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REVIEW

# Impact of water therapy on pain management in patients with fibromyalgia: current perspectives

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**Abstract:** Exercise-related interventions have been recommended as one of the main components in the management of fibromyalgia syndrome (FMS). Water therapy, which combines water's physical properties and exercise benefits, has proven effective in improving the clinical symptoms of FMS, especially pain, considered the hallmark of this syndrome. However, to our knowledge, the mechanisms underlying water therapy effects on pain are still scarcely explored in the literature. Therefore, this narrative review aimed to present the current perspectives on water therapy and the physiological basis for the mechanisms supporting its use for pain management in patients with FMS. Furthermore, the effects of water therapy on the musculoskeletal, neuromuscular, cardiovascular, respiratory, and neuroendocrine systems and inflammation are also addressed. Taking into account the aspects reviewed herein, water therapy is recommended as a nonpharmacologic therapeutic approach in the management of FMS patients, improving pain, fatigue, and quality of life. Future studies should focus on clarifying whether mechanisms and long-lasting effects are superior to other types of nonpharmacological interventions, as well as the economic and societal impacts that this intervention may present.

**Keywords:** hydrotherapy, exercise, pain management, chronic pain, physical therapy, aquatic therapy

## Introduction

Fibromyalgia syndrome (FMS) is a chronic syndrome characterized by widespread musculoskeletal pain, chronic fatigue, and nonrestorative sleep, among other symptoms.[1,2] It can be considered a clinical and pathological heterogeneous syndrome, thus requiring individualized and patient-tailored treatment.[3] FMS is one of the most common conditions seen in the general population and outpatient rheumatology practice.[1]

The burden of FMS is substantial and comparable to some other chronic disease such as osteoarthritis, rheumatoid arthritis, diabetes, and hypertension.[4–6] FMS patients incur direct costs approximately equal to rheumatoid arthritis patients, but visit more emergency physicians, physicians, and physical therapists than rheumatoid arthritis patients.[7] Several studies have evaluated the economic burden of FMS, including direct and indirect costs of the disease.[6,8–15] These costs include the large number of medical consultations and medication, and the health system and societal expenses of disability from work, accounting for more than three-quarters of total FMS-related costs.[16] Hence, a cost-effective treatment, or at least one that helps decrease the economic and societal burden, is more than welcome.[17]

Recent recommendations for the management of FMS have suggested the use of pharmacological and nonpharmacological interventions,[18] with exercise being

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recognized as one of the most important components of FMS treatment.[19–22] Moreover, aerobic and strengthening exercises were the only therapeutic approach with a "strong for" recommendation by the European League Against Rheumatism,[18] due to its positive effects on pain, physical function, and well-being, along with its availability, relatively low cost, and low risk.[23–26]

Among different types and modalities of exercises for FMS, water therapy can be considered one of the most known and doctor-recommended interventions, as it combines water physical properties and exercise benefits.[22,27] Indeed, several studies have investigated the effects of water therapy as a strategy in the management of FMS, reporting improvements in well-being, fitness, and symptoms, especially pain.[28–32] However, to our knowledge, mechanisms underlying the water therapy effects on pain are still scarce. Therefore, the aim of this narrative review is to present the current perspectives of water therapy and the physiological basis for the mechanisms supporting its use for pain management in patients with FMS.

## Clinical implication of water physics

Aquatic exercise describes an environment for structured activity rather than a type of exercise, as water's physical properties and the physiological effects of immersion turn this environment into a unique one.[33] According to the Chartered Society of Physiotherapists, water therapy or aquatic exercise refers to the use of water properties to design a therapy program aimed at improving function.[27,34] Indeed, there is evidence[27] that aquatic exercise is able to reduce the burden of musculoskeletal illnesses, which rely, basically, on the therapeutic effects achieved by the summation of physiological effects of immersion and principles of hydrodynamic exercises.[35] The four most important water physics principles are buoyancy, resistance (drag forces), hydrostatic pressure, and thermal conduction. Definitions of the water physics principles, their properties, and implications for clinical use are summarized in Table 1.[27,27,31,35–47]

## Water therapy physiological effects and its relationship with pain

Several studies have reported beneficial effects of aquatic therapy on several conditions,[33,39,48–50] among which stands FMS.[27,28,32,51,52] Indeed, guidelines for the management of FMS[18] have recommended water therapy mainly due to its analgesic effects and improvement in quality of life.[27,28,32,51,52]

Although this narrative review does not intend to perform a systematic review on the theme, Table 2 summarizes the clinical trials assessing the effects of hydrotherapy on FMS symptoms, especially pain. We carried out a search of the following databases: MEDLINE/PubMed, Scopus, Web of Science, SciELO, CINAHL, LILACS, ScienceDirect, and Springer. The following keywords were used: "aquatic exercise", "aquatic training", "balneotherapy", "fibromyalgia", "fibromyalgia syndrome", "fibromyalgic patients", "hydrotherapy", and "pool-based exercises". Two authors independently extracted data from all of the trials and all discrepancies or disagreements were resolved by consensus.

Randomized clinical trials, nonrandomized clinical trials, and crossover design studies assessing the effects of any aquatic intervention on pain in FMS patients were considered eligible for inclusion. The methodological quality of the studies was analyzed using the PEDro scale.

Thirty-five studies were included. Methodological quality varied between 1 and 9 according to the PEDro scale. Water temperature ranged between 28 and 37/38 ºC, and 7 studies did not report. Regarding the effectiveness of water therapy, only 2 studies reported no significant improvement compared to the baseline condition. However, one of these studies was composed of only 10 participants (5 in the Ai Chi group and 5 in a control group; PEDro score=1)[83] and the other comprised 18 participants (9 in the sauna group and 9 in the hydrotherapy group; PEDro score=4).[84] Thus, 94% of the included studies showed improvement in pain besides ameliorating other symptoms. In the following sections, we will discuss the possible mechanisms underlying the aquatic exercise effects.[11,28,30,31,83–82]

## Musculoskeletal and neuromuscular systems and the association with pain

The main symptom reported by FMS patients is pain.[1,2,85,86] Pain is a dynamic and complex phenomenon that is the final result of several factors. The association between nociceptive activity and pain perception depends on several intrinsic and extrinsic influences. For the same nociceptive stimulus, pain perception and related brain activity will greatly differ between subjects. In the case of chronic rheumatic diseases that do not regress spontaneously, such as FMS, functional and structural central nervous system changes cause a generalized reduction in the pain threshold that is not limited to the anatomical structures involved, thus leading to the hyperalgesia and allodynia in many, if

**Table 1** Summary of water physics principles

| Water property | Definition | Properties | Clinical significance |
|---|---|---|---|
| Buoyancy | Upward force that opposes gravity, and has a direct relationship with the immersion depth, movement speed, body composition, and gender[3637] | Archimedes principle states that, as the body submerges, it displaces water, and this displacement creates a floating force (buoyancy) equivalent to the water volume that has been displaced[38] | Buoyancy can be used to assist or to resist movements, to provide bodyweight offloading, and to help improve muscle activation and range of movement.[27,35,39] Also, buoyancy may assist in reduction of the perceived fatigue[40] |
| Hydrostatic pressure | Pressure exerted by the fluid on submersed objects | Pressure exerted by water on a submersed object is equal on all surfaces of the object, depending on the submersion depth[40] | Fluids are driven from the extremities toward the central cavity,[38] compressthe thorax, and increase respiratory load.[41] This property also provides support during movement performance underwater, improving static and dynamic balance,[42–46] including in women with FMS[31] |
| Hydrodynamic drag forces | Force that acts in an opposite direction to the line of the movement,[47] which is affected by the size and shape of the object[4147] | Drag force is a function of the velocity squared, which means that doubling the speed quadruples the drag force[41,47] | As the movement speed through water increases, resistance to motion increases[27]<br>If a person stops movement, the resistance drops almost immediately to 0, allowing improved control of exercises considering the patient's comfort[35,47] |
| Thermal conduction | Water conducts temperature 25 times faster than air and exchanges heat with the submerged object | The aquatic environment is stable to retain cold or heat.[41] The rate of temperature change depends on the mass and specific heat of the object | A submerged body adapts to the aquatic environment, quickly exchanging heat and achieving thermal balance.[41] Temperatures of 26–28 °C (80–84° F) are comfortably cool for exercising, while therapeutic pools are heated to between 30 and 32 °C (86 and 90° F)[27] |

**Abbreviation:** FMS, fibromyalgia syndrome.

**Table 2** Summary of studies using water therapy for FMS treatment

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altan et al (2004)[53] | 8 | RCT | Pain, tender points, fatigue, sleep, stiffness, health-related quality of life, muscle endurance, patient-rated disability, clinician-rated disability, depression | 2 groups: Aquatic exercise (n=24) Balneotherapy (n=22) | 35 min/session, 3×/week 12 weeks Protocol: Aquatic exercise – warm-up aerobics, muscle activation exercises, stretching, relaxation Balneotherapy – no exercise | Aquatic exercise: not reported Balneotherapy: no exercise | 37 °C | Aquatic exercise: significant decrease in pain (VAS and 5-point scale), fatigue (VAS and 5-point scale), morning stiffness, number of tender points, myalgic score, FIQ, sleep disorder, patient's and physician's global evaluation, and BDI. Significant increase in algometric score Balneotherapy: significant decrease in pain (VAS and 5-point scale), fatigue (VAS and 5-point scale), number of tender points, myalgic score, patient's and physician's global evaluation. Significant increase in algometric score. Significant difference between groups after 12 and 24 weeks for BDI favoring aquatic exercise group | Aquatic exercise after 12 weeks: ain (VAS)=1.06; ain (5-point scale)=0.99; number of tender points=2.11; myalgic score=1.62; FIQ=0.83; algometric score=0.62. Aquatic exercise after 24 weeks: pain (VAS)=1.01; pain (5-point scale) =1.18; number of tender points=1.97; myalgic score=1.32; FIQ=0.74; algometric score=0.78. Balneotherapy after 12 weeks: pain (VAS)=1.08; pain (5-point scale) =1.28; number of tender points=2.15; myalgic score=2.00; FIQ=0.62; algometric score=0.93. Balneotherapy after 24 weeks: pain (VAS)=0.54; pain (5-point scale) =0.82; number of tender points=1.18; myalgic score=0.91; FIQ=0.30; algometric score=0.60. | NA | Aquatic exercises and balneotherapy significantly decreased pain. Aquatic exercises proved longer-lasting effects. There was no superiority of aquatic exercises over balneotherapy | NA |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Andrade et al (2018)[54] | 9 | RCT | Peak oxygen uptake, PPT, pain (VAS) | 2 groups: Aquatic exercise (n=27) No exercise control (n=27) | 45 min/session 2×/week 16 weeks Protocol: warm-up, stretching, aerobic exercises (30 min), resistance exercises of upper limbs using floats (5 min), relaxation (5 min) | Aerobics: three HR percentages reached at VAT. Level 1: lower limb exercises sitting on floats (5 min) at 80% VAT HR; level 2: jumping on a trampoline (10 min) at 110% VAT HR; level 3: exercises in aquatic cycle with resistance adjustment at 100% VAT HR (10 min) | 30 °C (±2°C) | Aquatic exercise: significant increase in relative $VO_2$, PPT, VAS well-being, and decrease in VAS pain and FIQ scores. No-exercise control group: did not present any significant improvement | Aquatic exercise: PPT=0.31; VAS pain= −0.20. No-exercise control group: PPT=−0.33; VAS pain=0.43 | NA | Aquatic exercise: PPT=0.31; VAS pain=−0.20. No-exercise control group: PPT= −0.33; VAS pain=0.43 | Not reported |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arcos-Carmona et al (2011)[55] | 8 | RCT | Sleep, pain, fatigue, health-related quality of life, self-rated physical function, mental health, anxiety, depression | 2 groups:<br>Experimental (n=27)<br>Placebo control (n=26) | 60 min/session<br>2×/week<br>10 weeks<br>Protocol:<br>Experimental – 30 min of pool-based aerobic exercises and Jacobson relaxation<br>Placebo control –20 min of sham magnet therapy applied at cervical (10 min) and lumbar (10 min) spine. | Not reported | 28 °C | Experimental group: SF-36 scores were lower after intervention<br>Placebo control group: no significant differences from baseline | Not reported | Not reported | Not reported | Not reported |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Assis et al (2006)[56] | 9 | RCT | Pain (VAS) | 2 groups:<br>DWR (n=26)<br>land-based exercises (n=26) | 60 min/session, 3×/week<br>15 weeks<br>Protocol: a) stretching warm-up (10 min), DWR aerobic training (40 min), relaxation (10 min); b) land-based exercises – stretching warm-up (10 min), aerobic training on a treadmill (40 min), relaxation (10 min) | DWR: first 2 weeks: low-intensity exercises for adaptation. Then, exercises performed at the anaerobic threshold level controlled by HR<br>Land-based exercises: first 2 weeks: low-intensity exercises for adaptation. Then, exercises performed at the anaerobic threshold level controlled by HR | 28–31 °C | DWR: significant improvement in pain (VAS)<br>Land-based exercises: significant improvement in pain (VAS) | Not reported | Patient global assessment of response to therapy on a 5-point scale; SF-36; BDI; and FIQ | NA | NA |

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**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avila et al (2017)[28] | 5 | Single-arm clinical trial | Scapular three-dimensional motion measured with electromagnetic tracking device (Flock of Birds) | 1 group: (n = 20) | 45 min/session, 2×/week 16 weeks Protocol: stretching, warm-up, aerobics, muscle activation exercises, stretching, relaxation | Patient determined | 31 °C (±2 °C) | No significant changes in scapular kinematics | NA | Pain, quality of life, function | Pain significantly decreased (lower NPRS and PPT), function (lower FIQ scores), and quality of life (greater SF-36 scores for most domains) significantly improved | PPT: 041–1.61 NPRS: −1.41 to −1.93 |

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**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Biezus et al (2006)[57] | 5 | RCT | Pain (VAS) | 3 groups:<br>GA – general aquatic exercises (n=5)<br>GB –passive aquatic relaxation (n=5)<br>GC –control (n=6) | 60 min/session, 2×/week<br>8 weeks<br>Protocol: GA – warm-up, strengthening, stretching, and relaxation. Number of exercises in each therapy was approximately 13<br>GB – passive aquatic relaxation. TheExercises were done slowly and smoothly<br>GC – no physical therapy intervention | Not reported | 32 °C | Aquatic exercises and aquatic relaxation significantly decreased pain. However, aquatic exercises provided greater pain decrease than the aquatic relaxation program | GA – general aquatic exercises: d=0.55<br>GB – passive aquatic relaxation: d=1.26<br>GC – control group: d=0.20 | NA | NA | NA |

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**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bote et al (2014)[58] | 7 | RCT | Neutrophil function | 2 groups: Aquatic exercise program (n=10) Control no exercise (n=10) | 60 min/session, 2×/week 32 weeks Protocol: stretching out of the water (5 min), aerobic warm-up in the water (5 min), passive stretching of the main muscle groups in the water (5 min), aerobic aquatic choreography (25 min), strength exercises involving the main muscle groups of the upper limbs (15 min), and cool-down (10 min) | Parts (a), (b), (c), and (f) were performed at low exercise intensity (40–50% maximal HR). Part (d) was performed at low-to-moderate intensity (50–60% maximal HR) at the beginning of the program, and with increased intensity at the end of the program (65–75% maximal HR) | 32 °C | Aquatic exercise group had lower concentrations of IL-8 and noradrenaline together with reduced chemotaxis of neutrophils compared with the values determined in the same month in the control group of non-exercised FMS women | Not reported | Weight, body mass index, waist-to-hip ratio, body fat, flexibility, grip strength, balance, 6MWT, FIQ | Significant decrease of weight, body mass index, body fat and FIQ. Significant increase in grip strength | Not reported |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Calandre et al (2009)[59] | 7 | RCT | FIQ and PSQI | 2 groups:<br>Stretching in water (n=39)<br>Ai Chi–water Tai Chi (n=42) | 60 min/session, 3×x/week<br>6 weeks<br>Protocol: stretching performed over muscles of main body areas: cervical, upper, and lower extremities and trunk;<br>Ai Chi: 16 movements which constitute the Tai Chi therapy | Adjusted according to the degree of pain and fatigue<br>Adjusted according to the degree of pain and fatigue | 36 °C | Significant reduction in the FIQ and PSQI scores observed in Ai Chi but not in stretching group, with longer effect duration on sleep measures | Stretching in water: FIQ total score (d=0.35), FIQ-VAS (d=0.26), PSQI total scores (d=0.28)<br>Ai Chi–water Tai Chi: FIQ total score (d=0.53), FIQ-VAS (d=0.53), PSQI total scores (d=0.72) | FIQ difficulty at work, fatigue, morning tenderness, stiffness, anxiety, and depression | BDI decreased in stretching but not in Ai Chi group.<br>Trait-anxiety scores decreased in both groups | Stretching in water: FIQ difficulty at work (d=0.26), fatigue (d=0.21), morning tenderness (d=0.26), stiffness (d=0.17), anxiety (d=0.25). and depression (d=0.32)<br>Ai Chi–water Tai Chi: FIQ difficulty at work (d=0.47), fatigue (d=0.64), morning tenderness (d=0.29), stiffness (d=0.58), anxiety (d=0.32), and depression (d=0.43) |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Carbonel-Baeza et al (2010)[60] | 6 | RCT | Tender points, blind flamingo test, chair stand test, body composition, chair sit and reach, back scratch, 8 feet up andgo, handgrip strength, and 6MWT | 2 groups: Intervention (n=27) Usual care (n=32) | 120 min/session, 1×/week 12 weeks Protocol: a) verbal phase (35–45 min); b) moving/dancing according both to the suggestion given by the facilitator and the music played (75–80 min) Usual care: asked not to change their activity levels and medications during the 12-week intervention period | Adjusted according to the degree of pain and fatigue Intervention intensity was controlled by the RPE based on Borg's conventional (6–20-point) scale. The medium values of RPE were 11±1. These RPE values correspond to a subjective perceived exertion of "fairly light exertion," that is, low intensity | Not reported | Biodanza intervention reduced pain and FM impact (measured by FIQ). There was significant decrease in body fat percentage. There was no significant improvement in physical fitness tests. The program was well tolerated and did not have any deleterious effects on the patients' health | Not reported | NA | NA | NA |

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**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cuesta-Vargas et al (2011)[61] | 5 | Nonrandomised pilot clinical trial | FIQ | 2 groups: MMPP+DWR (n=22) Control (n=22) | 60 min/session, 3×/week 8 weeks Protocol: land-based exercises (stretching of tonic muscle and strengthening of phasic muscles combined with advice and education – 30 min) and DWR (30 min) Control: waiting list (no intervention) | Exercise training at anaerobic threshold determined by a graded treadmill exercise test and DWR test with lactate and HR analyses | 28–31 °C | Significant decrease in FIQ | Not reported | SF-12: physical component, mental component, EuroQoL-5D, EuroQoL-VAS | Significant improvement in pain, physical function, sleep, fatigue, morning stiffness, quality of life, and psychological symptoms (depression and anxiety) | Not reported |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| De Andrade et al (2008)[62] | 9 | RCT | Pain intensity, fatigue, number of tender points, physical functional capacity, general health status, sleep quality and depression | 2 groups: Pool-based exercises (n=23) Thalassotherapy (n=23) | 60 min/session, 3×/week 12 weeks The program was composed of 10-min stretching, 40 min of various forms of low-impact aerobic exercise according to the desired intensity, and then a 10-min relaxation period | Patients were monitored each for 10 min and were oriented to remain between levels 12 and 13 on BORG scale (from light to moderate). The first 2 weeks were used for familiarization, with light-intensity exercises only (between levels 10 and 11 on BORG scale) and learning the exercises. When pain occurred while they were exercising, patients were taught to decrease the intensity for a short time | Pool-based exercises (28–33 °C) Thalassotherapy (28–33 °C) | There was a statistically significant improvement in pain, fatigue, tender points, FIQ, PSQI, and BDI in both groups. Improvement in BDI was greater in the thalassotherapy group | Not reported | NA | NA | NA |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Evcik et al (2008)[63] | 5 | RCT | Number of tender points, pain, depression, and functional capacity | 2 groups:<br>Home-based exercise program (n=30)<br>Aquatic exercise program (n=33) | 60 min/session<br>3×/week<br>5 weeks<br>Protocol.:<br>home-based exercise program: warm-up, ROM, relaxation, aerobic, stretching, and cool-down exercises.<br>Aquatic exercise program: warm-up (20 min), aerobic exercises, active ROM, stretching, relaxation (35 min) and cool-down (5 min) | Not reported | 33 °C | Both aquatic therapy and home-based aerobic exercise programs improved well-being, quality of life, and pain parameters in FMS. Aquatic therapy seems to have more advantage in long-term pain management | Not reported | NA | NA | NA |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fernandes et al (2016)[64] | 9 | RCT | Pain (VAS) | 2 groups: Swimming (n=39) Walking (n=36) | 50 min/session 3×/week 12 weeks Protocol for both groups: warm-up (5 min), exercise (40 min), and cool-down (5 min) Swimming: freestyle swimming without floatation devices Walking: open-air walking | Swimming group: HR was kept at 11 beats below the anaerobic threshold Walking group: HR was kept at the anaerobic threshold | Not reported | Swimming, like walking, is an effective method for reducing pain in patients with FM | Not reported for intragroup comparisons. Effect size=0.168 for between-group comparison | Not reported | Swimming, like walking, is an effective method for improving both functional capacity and quality of life in patients with FM | Not reported |
| Gowans et al (2001)[65] | 8 | RCT | BDI and 6MWT | 2 groups: Supervised exercise (n=15) Control (n=16) | 30 min/session 3×/week 23 weeks Protocol: stretching (5 min before and 5 min after exercise) and aerobic exercise (20 min) | The aerobic component of the classes was designed to generate HRs equivalent to 60–75% of age-adjusted maximum HRs (210 – age [years]) | Not specified: "a warm therapeutic pool" | There were significant improvements for exercise group subjects in 6MWT distances and BDI | Not reported | Anxiety, general mental health, number of tender points, isokinetic maximal voluntary strength, FIQ, and self-efficacy | There was a significant improvement in anxiety, FIQ, self-efficacy, and mental health | Not reported |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gusi et al (2006)[66] | 6 | RCT | Pain, isokinetic muscle strength, health-related quality of life, spare time and work activities | 2 groups: Exercise (n=17) Control (n=17) | 60 min/session 3×/week 12 weeks Protocol: exercise – warm-up (10 min), aerobic exercises (10 min), overall mobility and lower-limb strength exercises (20 min), another set of aerobics (10 min), and cool-down (10 min) Control – follow normal daily activities, which did not include any form of exercise related to those in therapy | Aerobic exercises were performed at 65–75% of maximal HR | 33 °C | Therapy relieved pain and improved HRQOL and muscle strength in the lower limbs at low velocity | Not reported | NA | NA | NA |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hecker et al (2011)[67] | 9 | RCT | Quality of Life (SF-36) | 2 groups: Kinesiotherapy (n=12) Hydrokinesiotherapy (n=12) | 60 min/session 1×/week 23 weeks Protocol: muscle stretching exercises (15 min); passive and active movement of the lower limbs, upper limbs, trunk, and neck (30 min); and same stretching exercises performed at beginning of session (15 min) | Not reported objectively (low intensity during the entire protocol) | 32–34 °C | No significant differences between groups after the intervention program. Both groups improved physical functioning, pain, social aspects, and mental health. Hydrokinesiotherapy group improved also emotional aspects, while the kinesiotherapy group improved physical aspects | Not reported | NA | NA | NA |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ide et al (2008)[68] | 6 | RCT | PAIN (VAS – 10 cm, number of tender points) | 2 groups:<br>ARG (n=18)<br>CG (n=17) | Both groups: 60 min/session, 1×/week, 4 weeks: supervised recreational activities (involved no exercises or health-related issues)<br>ARG: 60 min/session, 4×/week; 4 weeks: warm-up, general exercises targeting specific breath patterns (45 min), and relaxation exercises | Not specified | 32 °C | Decrease in pain (lower VAS scores); no difference in tender points count | Not reported | Dyspnea, function, quality of life, anxiety, sleep | Improvement in dyspnea (lower VAS scores), sleep quality (lower PSQI scores), anxiety (lower HAS scores), function (lower FIQ scores), and quality of life (greater SF-36 values) | NA |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jentoft et al (2001)[69] | 5 | RCT | Function (FIQ) | 2 groups: PE (n=18) LE (n=16) | 60 min/session, 2×/week, 20 weeks. Both groups: body awareness training, ergonomics, warm-up, stretching, strengthening exercises, relaxation. Pool-based exercise group performed adapted protocol in water | 60–80% of maximum HR for age (during 40–50% of session) | 34 °C | No differences between groups for function; function equally improved for both groups (lower FIQ scores) | NA | Pain (FIQ pain subscore and VAS for local pain), self-efficacy, cardiovascular capacity, grip strength, walking time and endurance time of shoulder muscles | Improved grip strength (hand-held dynamometry) in LE group; within-group improvements in cardiovascular capacity (maximum $O_2$ uptake), and walking time (s/100 m); within-group improvements in the PE group for several FIQ subscales including pain, anxiety, and depression | Not reported |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kesiktas et al (2011)[70] | 3 | Quasi-randomized trial | Pain (tender points count, VAS – 10 cm, and total PPTon tender points) | 2 groups:<br>PTM+BT (n=16)<br>PTM (n=20)<br>PTM+HT (n=20) | PTM: 36 min/session, 5×/week, 3 weeks: conventional TENS (15 min), ultrasound (6 min). and infrared (15min);<br>PTM+BT: PTM added to 19 sessions of thermal pool bath (20 min of immersion/session);<br>PTM+HT: PTM added to 20-min sessions of hydrotherapy (protocol not described) | Not specified | Thermal pool bath: 37–38 °C<br>Hydrotherapy: 37 °C | Total PPT was lower for PTM+BT (compared to PTM+HT); improvement in pain symptoms (lower VAS, total PPTs and tender point count) was observed for all groups after treatment and only for PTM+BT and PTM+HT in the follow-up (after 6 months) | Not reported | Depression, pulmonary function | Improvement in depressive symptoms (lower BDI and HDRS scores) for all groups after treatment; only PTM+BT maintained better scores at follow-up; pulmonary function only improved for PTM+BT and PTM+HT groups after treatment, but only PTM+BT maintained improved pulmonary function at follow-up | NA |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Latorre et al (2013)[30] | 5 | Nonrandomized clinical trial | Pain (tender point count, VAS – 10 cm, PPT over tender points) | 2 groups:<br>EG (n=48)<br>CG (n=37) | CG: no activities or exercises other than usual, and none similar to EG protocol<br>EG: 60 min/session, 3×/week (2×/week pool exercises and 1×/week land exercises), 24 weeks<br>Protocol: warm-up, exercises of muscular strengthening, aerobic exercises, cool-down | Not specified (controlled by Borg scale) | Not reported | EG significantly improved pain symptoms (lower VAS scores, greater PPT and reduced number of tender points) | Not reported | Functional capacity, body composition, and quality of life | EG improved functional capacity (greater hand-held grip dynamometry values, greater maximum $O_2$ uptake, greater agility and balance indexes), quality of life (greater FIQ scores), and body composition (reduced fat percentage) | NA |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Latorre Román et al (2015)[71] | 6 | RCT | Pain (tender point count, VAS – 10 cm, PPT over tender points) | 2 groups: EG (n=20) CG (n=16) | CG: no activities or exercises other than usual, and none similar to EG protocol EG: 60 min/session, 3×/week (2×/week pool exercises and 1×/week land exercises), 18 weeks Protocol: warm-up, exercises of muscular strengthening and balance, cool-down | Patient determined | 30 °C | EG significantly improved pain symptoms (lower VAS scores, greater PPT and reduced number of tender points) | Not reported | Impact of fibromyalgia, strength, and balance | EG significantly improved: lower impact of fibromyalgia (lower FIQ scores), greater strength (leg and handgrip) and balance (agility dynamic and balance) | NA |
| Letieri et al (2013)[72] | 6 | RCT | Pain (VAS – 10 cm) | 2 groups: HG (n=33) CG (n=33) | 45 min/session, 2×/week, 15 weeks. Protocol: warm-up, strengthening, balance, coordination and agility exercises, stretching, and relaxation | Moderate according to the perceived effort modified scale | 33 °C | Decrease in pain (lower VAS scores) | Not reported | Quality of life, depressive symptoms | Improved quality of life (lower FIQ scores) and depressive symptoms (lower BDI scores) | NA |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| López-Rodríguez et al (2013)[73] | 6 | RCT | Pain (VAS – 10 cm, MPQ, PPT) | 2 groups: ABD (n=29) CG (n=30) | 60 min/session, 2×/week; 12 weeks. Protocol: ABD – flexibility and breathing exercises, rhythmic dancing movements, and mild exercises; CG – stretching exercises for different body parts | Not specified | 29 °C (preceded by a bath of 33–35 °C) | Decrease in pain (lower VAS and MPQ scores and lower number of active tender points for PPT) | Not reported | Sleep, anxiety, depression, function | Improvement in sleep quality (lower PSQI scores), anxiety (lower SAI scores), function (lower FIQ scores) for ABD | NA |
| Mannerkorpi et al (2000)[74] | 4 | Quasi-randomized clinical trial | Impact of fibromyalgia (FIQ – total score), physical capacity (6MWT) | 2 groups: TG (n=37) CG (n=32) | 35 min/session, 1×/week, 24 weeks. Protocol: exercises for endurance, flexibility, coordination, and relaxation along with education sessions (6 sessions, 1 h/session) | Patient determined | Not reported | Decreased fibromyalgia impact (lower FIQ total scores) and improved physical capacity (better scores in the 6MWT) | NA | FIQ subscores (including pain), pain, quality of life, self-efficacy, functional limitations | TG significantly improved physical functioning (lower FIQ subscores), anxiety (lower FIQ and AIMS subscores), depression (lower AIMS subscores), strength (greater grip strength), general health (greater SF-36 scores), social functioning (greater SF-36 scores), and pain (lower scores for pain severity and affective distress for the MPI-S) | Not reported |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mannerkorpi et al (2009)[75] | 8 | RCT | Impact of fibromyalgia (FIQ – total score), physical capacity (6MWT) | 2 groups:<br>Ex-Edu (n=81)<br>Edu (n=85) | 45 min/session, 1×/week, 20 weeks.<br>Protocol: exercises for endurance, flexibility, coordination, and relaxation along with education sessions (6 sessions, 1 h/session) | 48–65% of maximum HR (light to moderate intensity) | 33 °C | Decreased fibromyalgia impact (lower FIQ total scores) and improved physical capacity (better scores in the 6MWT) | NA | FIQ subscores (including pain), pain, quality of life, anxiety and depression, leisure-time physical activity, stress, fatigue | Significant improvement for change in pain (lower FIQ pain subscores) and for leisure time (decreased LTPAI scores) | 0.69 (0.45 for the intention-to-treat analysis) |
| Munguía-Izquierdo and Legaz-Arrese (2007)[76] | 7 | RCT | Tender point count, PPT on the tender points, and FIQ pain subscore (VAS – 100 mm) | 3 groups:<br>Ex (n=35)<br>CG (n=25)<br>Healthy group (n=25) | 60 min/session, 3×/week, 16 weeks<br>Protocol: warm-up with slow walks and mobility exercises, strength exercises, aerobic exercises, and cool-down | 50–80% of predicted maximum HR according to age | 32 °C | Decreased pain (reduced number of tender points, increased PPT over all tender points, and reduction in FIQ pain subscore) compared to control group | Not reported | Severity of FM and cognitive function | Improvement of FM severity (lower FIQ scores) and in cognitive function (improvement in neuropsychological tests) | NA |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Munguía-Izquierdo and Legaz-Arrese (2008)[77] | 8 | RCT | Tender point count, PPT over tender points, health status (FIQ) | 3 groups:<br>Ex (n=35)<br>CG (n=25)<br>Healthy group (n=25) | 60 min/session, 3×/week, 16 weeks<br>Protocol: warm-up with slow walks and mobility exercises, strength exercises, aerobic exercises, and cool-down | 50–80% of predicted maximum HR according to age | 32 °C | Decreased pain (reduced number of tender points, increased PPT over all tender points) compared to control group, Improvement in health status (lower FIQ scores) | Not reported | Anxiety, sleep quality, cognitive function, physical function | Improvement in sleep quality (lower PSQI scores), cognitive function (greater PASAT scores) and physical function (increased muscle endurance for upper and lower limbs) | NA |
| Pérez de la Cruz and Lambeck (2016)[78] | 3 | Pilot study | VAS (10 cm) for pain | 1 group:<br>FMS (n=20) | 45 min/session, 2/week, 10 weeks<br>Protocol: warm-up, Ai Chi program, cool-down | Not reported | 33 °C ±0.5 °C | Significant improvement in pain (lower VAS scores) | Not reported | Health-related quality of life | Improved quality of life (increased scores in all domains of SF-36 except role physical and role emotional) | NA |
| Piso et al (2001)[54] | 4 | Case–control study | PPT over tender points | 2 groups:<br>Sauna (n=9)<br>HT (n=9) | 30 min/session, 2×/week, 6 weeks.<br>Protocol: bodily awareness exercises, low-impact strength exercises | Patient determined | Sauna: 90 °C<br>HT: 35 °C | No significant differences comparing groups; significant improvement in PPT only for sauna group | Not reported | Previous treatment | Out of 18, 12 patients consider HT as first-choice treatment | NA |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Santana et al (2010)[53] | 1 | Analytical clinical trial | FM impact and pain over tender points | 2 groups: Ai Chi (n=5) CG (n=5) | 40 min/session, 10 sessions (number of weeks not specified) Protocol: Ai Chi program (sequence of slow and wide movements with upper limbs, lower limbs, and trunk, emphasizing deep breathing during the exercises) | Not reported | 34–36 °C | No significant improvement was observed for intervention group compared to CG | Not reported | NA | NA | NA |
| Segura-Jiménez et al (2013)[79] | 2 | Uncontrolled clinical trial | Tender point count and immediate pain (VAS – 10 cm) | 1 group: FMS (n=33) | 45 min/session, 2×/week, 12 weeks Protocol: warm-up, general exercises (on Mondays: strength; on Wednesdays: balance), stretching, and relaxation | RPE (Borg): 12 ±2 points | 34 °C | Improvement in immediate pain (decreased VAS scores) | Not reported | Body composition | No differences were observed in body composition | NA |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sevimli et al (2015)[80] | 5 | RCT | Pain (VAS – 100 mm) | 3 groups:<br>ISSEP (n=25)<br>AEP (n=25)<br>AAEP (n=25) | ISSEP: 15 min/day (3 months) of home-based stretching and strength exercises<br>AEP and AAEP: 40–50 min/session, 2×/week, 12 weeks<br>Protocol not described for AEP and AAEP | 60–80% maximal HR | Not reported | Pain improved for AEP and AAEP (lower VAS after treatment) | Not reported | Health status, endurance, quality of life, depression | Improvement in quality of life (greater SF-36 scores), depression (lower BDI scores), health status (lower FIQ scores) and endurance (greater scores for 6MWT) for AAEP and AEP | NA |
| Tomas-Carus et al (2007)[81] | 7 | RCT | FM impact (FIQ total score) | 2 groups:<br>EG (n=17)<br>CG (n=17) | 60 min/session, 3×/week, 12 weeks<br>Protocol: warm-up, mobility exercises, aerobic exercises, lower limb exercises, cool-down exercises, and relaxation | 60–65% maximal hear rate | 33 °C | Improvement of FM impact (lower FIQ scores) | NA | FIQ subscores (including pain) | Improvement of all FIQ subscores (lower scores for all, including pain) | Not reported |

(*Continued*)

**Table 2** (Continued)

| Author (year) | PEDro score | Design | Primary outcome | Groups (number in each group) | Water therapy protocol | Exercise Intensity | Water temperature | Main results | Effect sizes (reported for pain) | Secondary outcomes | Main results of Secondary outcomes | Effect sizes (reported for pain) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tomas-Carus et al (2009)[82] | 7 | RCT | FM impact (FIQ total score and subscores, including pain) and anxiety state (STAI) | 2 groups:<br>EG (n=15)<br>CG (n=15) | 60 min/session, 3×/week, 24 weeks<br>Protocol: warm-up, mobility exercises, aerobic exercises, lower limb exercises, cool-down exercises | 60–65% maximal hear rate | 33 °C | Significant reduction of FM impact (lower FIQ total scores, and FIQ pain subscores) | Treatment effect of −0.5 (−1.8 to 0.7) for the FIQ pain subscore | Physical fitness | Improvement of physical fitness (increase in maximal oxygen uptake, and increased scores for mobility and balance tests) | NA |
| Trevisan et al, (2015)[31] | 1 | Single-arm study | Postural control (center of pressure sway) | 1 group:<br>FMS (n=17) | 45 min/session, 2×/week, 16 weeks.<br>Protocol: familiarization, warm- up, exercises (aerobic and strength exercises for upper and lower limbs and trunk), cool-down stretching, and relaxation | Patient determined | 30 °C ±2 °C | Improvement in postural sway (lower center of pressure sway in different situations) | NA | Pain (VAS – 100 mm during rest and movement) and function (FIQ) | Improvement in pain (lower VAS scores) and function (lower FIQ scores) | VAS:<br>Rest: −2.12 (−2.90 to −1.23)<br>Movement: −1.94 (−2.70 to −1.08) |

**Abbreviations:** 6MWT, 6-min walking test; AAEP, pool-based aquatic aerobic exercise program; ABD, aquatic biodance; AEP, gymnastic-based aerobic exercise program; AIMS, Arthritis Impact Measurement Scales; ARG, aquatic respiratory exercise-based program; BDI, Beck Depression Inventory; CG, control group; DWR, deep water running; Edu, education group; EG, exercise group; EuroQoL-5D, EuroQol Research Foundation Quality of Life Questionnaire; EuroQoL-VAS, EuroQol Research Foundation Quality of Life Questionnaire Visual Analog Scale; Ex, exercise group; Ex-Edu, exercise and education group; FIQ, Fibromyalgia Impact Questionnaire; FMS, fibromyalgia syndrome; HAS, Hamilton Anxiety Scale; HDRS, Hamilton Depression Rank Scale; HG, hydrotherapy group; HR, heart rate; HRQOL, health-related quality of life; HT, hydrotherapy; ISSEP, home-based isometric strength and stretching exercise program; LE, land-based exercise group; LTPAI, leisure-time physical activity instrument; MMPP+DWR, multimodal physiotherapy program+deep water running; MPI-S, Multidimensional Pain Inventory – Swedish Version; MPQ, McGill Pain Questionnaire; NA, not applicable; NPRS, numerical pain rating scale; PASAT, Paced Auditory Serial Addition Task; PE, pool-based exercise group; PPT, pressure pain threshold; PSQI, Pittsburgh Sleep Quality Index; PTM, physical therapy modalities; PTM+BT, photobiomodulation +balneotherapy; PTM+HT, photobiomodulation+hydrotherapy; RCT, randomized controlled trial; ROM, range of motion; RPE, rate of perceived exertion; SAI, State Anxiety Inventory; SF-36, Medical Outcomes Study 36-item Short Form Health Survey; STAI, State-Trait Anxiety Inventory; TENS, transcutaneous electrical nerve stimulation; TG, training group; VAS, visual analog scale; VAT, ventilatory anaerobic threshold; $VO_2$, oxygen uptake.

not all, body regions.[21] FMS is associated with changes in the central nervous system that affect sensory information processing, amplifying peripheral input and/or generating pain perception in the absence of a noxious stimulus.[21] People with FMS are reported to present hyperactivity of the hypothalamic–pituitary–adrenal axis,[86,87] and this may be linked to the initiation or worsening of FMS symptoms. Moreover, dopamine dysfunctions have been linked to the pathophysiology of FMS, which are associated with hyperalgesia and deficient pain inhibition.[59]

Accordingly, exercise has been one of the most recommended nonpharmacological interventions for FMS.[19,20] It has been shown that exercise is able to influence gene expression and structural complexity in the limbic structures that regulate the hypothalamic–pituitary–adrenal axis[21] and can improve conditioned pain modulation due to increased endogenous opioids, stimulation of brain structures involved in the inhibitory descending pathways that regulate painful response.[88] Geytenbeek[89] has examined over 500 articles that were available on the theme and has concluded, after examining randomized controlled trials, case–control studies, and cohort studies, that high to moderate quality evidence supports the use of hydrotherapy for pain, function, joint mobility strength, and balance. Moreover, exercise seems to be the most effective component of a hydrotherapy program for FMS.[89,90]

Hence, exercising in an aquatic environment is advantageous. The pain-relieving effect of water-based exercises is suggested to be due to the joint effect of exercise, warm water, and buoyancy on thermal receptors and mechanoreceptors.[33] Sensory-motor hyperstimulation exerted by the hydrostatic pressure, viscosity, and water temperature increases the triggers of thermal receptors and mechanoreceptors while blocking nociceptors.[48,91] The viscosity of the water provides an environment with three-dimensional resistance, which facilitates proprioceptive feedback through functional patterns of movement and increases the synchronization of the motor units due to slowed movement.[92] Also, immersion in warm water helps to increase blood flow and oxygen supply, improving nutrition and removal of catabolites, and thereby reducing signal molecules, such as IL-8 and noradrenaline,[58] responsible for activation of nociceptors.[93] In addition, regular exercise has been shown to improve overall health, as shown in other chronic conditions.[27] This prominent effect on pain could be previously observed in several studies.[27,28,31,32,53]

It is noteworthy to mention that patients with FMS present abnormalities regarding pain modulation, including central sensitization and other pathophysiological mechanisms, such as the accumulation of cytotoxic substances in the extracellular space (glutamate, lactate, bradykinin, prostaglandins, etc.) generated by muscle activity, which exert algogenic effects by sensitizing and exciting nociceptors.[94,95] Glutamate is a major cortical excitatory neurotransmitter that acts in pain neurotransmission. Increased levels of insular glutamate have been reported to be present in FMS. In addition, the concentration of this molecule is correlated with pain report. Enhanced glutamatergic neurotransmission resulting from higher concentrations of glutamate within the posterior insula may play a role in the pathophysiology of FMS and other central pain augmentation syndromes.[96] Moreover, the sympathetic nervous system, which is already in a condition of hyperactivity (see section "Cardiovascular and respiratory systems and the association with pain"), under the action of bradykinin stimulates the release of noradrenaline and prostaglandins that further potentiate sympathetic hyperactivity and sensitize the nociceptors.

Therefore, another mechanism explaining the pain improvement may rely on the combination of hydrostatic pressure and temperature on nerve endings, which would lead to competing stimuli that would diminish the peripheral nociceptive input.[97] Aquatic therapy also leads to muscle relaxation,[98] which would in turn lead to less pain. Buoyancy decreases compressive weight-bearing stresses on joints and allows functional exercise with lessened gravitational load, making the movements easier, and even facilitating the improvement of both strength and range of motion.[39,99] Furthermore, drag forces can be used as a resource to assist movements or to impose resistance favoring muscle strengthening.[33] Nonetheless, quantifying the resistance training intensity and planning a progressive overload program in aquatic environments is challenging due to several factors (eg, speed of movements, range of motion, shape and size of floats, etc.). Therefore, it is still not clear whether aquatic exercises can really induce strength gains, since controversial results have been reported.[33]

Regarding chronic fatigue, another core feature of FMS, its perception may be reduced after water therapy due to the buoyancy effects.[40] Buoyancy helps reduce the musculoskeletal system's gravitational forces due to gravitational muscle relaxation and energy conservation, which seems to reduce perceived fatigue. Water immersion may also reduce neuromuscular responses or trigger inhibitory mechanisms, with an overall reduction in neural transmissions, which would impact not only on the perceived fatigue but also on the nociceptive input, reducing pain perception.

## Cardiovascular and respiratory systems and the association with pain

FMS patients present cardiorespiratory dysfunction characterized by reduced respiratory muscle endurance, inspiratory muscle strength, and thoracic mobility.[100] Moreover, cardiovascular autonomic control and baroreflex sensitivity have been also shown to be altered in this population.[32,101,102] In addition, although it is not possible to identify a causal relationship, several studies have shown that these cardiorespiratory abnormalities are related to the pain in these subjects. Forti et al[100] showed that inspiratory muscle strength is associated with the number of active tender points. In addition, Zamunér et al[103] found that FMS show reduced respiratory sinus arrhythmia magnitude as compared to healthy women. Also, the indices obtained during the deep breathing test, a vagal maneuver, had an important association with pain in FMS. In another study, Zamunér et al[104] also showed that sympathetic activity, as assessed by muscle sympathetic nerve activity, was related to pain in this population.

Several studies have described the interaction between autonomic and nociceptive pathways occurring at multiple levels,[105–107] with the nucleus tractus solitarius playing an important role. The nucleus tractus solitarius, located in the brainstem, receives visceral information through the primary afferents of the vagus nerve and receives the spinal pathways involved in pain processing, functioning as an interface between the autonomic and sensory systems.[107,108] Therefore, improving cardiovascular and respiratory outcomes in FMS patients should be considered one of the aims in the management of FMS.

It is well established that aerobic exercise improves cardiorespiratory function in patients with FMS.[19,109] In addition, an aquatic environment can allow higher-intensity exercises to be undertaken, with lower cardiovascular stress than is possible on land.[19,110] In this sense, some studies have assessed the effects of water therapy on the cardiorespiratory system. Zamunér et al[32] found that a 16-week aquatic therapy program proved to be effective in ameliorating symptoms, aerobic functional capacity, and cardiac autonomic control in FMS patients. Surprisingly, improvements in cardiac autonomic control were related to the improvements in pain and the impact of FMS on quality of life, thus suggesting an important role of autonomic control mediating symptoms. Regarding the improvement of functional aerobic capacity, aquatic therapy has also been proven to be effective.[32,51,80] However, studies have shown no association between cardiorespiratory fitness improvements and FMS symptom improvements.[32,51,111–113]

In summary, cardiorespiratory function and cardiac autonomic control should be routinely monitored in the management of FMS patients since they seem to be related to the symptoms; and water therapy might be seen as a strategic method to improve these outcomes in this population. However, improving cardiorespiratory fitness should not be the main goal in the therapy, but instead a tailored approach directed to the key FMS symptoms (pain, sleep disorders, fatigue, depression, disability) with exercise assignment that does not exacerbate post-exercise pain should take place.[114,115]

## Neuroendocrine system and inflammation

Growing interest has been shown in the study of the benefits of aquatic therapy on the neuroendocrine system[116–118] and inflammation. However, little is known about these in FMS patients. This is of interest since neurohormonal abnormalities have been reported in this population, such as low levels of serotonin,[119] hypothalamic–pituitary–adrenal axis dysfunction,[120–122] and low levels of growth hormone, which is associated with poor sleep quality.[123,124] Moreover, although there are no specific biomarkers for FMS, some studies have suggested the involvement of inflammatory disorders on its etiology.[125,126] Those disorders involve cytokines, proteins responsible for mediating the inflammatory reaction in the immune system.[127] Studies have shown that FMS patients have increased levels of serum IL-8,[128] IL-6, IL-10, and IL-1β.[129] Ortega et al[130] found that FMS patients present a higher circulation concentration of C-reactive protein and that their monocytes release more IL-1β, tumor necrosis factor alpha, IL-6, and IL-10 than those from an age-matched healthy control group. Additionally, FMS patients present a greater concentration of IL-8 in cerebrovascular fluid.[131,132] IL-8 release is stimulated by substance P secretion and promotes sympathetic pain,[133] and thus is considered an inflammatory marker of FMS,[62] which is indicative of underlying low-grade systemic inflammation. There is evidence showing the participation of chemokines (signaling molecules present in inflammatory and immune responses) in FMS, with higher concentrations of inflammatory chemokines (TARC/CCL17, MIG/CXCL9, MDC/CCL22, I-TAC/CXCL11, and eotaxin/CCL11).[134]

Aquatic therapy has been shown to reduce plasma levels of norepinephrine,[135–137] epinephrine,[135,138] β-endorphin, and cortisol[139] in healthy men. In this context, we may suggest that aquatic therapy may contribute to a reduction of stress, improvement of sleep quality, and reduction of pain sensitivity.[26,137] Regarding FMS patients, to our knowledge, no studies have assessed the effects of aquatic therapy on the neuroendocrine system. However, Bote et al[140] found that a single session of moderate cycling improved the inflammatory and stress status of FMS patients. Moreover, their results also suggest that the neuroendocrine mechanism seems to be an exercise-induced decrease in the stress response of these patients, since they observed a reduction in the systemic concentration of cortisol, noradrenaline, and extracellular heatshock protein 72. In agreement with these findings, Ortega et al[130] studied the effects of an aquatic fitness program performed for 8 months twice a week. After the program, monocytes from FMS patients presented similar spontaneous release of IL-1β and IL-6 to that of healthy controls and a reduction in C-reactive protein, showing that aquatic exercise might exert anti-inflammatory effects.

## Current perspectives

A considerable amount of evidence[27] has shown that water therapy improves pain, fatigue, and quality of life. However, current recommendations for the management of fibromyalgia elaborated by the European League Against Rheumatism[18] suggest a "weak for" recommendation, implying that most therapists would, although a substantial minority would not, recommend water therapy for FMS patients. This recommendation underlies the small amount of evidence suggesting superiority of water therapy over land-based therapies.[141]

Therefore, future studies should focus on the possible mechanisms explaining the beneficial effects of water therapy in order to elucidate whether they are similar or not to the mechanisms leading to the improvement of symptoms and quality of life promoted by land-based exercises. Moreover, studies should also compare the detraining effects or long-lasting effects promoted by water therapy and land-based exercises since these have been addressed only by a few studies and the results are controversial. A recent study[54] showed that 16 weeks of aquatic exercise therapy was effective in improving aerobic capacity and symptomatology such as pain, quality of life, and fatigue in FMS patients. However, after 16 weeks of detraining, all variables returned to near baseline. Thus, elucidating whether this is comparable to land-based exercises would assist FMS patients and therapists on the proper therapeutic approach recommendation and selection.

Another noteworthy point to be mentioned regards the FMS patient's adherence to treatment and engagement with aftercare tasks in the long term.[86] Coupled with the fact that pharmacological interventions seem to be ineffective, as they seldom induce minimally important clinical differences in pain after 3 months of therapy,[142,143] this makes the development of treatments that benefit patients over their lifetime extremely challenging. Hence, a multidisciplinary approach and educational strategies may be helpful additions to physical treatment, in this case, water therapy; these strategies show the importance of continuing with treatment, that the disease may vary in intensity over the time, and, more importantly, that they have to take responsibility for their healthcare and habits that influence on FMS symptoms, giving them tools to help with daily FMS management. Water therapy, in this context, comes as an alternative that makes movement easier and may increase compliance with the treatment.

Another topic to be discussed is the cost-effectiveness of water therapy for FMS. One previous study[11] has shown that adding water therapy to the usual care for FMS patients is cost-effective for both healthcare and societal costs. The authors also concluded that the characteristics of facilities (distance from patients' homes and the number of patients who can participate per session) are major determinants that have to be considered before a health manager decides to invest in such a program. Therefore, this point should be addressed in future studies that aim to elucidate whether the cost-effectiveness differs among other kinds of interventions. Studies involving cost-effectiveness may also be helpful in guiding the development of public policies for the healthcare of FMS patients, and, as such, are much needed.

The present study has some limitations, as it is not a systematic review. As such, performance of a metaanalysis was not possible. As a narrative review, the scope of the present study was to highlight and discuss the possible mechanisms involved in the improvement of pain for FMS patients who undergo water therapy. Nonetheless, this discussion is still difficult as the protocols described vary in duration, session length, and techniques used into the swimming pool, as well as the outcomes chosen; also, several outcomes are not sufficiently described.

## Conclusion

Water therapy may be recommended as a nonpharmacologic therapeutic approach for the management of FMS patients, improving pain, fatigue, and quality of life; these therapeutic effects are achieved by the physiological changes caused by in-water exercising. However, future studies should be conducted in order to clarify the action mechanisms and whether long-lasting effects are superior to other types of intervention, especially land-based exercises.

## Disclosure

The authors declare no conflicts of interest in this work.

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