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Systematic Review

Effectiveness of Aquatic Exercise in the Management of Fibromyalgia Syndrome: A Systematic Review and Meta-Analysis

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Abstract

Background/Objectives: Fibromyalgia syndrome (FMS) is a chronic condition characterized by widespread pain, fatigue, sleep disturbances, and psychological symptoms. Aquatic exercise offers the benefits of physical activity with reduced mechanical stress. This meta-analysis evaluated the effectiveness of AE on pain, functional physical status, and health-related quality of life. **Methods:** A PRISMA-guided systematic review and meta-analysis (PROSPERO CRD42025115158) included randomized and non-randomized trials up to October 2025 from MEDLINE (PubMed), Cochrane Library, PEDro, CINAHL Complete, SPORTDiscus, and Academic Search Ultimate. Eligible participants were adults diagnosed with FMS undergoing AE programs, alone or combined with other modalities. Standardized mean differences (SMD) with 95% confidence intervals were pooled using random- or fixed-effects models. Methodological quality, risk of bias, and certainty of evidence were evaluated using the PEDro scale, the RoB 2.0 tool, and the GRADE approach. **Results:** 27 trials (n = 1785; >95% women; mean age 44–62 years) were included. AE significantly improved pain (SMD = −0.92; 95% CI: −1.03 to −0.80; $p < 0.00001$), physical function (SMD = −0.74; 95% CI: −0.84 to −0.63; $p < 0.00001$), and HRQoL (SMD = 0.57; 95% CI: 0.42 to 0.72; $p < 0.00001$). Effects were consistent across time frames, though overall heterogeneity was considerable ($Tau^2 = 4.93$; $I^2 = 97\%$). The mean PEDro score was 5.2/10, and RoB 2.0 indicated moderate methodological limitations mainly due to a lack of blinding. Evidence certainty was low for the main outcomes and moderate for adverse events. **Conclusions:** Aquatic exercise is an effective and safe complementary therapy for patients with FMS, alleviating pain while enhancing function and quality of life. However, methodological variability and small sample sizes warrant further high-quality trials to confirm these findings and explore underlying mechanisms.

Keywords: fibromyalgia; aquatic exercise; hydrotherapy; chronic pain; physical function; quality of life

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1. Introduction

Fibromyalgia syndrome (FMS) is a chronic and heterogeneous condition of idiopathic origin, characterized by widespread musculoskeletal pain, fatigue, sleep disturbances,

cognitive dysfunction, and psychological symptoms such as anxiety and depression [1–3]. Although its etiology remains uncertain, FMS represents one of the leading causes of chronic generalized pain worldwide, with prevalence estimates ranging from 0.2% to 6.6%, depending on the diagnostic criteria and population studied [4]. In the United States, this condition affects more than 5 million people, representing approximately 2–5% of the adult population [5].

Beyond its epidemiological relevance, FMS imposes a considerable social and economic burden. In Spain, the estimated annual cost ranges from EUR 1.8 to EUR 7.1 billion, largely driven by productivity losses and the demands of informal caregiving [6]. The level of patient dependency emerges as a critical factor shaping work capacity and the extent of required external support [7].

Although FMS is an established clinical entity, its diagnosis and management remain challenging because of the lack of specific biomarkers and the marked variability in clinical manifestations [8,9]. From a pathophysiological standpoint, the syndrome is characterized by an altered central pain processing, neuroendocrine dysregulation, autonomic imbalance, and low-grade inflammation [10–12]. Although pharmacological treatments—such as antidepressants, anticonvulsants, and analgesics—are commonly prescribed, their effects are often modest and short-lived, and adverse events frequently limit both adherence and long-term effectiveness [13,14].

In recent years, therapeutic strategies have increasingly shifted toward multimodal and non-pharmacological approaches, with exercise therapy emerging as a cornerstone in the management of chronic pain [15,16]. Exercise provides a wide spectrum of physiological and neurobiological benefits through the activation of descending pain-inhibitory pathways, neuroplastic modulation of central sensitization, and regulation of the immune system and inflammatory responses [17,18]. These effects contribute to autonomic and neuroendocrine balance, reflected in reduced sympathetic overactivity, enhanced parasympathetic tone, lower stress reactivity, and improvements in sleep quality and mood stability [19,20].

Nevertheless, not all exercise modalities are equally well tolerated by patients with FMS. In fact, land-based exercise often triggers symptom exacerbation, exercise intolerance, and kinesiophobia, which may compromise adherence and increase the risk of relapse and program discontinuation [21–23]. This clinical limitation underscores the need for interventions that preserve the physiological benefits of exercise while minimizing mechanical stress and pain perception [24]. Within this context, aquatic exercise (AE)—structured therapeutic exercise performed in water under professional supervision—has emerged as a promising alternative [25], as the unique physical and thermal properties of water, including buoyancy, hydrostatic pressure, viscosity, and thermal conductivity, reduce joint loading, facilitate controlled movement, and promote muscle relaxation [26,27].

Furthermore, immersion in thermoneutral or warm water enhances circulatory dynamics, reduces muscle stiffness, and improves psychological well-being [28]. From a neurophysiological perspective, these evident benefits are attributable to the aquatic environment's capacity to support autonomic homeostasis, attenuate central and peripheral sensitization, and activate mechanoreceptive and baroreceptive feedback mechanisms, thereby contributing to overall analgesic and anxiolytic effects [29,30].

Consequently, AE enables individuals with FMS to engage in physical activity with lower perceived pain and greater tolerance, fostering adherence and functional recovery [31]. Clinical trials consistently show that AE improves aerobic capacity, muscle strength, physical functionality, and health-related quality of life (HRQoL) without exacerbating symptoms. Moreover, AE has the potential to improve co-occurring symptoms such as fatigue, depression, and sleep disturbances prevalent in this population [32].

Despite this, the current literature remains heterogeneous in study design, intervention protocols, and outcome assessment tools, which makes it difficult to establish standardized recommendations. Therefore, this systematic review and meta-analysis aims to synthesize and critically evaluate the available evidence on the application of AE in FMS management, with a particular emphasis on linking physiological mechanisms to clinical outcomes.

2. Materials and Methods

2.1. Data Sources and Search Strategy

The systematic review and meta-analysis were conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Supplementary Table S1) [33]. Moreover, the review protocol was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO) database (CRD42025115158; https://www.crd.york.ac.uk/PROSPERO/view/CRD420251151583 (accessed on 20 September 2025)). A comprehensive literature search was performed from 21 September 2025 to 21 October 2025 to identify all available studies evaluating the effectiveness of AE-based rehabilitation on pain, functionality, and QoL in patients with FMS. The databases searched included MEDLINE (PubMed), Cochrane Library, PEDro Database, CINAHL Complete, SportDiscus, and Academic Search Ultimate.

In MEDLINE (PubMed), the search strategy combined Medical Subject Headings (MeSH) and free-text terms, using the following Boolean equations: (“*fibromyalgia*”[MeSH Terms]) AND (“*hydrotherapy*”[tiab]); (“*fibromyalgia*”[MeSH Terms]) AND (“*swimming*”[MeSH Terms]); and (“*fibromyalgia*”[MeSH Terms]) AND (“*aquatic*”[tiab]) AND (“*exercise*”[tiab] OR “*rehabilitation*”[tiab]). In the Cochrane Library, searches were conducted using free-text terms related to fibromyalgia and aquatic interventions, combined with Boolean operators. The applied equations were: (“*fibromyalgia syndrome*”[tiab]) AND (“*water exercise*”[tiab] OR “*hydrotherapy*”[tiab]); (“*fibromyalgia*”[tiab]) AND (“*aquatic exercise*”[tiab]); and (“*fibromyalgia*”[tiab]) AND (“*pool exercise*”[tiab] OR “*water therapy*”[tiab]).

For the PEDro database, simplified keyword combinations were employed due to database-specific constraints. The following strategies were used: (“*fibromyalgia*”) AND (“*hydrotherapy*”); (“*fibromyalgia*”) AND (“*pool exercise*” OR “*water-based exercise*”); and (“*fibromyalgia*”) AND (“*aquatic rehabilitation*” OR “*aquatic therapy*”). In CINAHL Complete, the search combined fibromyalgia-related terms with aquatic exercise and rehabilitation concepts using Boolean operators as follows: (“*fibromyalgia*”[tiab]) AND (“*hydrotherapy*”[tiab]); (“*fibromyalgia*”[tiab]) AND (“*aquatic exercise*”[tiab] OR “*rehabilitation*”[tiab]); and (“*fibromyalgia*”[tiab]) AND (“*pool exercise*”[tiab] OR “*water therapy*”[tiab] OR “*aquatic therapy*”[tiab]).

The SPORTDiscus search strategy focused on exercise-based aquatic interventions and included the following equations: (“*fibromyalgia*”[tiab]) AND (“*aquatic exercise*”[tiab]); (“*fibromyalgia*”[tiab]) AND (“*pool exercise*”[tiab] OR “*water-based program*”[tiab]); and (“*fibromyalgia*”[tiab]) AND (“*hydrotherapy*”[tiab] OR “*aquatic rehabilitation*”[tiab]). Finally, in Academic Search Ultimate, searches were performed using combinations of fibromyalgia and water-based therapeutic approaches, applying the following equations: (“*fibromyalgia*”[tiab]) AND (“*water therapy*”[tiab]); (“*fibromyalgia*”[tiab]) AND (“*aquatic therapy*”[tiab] OR “*hydrotherapy*”[tiab]); and (“*fibromyalgia*”[tiab]) AND (“*pool exercise*”[tiab] OR “*aquatic resistance training*”[tiab] OR “*exercise in water*”[tiab]).

The literature search was conducted independently by two reviewers (J.D.G. and L.G.B.B.) while a third reviewer (D.G.L.), blinded to study details, screened all retrieved records based on titles and abstracts and subsequently evaluated full texts for eligibility. Any disagreements were resolved by a fourth author (S.E.M.P.), who served as a referee. The complete search strategy is presented in Table S2.

2.2. Study Selection

The inclusion criteria for study selection were as follows: (1) clinical trials, randomized or non-randomized; (2) studies published from 1 January 2021 to 21 October 2025, and (3) publications available in English, Spanish, French, or Portuguese. In addition, (4) participants were required to have a diagnosis of FMS based on the 2016 American College of Rheumatology (ACR) criteria [34], and (5) the interventions had to include AE, either as a stand-alone program or combined with other treatment modalities such as land-based exercise, educational or psychological support, excluding passive hydrothermal interventions (e.g., balneotherapy or spa therapy) Finally, (6) studies were required to report at least one clinically relevant outcome, prioritized as follows: pain intensity, stiffness (e.g., objective or perceived), fatigue, cognitive disturbances (e.g., concentration or memory), sleep quality, functionality, health-related quality of life (HRQoL), psychological outcomes, including stress perception and depression and pain-related cognitive–behavioral factors such as kinesiophobia and catastrophizing.

2.3. Data Extraction

Data extraction was independently carried out by two authors (J.D.G. and L.G.B.B.). In the event of discrepancies, a third author (D.G.L.) resolved disagreements. Relevant data were collected using a standardized template based on PICO questions, including information on authorship, year and country of publication, study design, objectives, results, and participant characteristics (e.g., disease status, medical intervention, sample size, gender, distribution, etc.), as well as details of intervention and control groups, measured outcomes, and conclusions. These procedures were conducted in accordance with the Cochrane Handbook for Systematic Reviews of Interventions (version 5.1.0) [35]. The reliability of the data extraction table was verified through cross-checking a representative sample of the included studies.

2.4. Methodological Quality Assessment: PEDro Scale

The methodological quality of the clinical trials included in this review was assessed using the PEDro scale [36]. This tool comprises 11 items, each scored with one point, and is designed to evaluate both the internal validity of randomized controlled trials (criteria 2–9) and the adequacy of statistical information to allow interpretation of the results (criteria 10–11). Trials achieving scores of 9–10 were classified as having "Excellent" methodological quality, those scoring 6–8 as "Good", and those scoring below 4 as "Poor".

2.5. Risk of Bias Assessment (RoB 2.0)

The risk of bias in the included randomized clinical trials was evaluated using the Cochrane Risk of Bias 2.0 tool (*RoB 2.0*) [37]. This tool assesses potential bias across five domains: (1) the randomization process; (2) deviations from intended interventions; (3) missing outcome data; (4) outcome measurement; and (5) selection of the reported result. A rating of low risk of bias suggests that systematic errors are unlikely to meaningfully influence the study's findings, whereas a high risk of bias indicates decreased confidence in the validity of the results. Discrepancies between reviewers were resolved through discussion, with a third reviewer (S.E.M.P.) consulted when consensus was needed.

2.6. Certainty of Evidence (GRADE)

The overall certainty of the evidence was evaluated using the Grading of Recommendations, Assessment, Development and Evaluation (*GRADE*) framework [38]. This method assesses five domains: study design, imprecision, indirectness, inconsistency, and publication bias. Based on these criteria, the quality of evidence was classified into four levels:

high (all domains satisfied), moderate (one domain not satisfied), low (two domains not satisfied), or very low (three or more domains not satisfied).

2.7. Synthesis of Results

Meta-analyses were performed using Review Manager (RevMan v.5.3; Cochrane Collaboration, Oxford, UK) [39] when at least two studies reported comparable outcomes. For analyses stratified by study duration, data were grouped into short-term (<4 weeks), medium-term (5–20 weeks), and long-term (>20 weeks), following prior research. When unit conversion was not feasible, the standardized mean difference (SMD) was used.

Results are presented as SMDs with 95% confidence intervals (CI). Statistical heterogeneity was evaluated using the I^2 statistic, with thresholds of 0–40% indicating low heterogeneity, 30–60% moderate heterogeneity, 50–90% substantial heterogeneity, and 75–100% considerable heterogeneity. A fixed-effects model was applied initially; however, when I^2 exceeded 40%, a random-effects model was employed.

3. Results

3.1. Data Sources and Search Strategies

A total of 1492 records were identified through database searches, including MEDLINE (PubMed) (n = 415), the Cochrane Library (n = 723), CINAHL (n = 131), Academic Search Ultimate (n = 168), and the PEDro Database (n = 55). After duplicate records were removed (n = 805), 687 unique studies remained for title and abstract screening. This process led to the full-text assessment of 529 articles for eligibility.

Of these, 502 were excluded for the following reasons: differing study designs (n = 140), publication in languages other than English, Spanish, French, or Portuguese (n = 89), interventions that did not satisfy the inclusion criteria (n = 129), or outcome measures not relevant to the research question (n = 144). In the final stage, 27 studies were included in the qualitative synthesis and meta-analysis. The study selection process is presented in Figure 1.

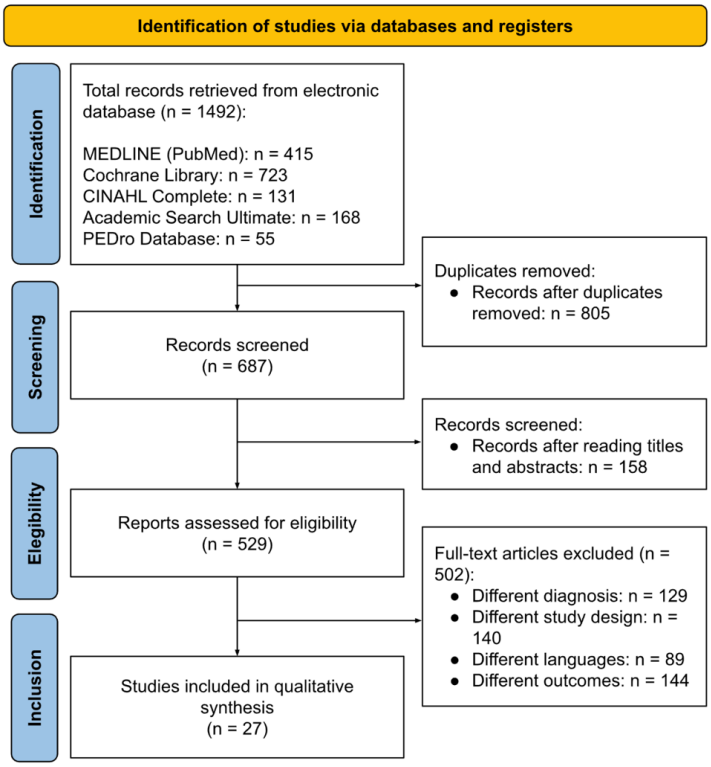


Figure 1. PRISMA 2020 flow diagram.

3.2. Study Characteristics

Following the study selection process, 27 studies met the predefined eligibility criteria [40–66]. Of these, 21 were prospective randomized controlled trials (RCTs) [40–43,45,47–58,60,61,63–65], 4 were prospective single-blinded RCTs [44,49,50,62], 1 was an assessor-blinded RCT [46], and 1 was a multicenter RCT [59]. Except for a single study conducted in individuals with myalgic encephalomyelitis/chronic fatigue syndrome [44], all studies involved participants diagnosed with FMS. Overall, n = 1785 participants were included, more than 95% of whom were women, with mean ages ranging from 44 to 62 years.

Most interventions involved supervised AE performed in pools maintained at 30–34 °C, with sessions conducted 2–3 times per week for 45–60 min, over a period of 8 to 32 weeks. The AE protocols commonly incorporated aerobic activities (e.g., walking, jogging, deep-water running, mobility or functional drills) [40–43,48,49,57,58,60–62,64,65], often complemented by different strategies of resistance training using floats or elastic implements [40,43,57,58,61]. Several programs included flexibility, stretching, postural control, and relaxation components [41,47,55,60,64]. In addition, aquatic Pilates-based approaches [49,63], and 1 study compared aquatic HIIT with MICT [46].

The comparison arms varied and included land-based exercise programs matched for frequency and intensity [40,43,49,62,63], home-based stretching protocols [41,50,55], usual care or waiting-list controls [42,47,53,57,61,64,65], and aerobic exercise performed in seawater [48]. Further, several studies also examined multimodal spa therapy or balneotherapy [45,56,59], and one incorporated exergaming (e.g., Wii Fit) as a comparator [54]. Follow-up durations ranged from short-term post-intervention assessments at 3 weeks [45,56] to long-term evaluations extending to 6–12 months [44,45,47,59,62]. Detraining effects, examining the persistence or loss of benefits after intervention cessation, were reported in 2 trials [64,65].

The included studies were conducted across several regions, including Brazil [42,43,48,49,51,52], Spain [40,54,57,58,61–65], Turkey [41,50,56,63], Norway [46,55], Sweden [60], Switzerland [47], Germany [45], France [59], Canada [53], and Australia [44], indicating the international relevance and widespread clinical adoption of AE in the management of FMS. Detailed information is provided in Table S3.

3.3. Methodological Quality Assessment (PEDro Scale)

Overall, the methodological quality of the 27 included studies ranged from acceptable to good, with an average PEDro score of 5.2/10 (SD = 0.8). 9 studies (33.3%) were rated as good quality [40,42,45,47,52,54,59,62,63], while the remaining 18 trials (66.7%) were rated as acceptable [41,43,44,46,48–51,53,55–58,60,61,64–66]. None of the included trials met the criteria for an excellent quality rating.

The most frequent methodological shortcomings were the absence of therapist blinding in all studies and the limited use of participant blinding, which was implemented in only a minority of trials [49,62]. In addition, concealed allocation and intention-to-treat analyses were inconsistently applied. Nevertheless, most studies reported adequate random allocation, baseline comparability, and outcome reporting, providing a reasonably solid methodological foundation for evaluating the effects of AE interventions in FMS. More details are explained in Table 1.

Table 1. Methodological quality analysis (PEDro Scale).

Author, Year	Score (0–10)	Quality	1	2	3	4	5	6	7	8	9	10	11
Acosta-Gallego et al., 2018 [40]	6	Good	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Altan et al., 2004 [41]	5	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes
Assis et al., 2006 [42]	6	Good	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Britto et al., 2020 [43]	5	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes
Broadbent et al., 2025 [44]	4	Acceptable	Yes	No	No	Yes	No	No	Yes	Yes	No	Yes	Yes
Brockow et al., 2007 [45]	6	Good	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Bunæs-Næss et al., 2025 [46]	4	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	No
Cedraschi et al., 2004 [47]	6	Good	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
de Andrade et al., 2008 [48]	5	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes
de Medeiros et al., 2020 [49]	5	Acceptable	Yes	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Deniz-Evcik et al., 2008 [50]	4	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes
Fernandes de Melo-Vitorino et al., 2006 [51]	4	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes
Fonseca et al., 2019 [52]	6	Good	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Gowans et al., 2004 [53]	5	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes
Gusi et al., 2016 [54]	6	Good	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Jentoft et al., 2001 [55]	4	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes
Kurt et al., 2016 [56]	4	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	No
Latorre-Román et al., 2013 [57]	5	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes
Latorre-Román et al., 2015 [58]	5	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes
Maindet et al., 2021 [59]	6	Good	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Mannerkorpi et al., 2009 [60]	4	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes
Munguía-Izquierdo et al., 2008 [61]	5	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes
Rivas Neira et al., 202 [62]	6	Good	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes

Table 1. *Cont.*

Author, Year	Score (0–10)	Quality	1	2	3	4	5	6	7	8	9	10	11
Şevgin et al., 2025 [63]	6	Good	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Tomás-Carús et al., 2007 [64]	5	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes
Tomás-Carús et al., 2008 [65]	5	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes
Tomás-Carús et al., 2009 [66]	5	Acceptable	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes

The quality of the included studies was evaluated using a predefined 10-item scoring system (range: 0–10). Studies scoring 4–5 points were classified as Acceptable quality, whereas those with scores of 6 or higher were classified as Good quality.

3.4. Risk of Bias Assessment (RoB 2.0)

The overall risk of bias among the randomized clinical trials, as evaluated using the RoB 2.0 tool, ranged from low to moderate. As illustrated in Figure 2, the majority of studies demonstrated a low risk of bias related to the randomization process and selective outcome reporting [40–66]. Conversely, a high risk of bias associated with the absence of blinding of participants and study personnel was commonly observed across most trials, with the exceptions of Mannerkorpi et al., 2009 [60], Fernandes de Melo-Vitorino et al., 2006 [51], and Tomás-Carús et al., 2009 [65].

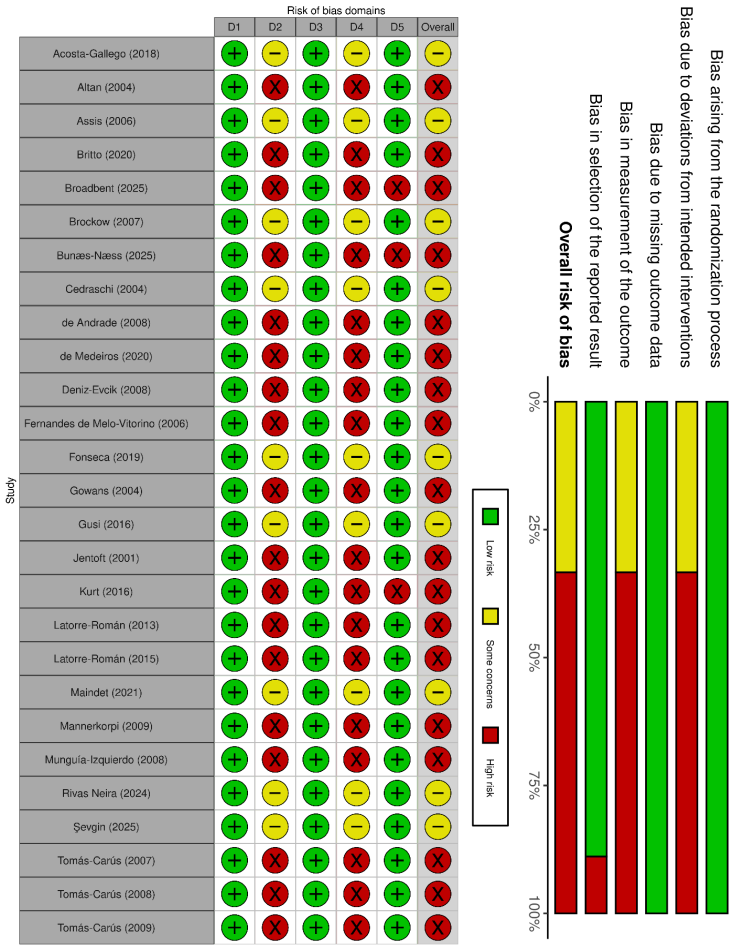


Figure 2. Risk of Bias (RoB 2.0) assessment of the included randomized clinical trials. References: Acosta-Gallego et al., 2018 [40]; Altan et al., 2004 [41]; Assis et al., 2006 [42]; Britto et al., 2020 [43];

Broadbent et al., 2025 [44]; Brockow et al., 2007 [45]; Bunæs-Næss et al., 2025 [46]; Cedraschi et al., 2004 [47]; de Andrade et al., 2008 [48]; de Medeiros et al., 2020 [49]; Deniz-Evcik et al., 2008 [50]; Fernandes de Melo-Vitorino et al., 2006 [51]; Fonseca et al., 2019 [52]; Gowans et al., 2004 [53]; Gusi et al., 2016 [54]; Jentoft et al., 2001 [55]; Kurt et al., 2016 [56]; Latorre-Román et al., 2013 [57]; Latorre-Román et al., 2015 [58]; Maindet et al., 2021 [59]; Mannerkorpi et al., 2009 [60]; Munguía-Izquierdo et al., 2008 [61]; Rivas Neira et al., 2024 [62]; Şevgin et al., 2025 [63]; Tomás-Carús et al., 2007 [64]; Tomás-Carús et al., 2008 [65]; Tomás-Carús et al., 2009 [65]. Note(s): Risk of bias was assessed according to the Cochrane RoB 2.0 tool. *Green* = low risk; *Yellow* = some concerns; *Red* = high risk.

With respect to allocation concealment, several studies were judged to raise some concerns or to be at high risk of bias [40,42,43,48,52]. Bias related to incomplete outcome data and outcome measurement was generally assessed as low to moderate, although a small number of studies were rated as having a high risk in these domains [41,44,46,50,56,63]. Overall, the lack of participant and personnel blinding emerged as the main source of bias across the included studies [40–66], while other domains such as randomization, selective reporting, and data completeness were largely considered adequate.

3.5. Certainty of Evidence (GRADE)

The strength of the evidence was evaluated using the GRADE approach. For outcomes of pain reduction and physical function, analyzed across 27 RCTs [40–66], the overall certainty was rated as low. This rating was mainly downgraded due to a serious risk of bias, as most studies lacked participant or assessor blinding, and serious imprecision stemming from the relatively small sample sizes in the included trials.

Similarly, QoL, analyzed in 8 RCTs [41,43,47,52,54,60,62,65], and fatigue, assessed in 6 RCTs [42,48,51,55,59,63], were both graded as low-certainty evidence, reflecting the same methodological limitations. Although some inconsistency was observed among QoL outcomes—largely attributable to the heterogeneity of measurement tools—it did not warrant additional downgrading.

In contrast, adverse events, reported in 10 RCTs [41,44,46,49,50,56–58,61,64], demonstrated moderate-certainty evidence. This higher rating was supported by the absence of serious bias, inconsistency, or indirectness, and the consistent finding of no major adverse events across studies. Nonetheless, some imprecision remained due to the relatively small sample sizes in certain trials. Further details are provided in Table 2.

Table 2. GRADE assessment.

Outcome	No. of Studies	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Overall Certainty of Evidence
Pain reduction (VAS, tender points)	27 RCTs [40–66]	Serious (lack of blinding)	Not serious	Not serious	Serious (small samples)	Possible	●●○○ Low
Physical function (FIQ, 6MWT, stair climbing, balance)	14 RCTs [42,49,52,54,55,57,58,60–66]	Serious	Not serious	Not serious	Serious	Possible	●●○○ Low
Quality of life (FIQ total, SF-36, STAI, BDI)	13 RCTs [43,45,47,49,54,57–60,62,64–66]	Serious	Some concerns	Not serious	Serious	Possible	●●○○ Low

Table 2. *Cont.*

Outcome	No. of Studies	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Overall Certainty of Evidence
Fatigue (FIQ item, SF-36 vitality)	10 RCTs [40–43,53,57,61, 62,64,65]	Not serious	Not serious	Not serious	Serious	Possible	●●○○ Low
Adverse events	10 RCTs [41,43,45,46,49, 52,56,59,63]	Not serious	Not serious	Not serious	Serious	Unlikely	●●●○ Moderate

Summary of Findings using the GRADE approach for randomized clinical trials included in the review. The overall certainty of evidence was downgraded mainly due to high risk of bias (lack of blinding in most studies) and imprecision (small sample sizes). Certainty of evidence symbols: ●●●● indicates high certainty, ●●●○ indicates moderate certainty, ●●○○ indicates low certainty, and ●○○○ indicates very low certainty of evidence.

3.6. Data Synthesis

3.6.1. Effectiveness of AE vs. Control in Patients with FMS in Pain Intensity

In the short-term subgroup (<4 weeks), 2 RCTs [45,56], including $n = 109$ participants. AE resulted in a significant reduction in pain intensity compared with control interventions, with a pooled standardized mean difference (SMD = −0.93; 95% CI: −1.21 to −0.66; $p < 0.00001$) and no heterogeneity ($I^2 = 0\%$). In these studies, baseline pain scores ranged from approximately 4.5 to 5.5 points, with post-intervention values decreasing to around 3.5–4.0 points in the AE groups.

In the medium-term subgroup (5–20 weeks), 17 RCTs [40–43,47–58,60–62], enrolling $n = 947$ participants, also showed a significant improvement in pain intensity in favor of AE (SMD = −0.89; 95% CI: −1.04 to −0.73; $p < 0.00001$), with low heterogeneity ($I^2 = 19\%$). Across trials reporting numerical data, mean pain scores decreased by approximately 1.5 to 3.0 points on a 10-point VAS/NRS in the AE groups, whereas changes in control groups were small or negligible.

In the long-term subgroup (>20 weeks), 3 RCTs [59,65,66] comprising $n = 140$ participants confirmed a persistent analgesic effect (SMD = −1.05; 95% CI: −1.30 to −0.80; $p < 0.00001$), again with no heterogeneity ($I^2 = 0\%$). Long-term follow-up data indicated sustained reductions in pain intensity, with post-intervention scores remaining approximately 1.5–2.5 points below baseline levels.

When all studies were pooled ($n = 1446$ participants), AE was associated with a robust overall reduction in pain intensity (SMD = −0.92; 95% CI: −1.03 to −0.80; $p < 0.00001$), and low heterogeneity ($I^2 = 8\%$). Whenever numerical pain scores were available, absolute baseline and post-intervention values were extracted and are summarized in Supplementary Figure S1, thereby providing direct clinical context to the standardized mean differences.

3.6.2. Effectiveness of AE vs. Control in Patients with FMS in Functionality

In the short-term subgroup (<4 weeks), only 1 RCT [45], including $n = 139$ participants, assessed functionality using numerical functional scales, primarily the FIQ. AE resulted in a significant improvement in functionality compared with control interventions, with a standardized mean difference (SMD = −0.59; 95% CI: −0.93 to −0.25; $p = 0.0007$). In this study, mean FIQ scores decreased from approximately 50 points at baseline to around 45 points post-intervention in the AE group, whereas the control group showed minimal change. Heterogeneity was not applicable due to the inclusion of a single study.

For the medium-term (5–20 weeks), 13 RCTs [40–43,47–52,55–58,61–63] enrolling $n = 1049$ participants demonstrated a significant effect in favor of AE, with a pooled SMD = −0.79 (95% CI: −0.91 to −0.66; $p < 0.00001$). Heterogeneity was negligible ($I^2 = 0\%$),

indicating high consistency across studies. Across trials reporting numerical functional outcomes, baseline FIQ scores generally ranged between 45 and 55 points, with post-intervention values typically reduced to 43–48 points in the AE groups, corresponding to mean improvements of approximately 8–12 points, while control groups exhibited smaller or no improvements.

In the long-term subgroup (>20 weeks), 3 RCTs [59,64,65] including $n = 266$ participants confirmed sustained improvements in functionality (SMD = −0.63; 95% CI: −0.88 to −0.38; $p < 0.00001$), again with no heterogeneity ($I^2 = 0\%$). Long-term follow-up data indicated that functional gains were maintained over time, with mean FIQ reductions remaining in the range of 6–10 points compared with baseline values.

When all studies were combined ($n = 1454$ participants), AE was associated with a robust overall improvement in functionality (SMD = −0.74; 95% CI: −0.84 to −0.63; $p < 0.00001$). Overall heterogeneity was negligible ($I^2 = 0\%$), suggesting that the beneficial effects of AE on functionality are consistent regardless of follow-up duration. Whenever numerical functional scores were available, absolute baseline and post-intervention values were extracted and are summarized in Supplementary Figure S2, thereby providing direct clinical context to the SMDs and addressing concerns regarding clinical interpretability.

3.6.3. Effectiveness of AE vs. Control in Patients with FMS in Quality of Life

A total of 18 RCTs assessing QoL using standardized instruments—primarily the SF-36, EQ-5D, and PGWB—were included in the meta-analysis, comprising $n = 1269$ participants. In addition to SMDs, absolute post-intervention scores are reported to enhance clinical interpretability, as suggested by the reviewer.

Overall, AE led to clinically meaningful improvements in HRQoL compared with control conditions (SMD = 0.57; 95% CI: 0.42–0.72; $p < 0.00001$), with low heterogeneity ($I^2 = 35\%$). Across studies, this effect corresponded to higher post-intervention QoL scores in the AE groups, with mean values generally ranging between 57 and 63 points, compared with approximately 49 to 55 points in control groups, depending on the instrument used.

In the short-term subgroup (<4 weeks), two RCTs [45,56] including $n = 219$ participants showed significant QoL improvements (SMD = 0.57; 95% CI: 0.30–0.84; $p < 0.0001$; $I^2 = 0\%$). Notably, mean QoL scores in the AE groups ranged from 52.8 to 57.1, compared with 41.9 to 51.8 in control groups, indicating an absolute between-group difference of approximately 5–11 points.

Similarly, the medium-term subgroup (5–20 weeks), comprising 9 RCTs [42,49,50,52,57,59–63] with $n = 452$ participants, demonstrated a significant benefit (SMD = 0.62; 95% CI: 0.43–0.81; $p < 0.00001$; $I^2 = 0\%$). Post-intervention QoL scores consistently favored AE, with experimental group means typically between 58 and 62, compared with 47 to 55 in control groups. Improvements were particularly evident in SF-36 physical functioning, vitality, and pain-related domains, suggesting a close relationship between enhanced functional capacity, reduced pain impact, and overall QoL.

For the long-term subgroup (>20 weeks), seven RCTs [47,54,59,64–66] involving $n = 598$ participants confirmed sustained QoL gains (SMD = 0.57; 95% CI: 0.22–0.91; $p = 0.001$), despite moderate heterogeneity ($I^2 = 71\%$). In this subgroup, AE participants maintained higher QoL scores (approximately 56–71) than controls (49–64) at follow-ups ranging from 6 to 8 months, particularly in physical and social functioning domains and in the EQ-5D health index.

No statistically significant differences were observed between subgroups ($\chi^2 = 0.14$; df = 2; $p = 0.93$), indicating a consistent beneficial effect of AE on QoL across follow-up durations. These results, illustrated in Supplementary Figure S3, demonstrate that the

observed SMDs correspond to clinically interpretable absolute improvements in QoL and pain-related functioning, thereby reinforcing the practical relevance of the findings.

3.7. Sensitivity Analysis

Despite the variability in AE protocols across studies—including differences in session duration, frequency, water temperature, and specific exercise components—the pooled analyses showed low statistical heterogeneity (I^2 values ranging from 0% to low–moderate levels). This finding reflects a high consistency in the direction and magnitude of effect estimates across trials. To assess the robustness of these results, sensitivity analyses were conducted using a leave-one-out approach, whereby each study was sequentially removed from the meta-analysis. These analyses revealed no substantial changes in pooled effect sizes or heterogeneity indices, indicating that the overall findings were not driven by any single study and supporting the stability of the results.

4. Discussion

The findings of this meta-analysis support the notion that AE—conceptualized as a structured and active form of therapeutic exercise performed in water under professional supervision—is associated with clinically meaningful improvements in pain intensity, physical functionality, and HRQoL in individuals diagnosed with FMS. These effects were consistently observed across short-, medium-, and long-term follow-up periods, supporting AE as a safe and potentially beneficial non-pharmacological intervention. However, while the included trials primarily reported clinical outcomes, the biological and neurophysiological mechanisms that may underlie these benefits were not directly assessed and therefore remain inferential.

Firstly, the robust reduction in pain intensity observed across trials (MD ≈ -0.79; $p < 0.00001$) may be interpreted in light of existing neurophysiological models of pain modulation in FMS, although causal inferences cannot be drawn. Immersion in thermoneutral water has been shown to stimulate cutaneous mechanoreceptors and cardiovascular baroreceptors, generating afferent input to supraspinal structures involved in descending inhibitory pain pathways within the central nervous system (CNS), such as the periaqueductal gray (PAG) and the rostral ventromedial medulla (RVM) [25,31,67,68].

Experimental evidence suggests that such stimulation may facilitate the release of endogenous opioids, serotonin, and noradrenaline, potentially attenuating nociceptive transmission at the spinal level and counteracting central sensitization mechanisms commonly described in FMS [6,14,15,69–71]. Nevertheless, these mechanisms were not directly measured in the included trials and should therefore be regarded as plausible but hypothetical explanatory pathways.

In parallel, biomechanical factors inherent to the aquatic environment may contribute to pain relief. Hydrostatic pressure and buoyancy reduce gravitational loading on muscles and joints, which may diminish peripheral nociceptor activation and attenuate peripheral sensitization processes [72,73]. Additionally, the warm aquatic environment promotes vasodilation, muscle relaxation, and improved tissue oxygenation, potentially facilitating the clearance of proinflammatory metabolites and reducing ischemia-related discomfort [23–26]. Together, these biomechanical and thermophysiological effects provide a biologically plausible framework for the reductions in pain intensity observed across the included studies, although they were not directly assessed within the trials [74–76].

The observed improvements in physical functionality (SMD = -0.74; $p < 0.00001$) may be related to sensorimotor adaptations induced by movement in water. Reduced gravitational resistance allows motor tasks to be performed under low-load conditions, which may facilitate neuromuscular re-education, enhanced proprioceptive feedback, and improved

motor coordination. Prior research suggests that aquatic exercise may support activation of the muscle spindles and Golgi tendon organs, reduce maladaptive co-contraction, and improve joint stability [77–79]. These adaptations may be particularly relevant in FMS, where altered motor control and inefficient movement patterns have been consistently reported [80,81]. However, as these neuromuscular mechanisms were not directly evaluated, their contribution remains speculative.

Autonomic modulation represents another potential pathway through which AE may influence functional outcomes. Previous studies have associated aquatic exercise with a shift toward parasympathetic predominance, often reflected by improvements in heart rate variability (HRV) and reductions in sympathetic overactivity—features commonly observed in FMS [82,83]. Improved autonomic regulation may hypothetically mitigate stress-related hyperexcitability and fatigue, thereby supporting functional recovery and exercise tolerance [84]. Nonetheless, autonomic markers were not measured in the present meta-analysis, precluding direct confirmation of this mechanism.

The significant enhancement in HRQoL (SMD = 0.57; $p < 0.00001$) suggests that AE may exert additional psychophysiological and psychosocial effects beyond physical symptom improvement. Immersion in warm water has been proposed to modulate serotonin and dopamine turnover [29,85], influence hypothalamic–pituitary–adrenal (HPA) axis activity, and reduce circulating proinflammatory cytokines such as IL-6 and TNF-α, which have been implicated in nociplastic pain mechanisms [86]. Although these biomarkers were not assessed in the included trials, such adaptations have been associated with improvements in mood, anxiety, and emotional regulation—key components of perceived quality of life in individuals with FMS.

Furthermore, the group-based nature of many AE programs may introduce contextual psychosocial factors that contribute to therapeutic benefit. Opportunities for social interaction, peer support, and shared therapeutic engagement may positively influence affective–motivational dimensions of pain perception and well-being [7,87], potentially contributing to the sustained physical and psychosocial improvements observed.

Importantly, the biological and neurophysiological mechanisms discussed above remain hypothetical and inferential in nature. None of the included trials directly assessed central pain modulation, autonomic function, inflammatory biomarkers, or neuroendocrine responses. Consequently, these mechanisms should not be interpreted as causal explanations, but rather as plausible biological pathways that may help contextualize the observed clinical benefits of AE, supported by prior mechanistic research but not directly shown within the present meta-analysis.

4.1. Limitations

Despite the robustness of the findings, several limitations should be acknowledged. Although FMS was defined according to the ACR 2016 criteria, several included trials relied on earlier diagnostic frameworks or local adaptations. This variability in diagnostic criteria may have affected symptom severity, clinical phenotype, and the generalizability of the results to routine clinical practice. In addition, variability in AE protocols, water temperature, and outcome measures may have contributed to the observed heterogeneity and affected the pooled effect estimates.

In addition, the limited availability of long-term follow-up data restricts conclusions regarding the durability of treatment effect [15,22,26], and publication bias cannot be excluded [21,23,27,28,31]. Furthermore, AE remains a promising non-pharmacological intervention for FMS [4,6]; however, findings should be interpreted in light of diagnostic heterogeneity, and AE prescriptions should be individualized to optimize therapeutic benefit.

4.2. Future Directions

Future studies should explicitly incorporate mechanistic and longitudinal designs to empirically test the biological hypotheses proposed in this meta-analysis. Specifically, the combination of AE with cognitive-behavioral therapy (CBT) could enhance descending pain inhibition through cortico-limbic modulation [88]. The measurement of proinflammatory cytokines (IL-1β, IL-6, TNF-α), neurotrophic molecules (BDNF), and HRV would further clarify the relationship between central modulation, inflammation, and functional outcomes [89,90]. Understanding these pathways will allow the development of tailored interventions that integrate physical, psychological, and neurobiological perspectives in FMS management.

5. Conclusions

To sum up, this meta-analysis shows that AE improves pain, physical function, and quality of life in individuals diagnosed with FMS, supporting its potential role as a safe complementary therapeutic approach. Nevertheless, due to the study heterogeneity, methodological limitations, small sample sizes, and short-term follow-up, the findings should be interpreted with caution. Well-designed randomized trials with long-term follow-up are needed to confirm these benefits and clarify their mechanisms.

Supplementary Materials: Supporting materials can be accessed at: https://www.mdpi.com/article/10.3390/rheumato6010005/s1: Table S1. PRISMA 2020 Checklist; Table S2. Search strategy; Table S3. Characteristics of included studies; Figure S1. Forest plot of pooled results on the effectiveness of aquatic exercise versus control on pain intensity in patients with fibromyalgia syndrome (FMS); Figure S2. Forest plot of pooled results on the effectiveness of aquatic exercise versus control on functionality in patients with fibromyalgia syndrome (FMS); Figure S3. Forest plot of pooled results on the effectiveness of aquatic exercise versus control on quality of life in patients with fibromyalgia syndrome (FMS).

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Abbreviations

The abbreviations used throughout this manuscript are as follows:

AE	Aquatic Exercise
BDNF	Brain-Derived Neurotrophic Factor
CBT	Cognitive Behavioral Therapy
CI	Confidence Interval
CNS	Central Nervous System
Df	Degree of Freedom

EQ-5D	EuroQol 5-Dimension Health Questionnaire
FMS	Fibromyalgia Syndrome
HIIT	High-Intensity Interval Training
HPA axis	Hypothalamic–Pituitary–Adrenal Axis
HRV	Heart Rate Variability
I^2	I-squared statistic
IL-1β	Interleukin-1 beta
IL-6	Interleukin-6
MD	Mean Difference
MIDC	Moderate-Intensity Continuous Training
PAG	Periaqueductal Gray
PGWB	Psychological General Well-Being Index
QoL	Quality of Life
RCT	Randomized Controlled Trial
RVM	Rostral Ventromedial Medulla
SF-36	Short Form Health Survey–36 items
SMD	Standardized Mean Difference
TNF-α	Tumor Necrosis Factor-Alpha
χ^2	Chi-Squared Test

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