarized in Table 1.

Table 1. Characteristics and main findings of studies included in the systematic review

Study	Condition	n	Intervention	Comparator	Main findings
Peng et al. (2022)	Chronic low back pain	113	Aquatic exercise, 12 weeks	Passive physiotherapy modalities	Improvements in disability, pain, QoL, sleep, and mental state
Rosenstein et al. (2025)	Chronic low back pain	34	Aquatic stabilization, 10 weeks	Standard care	No between-group differences in muscle morphology; some improvements occurred within the aquatic group
Wareham et al. (2026)	Chronic low back pain	76	Swimming + education, 8 weeks	Education	Disability improved at 8 weeks, but the difference was no longer present at 52 weeks
Slouma et al. (2025)	Knee osteoarthritis	60	Aquatic exercise, 8 weeks	Land-based exercise	Greater reductions in pain and improvements in function in the aquatic group
Mohammadi et al. (2026)	Knee osteoarthritis	30	Aquatic closed kinetic chain, 8 weeks	Land-based exercise	Aquatic was better for pain, WOMAC, and kinesiophobia; land-based was better for strength and proprioception
Fernandes et al. (2016)	Fibromyalgia	75	Swimming, 12 weeks	Walking	Both groups improved; no significant between-group difference
Rivas Neira et al. (2024)	Fibromyalgia	40	Aquatic therapy, 12 weeks	Land-based therapy	Aquatic was better for pain and sleep quality at follow-up
Nolte et al. (2021)	Ankylosing spondylitis	29	Swimming + land-based exercise, 6 months	Control	Physical function improved, but ESR and CRP did not change

Note: n = number of participants; QoL = quality of life; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index; ESR = erythrocyte sedimentation rate; CRP = C-reactive protein.

Source: Compiled by authors.

The findings in Table 1 indicate that the benefits of aquatic exercise were most consistently observed for symptom- and function-related outcomes, particularly when *aquatic exercise* was compared with passive interventions or education. Peng et al. (2022) reported that *therapeutic aquatic exercise* produced greater improvements in *disability, pain, quality of life, sleep quality, and mental state* than *transcutaneous electrical nerve stimulation* combined with *infrared thermal therapy*. Wareham et al. (2026) found

that *swimming* combined with education improved *disability* at eight weeks, with a mean difference of -2.5 points on the Roland–Morris Disability Questionnaire (95% CI -4.5 to -0.5) compared with education alone. In *knee osteoarthritis*, Slouma et al. (2025) reported that 93% of participants in the *aquatic* group achieved a $\geq 20\%$ reduction in WOMAC *pain*, compared with 33% in the *land-based* group ($p < 0.001$). These findings indicate that water-based exercise provides relatively consistent clinical benefits when compared with interventions that do not provide an equivalent active exercise load.

Effects on function and psychological *outcomes* showed more condition- and instrument-specific patterns. In *chronic low back pain*, Rosenstein et al. (2025) found no significant between-group differences in changes in the volume or fat infiltration of the *multifidus* and *erector spinae* muscles based on MRI, although some muscle segments increased in volume within the *aquatic* group and lumbar strength increased in both groups. In *fibromyalgia*, Fernandes et al. (2016) found that *swimming* and *walking* both improved *pain*, *functional capacity*, and *quality of life*, with no significant between-group differences. Meanwhile, Mohammadi et al. (2026) showed that *aquatic exercise* produced greater improvements in *pain*, WOMAC, and *kinesiophobia*, whereas land-based exercise was superior for *functional mobility*, *proprioception*, and *muscle strength*. Thus, the effects of exercise were not uniform across clinical domains, and the superiority of one modality cannot be generalized across all *outcomes*.

Biological findings also indicate that clinical improvements are not always accompanied by changes in structural or inflammatory markers. In Rosenstein et al. (2025), changes in paraspinal muscle morphology did not show a significant *time* $\times$ *group* difference, although some increases in muscle volume were observed within the *aquatic* group. In Nolte et al. (2021), a six-month program combining *swimming* with *stretching*, *strengthening*, and *breathing exercises* improved 11 of 19 physical variables in the exercise group, whereas *erythrocyte sedimentation rate* and *C-reactive protein* showed no meaningful changes. These findings indicate that the benefits of aquatic exercise in the available evidence are more consistently observed in physical function than in changes in systemic inflammatory activity or muscle morphology. Therefore, in inflammatory conditions such as *ankylosing spondylitis*, exercise is more appropriately positioned as part of the management of physical capacity and function rather than as a substitute for pharmacological disease control.

The methodological quality and *risk of bias* of the eight RCTs were assessed using the *Cochrane Risk of Bias 2 (RoB 2)* tool. The assessment showed that most studies were categorized as having *some concerns*, while two studies, Rivas Neira et al. (2024) and Nolte et al. (2021), were rated as having an overall *high risk*. In the first domain (D1), concerning bias arising from the randomization process, most studies were rated as having a low risk, although some studies had *some concerns* regarding the reporting of allocation procedures. The second domain (D2), concerning bias due to deviations

from the intended interventions, represented the most consistent source of concern, as all studies had at least *some concerns*, with Rivas Neira et al. (2024) and Nolte et al. (2021) rated as *high risk*. This issue warrants attention because participants and therapists in swimming or aquatic exercise interventions cannot be blinded to the type of exercise received.

Table 2. Risk-of-bias assessment of the included randomized controlled trials

Study	D1	D2	D3	D4	D5	Overall
Peng et al. (2022)	Low	Some concerns	Low	Low	Some concerns	Some concerns
Rosenstein et al. (2025)	Low	Some concerns	Low	Low	Low	Some concerns
Wareham et al. (2026)	Low	Some concerns	Low	Low	Low	Some concerns
Slouma et al. (2025)	Some concerns	Some concerns	Low	Some concerns	Low	Some concerns
Mohammadi et al. (2026)	Some concerns	Some concerns	Low	Some concerns	Low	Some concerns
Fernandes et al. (2016)	Low	Some concerns	Low	Low	Low	Some concerns
Rivas Neira et al. (2024)	Low	High	Some concerns	Low	Low	High
Nolte et al. (2021)	Some concerns	High	Some concerns	Some concerns	Some concerns	High

Note: D1 = bias arising from the randomization process; D2 = bias due to deviations from intended interventions; D3 = bias due to missing outcome data; D4 = bias in outcome measurement; D5 = bias in the selection of the reported result. Assessments were categorized as low risk, some concerns, or high risk.

Source: Authors' assessment using the Cochrane Risk of Bias 2 (RoB 2).

In the third domain (D3), most studies were assessed as *low risk*, indicating that missing *outcome* data were not a major concern in this body of evidence. The fourth domain (D4) also generally showed a low risk, although some studies had *some concerns*, particularly for measurements that relied heavily on outcomes reported by participants themselves. Meanwhile, the fifth domain (D5) indicated that most studies had a low risk of bias in the selection of reported results, with some concerns in studies with limitations in outcome prespecification or reporting. Overall, the RoB 2 assessment indicates that the available evidence provides a reasonable basis for interpreting the benefits of swimming and aquatic exercise, but the findings should be interpreted cautiously, particularly in light of limitations related to deviations from

the intended interventions, difficulties with *blinding*, and potential differences in adherence to the programs.

Taken together, the eight RCTs indicate that *swimming* and *aquatic exercise* provide benefits primarily for *pain*, *disability*, and several aspects of physical function, although the magnitude of these benefits varies according to the clinical condition, intervention type, comparator group, and *outcome* domain. The most consistent evidence was observed when aquatic exercise was compared with education or passive modalities, whereas comparisons with land-based exercise yielded more varied results. The *risk-of-bias* assessment also indicates that these findings should be interpreted cautiously, particularly because of limitations in *blinding* and the possibility of deviations from the intended interventions. Thus, the benefits of exercise in water should not be evaluated solely by asking whether *aquatic exercise* is more effective overall. Its effectiveness is better understood in relation to the patient's condition and targeted *outcomes*, with aquatic exercise tending to provide advantages for symptoms and exercise tolerance, while land-based exercise may provide greater stimuli for strength and proprioception.

Aquatic exercise versus land-based exercise: Complementary therapeutic effects

In fibromyalgia, direct evidence on swimming indicates that the aquatic environment does not automatically produce greater clinical effects than land-based exercise. Fernandes et al. (2016) compared 50-minute front-crawl swimming sessions performed three times per week for 12 weeks with walking among 75 women with fibromyalgia. Both groups experienced significant improvements in pain, functional capacity, and quality of life, with no significant between-group differences. These findings indicate that swimming can be an effective exercise option, but its superiority cannot be assumed simply because it is performed in water. Conversely, Slouma et al. (2025) found greater benefits from aquatic exercise among patients with knee osteoarthritis, particularly for pain and several functional indicators. Therefore, the effects of exercise should be interpreted according to the condition, comparator, and outcome.

In knee osteoarthritis, the advantages of aquatic exercise over land-based exercise were more apparent for symptom-related outcomes. Slouma et al. (2025) reported that 93% of participants in the aquatic group achieved at least a 20% reduction in WOMAC pain, compared with 33% in the land-based group ($p < 0.001$). The reduction in WOMAC pain was also greater in the aquatic group, at approximately 50% compared with 17%, accompanied by greater improvements in pain during walking, stiffness, and the Lequesne index. These findings are supported by Song and Oh (2022), who found in a meta-analysis of 20 studies that aquatic exercise reduced pain more than land-based exercise among patients with osteoarthritis (MD -0.28). Thus, aquatic exercise has

specific empirical support for symptom control in osteoarthritis, although this does not mean that aquatic exercise is superior across all aspects of physical capacity.

However, greater benefits of aquatic exercise for symptoms do not imply that all aspects of function will improve more than with land-based exercise. Mohammadi et al. (2026) demonstrated a clear pattern among women aged 40–70 years with knee osteoarthritis who underwent eight weeks of closed kinetic chain exercise. The aquatic group showed greater improvements in pain, WOMAC scores, and kinesiophobia, whereas the land-based group showed better outcomes for the Timed Up and Go test, 40-meter walking, stair climbing, knee proprioception, and muscle strength. These findings indicate that the exercise environment may influence which types of physical abilities are most responsive. The findings are also consistent with Xu et al. (2023), who demonstrated benefits of aquatic exercise for pain, stiffness, and function compared with no exercise, but did not establish aquatic exercise as a universal substitute for weight-bearing exercise.

In fibromyalgia, differences between aquatic and land-based exercise should also be considered in terms of when the effects emerge. Rivas Neira et al. (2024) compared aquatic therapy with land-based therapy among 40 women with fibromyalgia. Immediately after the program, no significant between-group differences were observed, but at the six-week follow-up, the aquatic group showed better outcomes for pain intensity ($p = 0.023$) and sleep quality ($p = 0.030$), with large effect sizes. This finding differs from Fernandes et al. (2016), who found relatively comparable effects of swimming and walking during the intervention period. Thus, differences between aquatic and land-based exercise are not limited to effect magnitude but also concern when the benefits become apparent. The meta-analysis by Ma et al. (2024) supports the benefits of aquatic exercise for fibromyalgia while placing these effects within the context of variation in outcomes and exercise programs.

In chronic low back pain, the magnitude of the benefits of aquatic exercise or swimming appears to be strongly influenced by the type of comparator. Wareham et al. (2026) found that individualized swimming added to education produced greater reductions in disability than education alone after eight weeks, with a mean difference of -2.5 points on the Roland–Morris Disability Questionnaire (95% CI -4.5 to -0.5). However, this difference was no longer evident at 52 weeks. Peng et al. (2022) also reported that a 12-week therapeutic aquatic exercise program was more effective than TENS and infrared thermal therapy for disability, pain, quality of life, sleep quality, and mental state, with benefits remaining evident at the 12-month follow-up. More broadly, Ma et al. (2022) found that aquatic physical therapy improved pain, quality of life, and disability in chronic low back pain, although the certainty of the evidence was low.

Differences in these outcome profiles may be partly explained by the different mechanical demands of exercise in water and on land. In the study by Mohammadi et al. (2026), aquatic exercise provided greater benefits for pain, WOMAC, and kinesiophobia, whereas land-based exercise was better for strength and proprioception. This pattern is consistent with the reduced weight-bearing demands of exercise in water, which may allow movement to be performed more easily when patients experience pain or fear of movement. In contrast, land-based exercise maintains mechanical demands that are more closely related to everyday functional activities. However, this relationship should be understood as an interpretation of the observed outcome patterns rather than as a causal mechanism directly tested across all RCTs. The meta-analysis by Faíl et al. (2022) also demonstrated benefits of aquatic exercise across various health and functional indicators, but variation in conditions and exercise programs makes it inappropriate to summarize these effects as a single universal advantage.

These findings support positioning aquatic exercise and swimming as complementary components of land-based exercise rather than as two competing alternatives. Among patients who have difficulty tolerating loading, the findings of Slouma et al. (2025) indicate that aquatic exercise may provide greater improvements in symptoms, whereas Mohammadi et al. (2026) showed that land-based exercise retains advantages for strength, proprioception, and load-based functional tasks. In fibromyalgia, Fernandes et al. (2016) even demonstrated that swimming and walking could produce comparable improvements. Thus, aquatic exercise may be considered to facilitate participation and symptom control, while land-based exercise can be used to develop capacities that require greater loading. This progressive approach is more consistent with the findings of the eight RCTs than positioning one modality as a replacement for the other.

Overall, the most appropriate clinical question is not whether swimming or aquatic exercise is better than land-based exercise, but rather for which conditions and outcomes each modality provides the greatest benefits. The evidence in this review shows a relatively consistent pattern: aquatic exercise is more prominent in controlling pain, disability, and kinesiophobia in some populations, whereas land-based exercise is more prominent for strength, proprioception, and functions requiring weight-bearing. For swimming, Fernandes et al. (2016) demonstrated effectiveness comparable to walking, whereas Wareham et al. (2026) showed benefits for disability when swimming was added to education, although these effects diminished over the long term. Therefore, intervention selection should consider the diagnosis, target outcomes, tolerance to loading, and stage of rehabilitation. This synthesis positions aquatic and land-based exercise as strategies that can be used sequentially or in combination.

Sustainability of effects, safety, and clinical implications

The sustainability of the benefits of swimming and aquatic exercise after completion of the program has not been entirely consistent. Peng et al. (2022) reported that the advantages of *therapeutic aquatic exercise* for *disability, pain, quality of life, sleep quality, and mental state* remained evident at the 12-month *follow-up*. In contrast, Wareham et al. (2026) found that *individualized swimming* improved *disability* at eight weeks, but the between-group difference was no longer evident at 52 weeks. This pattern is consistent with Duan et al. (2022), who analyzed 19 RCTs involving 1,592 patients with *lower-limb osteoarthritis*. The benefits of aquatic exercise were primarily observed in the short term, while some functional improvements remained at intermediate *follow-up* but no longer showed significant differences in the long term. Thus, the sustainability of effects should be viewed as a characteristic dependent on the condition, intervention, and evaluation period rather than as an automatic consequence of initial therapeutic success.

Differences in long-term findings also indicate that the timing of evaluation can influence the interpretation of aquatic exercise effectiveness. Wareham et al. (2026) showed greater benefits during the intervention period, followed by a reduction in effects at the 52-week assessment. In contrast, Rivas Neira et al. (2024) found no significant between-group differences immediately after the program, but identified advantages in the *aquatic* group for *pain* and *sleep quality* six weeks later, with large *effect sizes*. These differences indicate that responses to exercise do not necessarily end when the final session is completed and that post-intervention changes may follow different temporal patterns. Therefore, *post-test* results alone may not fully capture the overall therapeutic response. *Follow-up* assessments are necessary to distinguish effects that occur only during the program, effects that can be maintained after program completion, and changes that become apparent after subsequent periods of recovery or adaptation.

The sustainability of benefits should also be considered in relation to patient engagement with exercise programs. In Nolte et al. (2021), the six-month program combined *swimming* with *stretching, strengthening, and breathing exercises*, which were performed without direct supervision after participants had received instructions. Meanwhile, Wareham et al. (2026) provided physiotherapist support through *telehealth* as part of an *individualized swimming* program. External evidence from Dong et al. (2018), based on a meta-analysis of eight RCTs involving 579 patients with *knee osteoarthritis*, showed that aquatic exercise did not differ significantly from land-based exercise in *pain, physical function, and quality of life*, but participant *adherence* and *satisfaction* were higher with aquatic exercise. These findings provide context indicating that program sustainability is related not only to physiological effectiveness but also to patient acceptance and the ability to maintain participation in exercise.

Functional and structural responses to aquatic exercise do not always occur in parallel. Rosenstein et al. (2025) found no significant *time × group* differences in changes in the volume or fat infiltration of the *multifidus* and *erector spinae*, although several muscle segments showed increased volume in the aquatic group and lumbar strength increased in both groups. This pattern indicates that the benefits of exercise do not necessarily have to be manifested through greater structural changes compared with *standard care*. These findings are supported by Moreira et al. (2020), who, in an RCT involving 120 older adults with musculoskeletal disorders and a risk of falling, demonstrated improvements in functional capacity, perceptual aspects, and quality of life following aquatic exercise. Therefore, the evaluation of aquatic exercise benefits should not focus solely on morphological changes but should also consider functional capacity and symptom perception that are directly relevant to daily activities.

In musculoskeletal conditions with an inflammatory component, the benefits of exercise should also be distinguished from changes in disease activity. Nolte et al. (2021) showed that a six-month program combining *swimming* and land-based exercise improved 11 of 19 physical variables, but *erythrocyte sedimentation rate* and *C-reactive protein* did not change meaningfully. These findings indicate that improvements in physical capacity and function can occur without changes in systemic inflammatory markers. This distinction is important to avoid interpreting swimming or aquatic exercise as directly controlling inflammatory processes in musculoskeletal diseases. In *low back pain*, Shi et al. (2018) found through a meta-analysis of eight studies involving 331 participants that aquatic exercise significantly reduced *pain* and improved *physical function*. Thus, the evidence more strongly supports aquatic exercise as a rehabilitation strategy for symptoms and function than as an intervention that directly modifies inflammatory activity or disease processes.

From a safety perspective, aquatic exercise demonstrated a relatively favorable tolerability profile in the studies analyzed, although adverse events should still be considered. Peng et al. (2022) reported relatively few and non-serious *adverse events*, whereas Wareham et al. (2026) found that adverse events occurred more frequently in the *swimming* group, although almost all were non-serious. These findings are further supported by Duan et al. (2022), who reported in a meta-analysis of 19 RCTs involving 1,592 patients that none of the included studies reported *major adverse events* related to aquatic training and that minor events were also uncommon. This evidence supports the use of aquatic exercise as a relatively well-tolerated rehabilitation option, but it does not mean that the intervention is risk-free. Exercise intensity, technique, comorbid conditions, physical capacity, and individual responses should still be considered when planning and monitoring the program.

Clinically, the overall evidence indicates that aquatic exercise should be positioned as part of a rehabilitation strategy tailored to patient characteristics rather than as a

universal replacement for land-based exercise. Aquatic exercise may provide benefits when the primary goals include reducing *pain*, improving movement tolerance, reducing *kinesiophobia*, or addressing situations in which body loading limits exercise. Conversely, land-based exercise remains important when rehabilitation targets include *muscle strength*, *proprioception*, and *progressive loading*, as demonstrated by Mohammadi et al. (2026). Findings from Dong et al. (2018) also indicate that aquatic exercise is not consistently superior to land-based exercise across all *outcomes* in *knee osteoarthritis*. Therefore, modality selection should consider the clinical condition, target *outcomes*, loading tolerance, patient preferences, and rehabilitation phase. An approach that combines or progressively transitions between aquatic and land-based exercise may be more rational than treating them as mutually exclusive options.

Conclusion

This systematic review shows that *swimming* and *aquatic exercise* provide clinically relevant benefits for patients with various musculoskeletal disorders, particularly in reducing *pain* and *disability* and improving several aspects of physical function and quality of life. However, these benefits are not universal, as they are influenced by the clinical condition, intervention type, comparator group, target *outcome*, and evaluation period. The advantages of aquatic exercise were most evident when compared with education or passive modalities, whereas findings were more varied when compared with land-based exercise. This pattern may be understood in terms of the characteristics of the aquatic environment, which allow patients to perform movements with reduced loading, making exercise more tolerable in conditions dominated by pain or loading limitations. Thus, *aquatic exercise* is better understood as a rehabilitation strategy for achieving specific clinical targets rather than as a modality that is consistently superior to land-based exercise.

This review contributes by integrating RCT evidence on *swimming* and various forms of *aquatic exercise* across several musculoskeletal disorders and by more clearly distinguishing benefits according to *outcome* type, comparator, sustainability of effects, and safety. However, interpretation of the findings is limited by the relatively small number of studies, heterogeneity in clinical conditions and intervention protocols, limited sample sizes in several RCTs, and the presence of *some concerns* to *high risk of bias* across several methodological domains. Differences in intervention duration and *follow-up* periods also limit direct comparisons of the sustainability of benefits. Future research should employ RCTs with larger samples, more standardized aquatic exercise protocols, more consistent reporting of adherence, and longer *follow-up* periods. Further studies should also compare combined aquatic and land-based exercise to determine the optimal sequencing, dosage, and patient characteristics for benefiting from each modality.

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