



## Effectiveness of aquatic therapy on physical functional impairment in knee osteoarthritis: a meta-analysis study

*Eficacia de la terapia acuática en el deterioro funcional físico de la osteoartritis de rodilla: un estudio de metaanálisis*

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### Abstract

**Introduction:** Pain, reduced range of motion, and limited physical function are clinical signs of osteoarthritis (OA), a consequence of joint cartilage damage. OA is one of the main causes of disorders in older people. OA becomes more common with increasing age and a sedentary lifestyle. Aquatic therapy utilizes the physical properties of water.

**Objective:** This study compared the effects of aquatic therapy and land-based physiotherapy activities on osteoarthritis patients' pain, joint stiffness, range of motion, and reduced physical function.

**Methodology:** The study employed a meta-analysis, organized according to the PICO model framework. Articles were obtained from ScienceDirect and PubMed databases using keywords such as "aquatic therapy" OR "water exercises" OR "hydrotherapy" AND 'osteoarthritis' AND "randomized controlled trial". The data was examined using Review Manager 5.3.

**Results:** This meta-analysis study comprised eight articles and 423 samples from various countries. In individuals with osteoarthritis, aquatic therapy was found to significantly improve joint stiffness (SMD = -0.39; 95% CI = -0.77 to -0.01; p=0.05) and pain levels (SMD = -0.61; 95% CI = -0.85 to -0.36; p<0.001). Joint range of motion can also be increased by aquatic therapy (SMD = 0.26; 95% CI = -0.19 to -0.72; p=0.25), and physical function in patients with osteoarthritis (SMD = -0.23; 95% CI = -0.78 to -0.33; p=0.42).

**Discussion:** This meta-analysis is consistent with previous research, where water therapy has an improving effect on impaired physical function.

**Conclusion:** Compared with land-based physiotherapy exercises, aquatic therapy helps osteoarthritis patients overcome impaired physical function.

### Keywords

Aquatic therapy; hydrotherapy; joint pain; joint stiffness; osteoarthritis.

### Resumen

**Introducción:** El dolor, la reducción del rango de movimiento y la limitación de la función física son signos clínicos de la osteoartritis (OA), consecuencia del daño del cartílago articular. La OA es una de las principales causas de trastornos en personas mayores. La OA se vuelve más común con la edad y un estilo de vida sedentario. La terapia acuática aprovecha las propiedades físicas del agua.

**Objetivo:** Este estudio comparó los efectos de la terapia acuática y las actividades de fisioterapia en tierra sobre el dolor, la rigidez articular, el rango de movimiento y la reducción de la función física en pacientes con osteoartritis.

**Metodología:** El estudio empleó un metanálisis, organizado según el modelo PICO. Los artículos se obtuvieron de las bases de datos ScienceDirect y PubMed utilizando palabras clave como "terapia acuática" o "ejercicios acuáticos" o "hidroterapia" y "osteoartritis" y "ensayo controlado aleatorio". Los datos se analizaron con Review Manager 5.3.

**Resultados:** Este metanálisis incluyó ocho artículos y 423 muestras de varios países. En personas con osteoartritis, se observó que la terapia acuática mejoraba significativamente la rigidez articular (DME = -0,39; IC del 95 % = -0,77 a -0,01; p = 0,05) y los niveles de dolor (DME = -0,61; IC del 95 % = -0,85 a -0,36; p < 0,001). La terapia acuática también puede aumentar la amplitud de movimiento articular (DME = 0,26; IC del 95 % = -0,19 a -0,72; p = 0,25) y la función física en pacientes con osteoartritis (DME = -0,23; IC del 95 % = -0,78 a -0,33; p = 0,42).

**Discusión:** Este metanálisis concuerda con investigaciones previas, donde la terapia acuática tiene un efecto mejorador sobre el deterioro de la función física.

**Conclusión:** En comparación con los ejercicios de fisioterapia en tierra, la terapia acuática ayuda a los pacientes con osteoartritis a superar el deterioro de la función física.

### Palabras clave

Dolor articular; hidroterapia; osteoartritis; rigidez articular; terapia acuática

## Introduction

A frequent degenerative joint condition among the elderly is osteoarthritis, or OA for short, characterized by progressive damage to joint cartilage (Sudaryanto et al., 2023). Patients with OA typically experience pain and stiffness in the joints, resulting in decreased physical function and a decrease in joint range of motion (ROM), making it difficult to perform daily activities and engage in social interactions (Awal et al., 2023; Masyitah et al., 2024).

The prevalence of musculoskeletal disability due to OA worldwide continues to increase along with increasing life expectancy, which can lead to a decreased quality of life and place a financial and social burden on the healthcare system (Isfawati, 2025). OA treatment is symptomatic, involving both pharmacological and non-pharmacological interventions. OA management aims to control inflammation, reduce pain, maintain or restore joint function, improve mobility, prevent disability, and achieve optimal quality of life (Arfianti, 2025; Beverly, M; Murray, 2023).

Non-pharmacological interventions in the form of structured and measured physical exercise are a key component in the treatment of OA. Physical exercise has been proven to provide significant benefits for OA patients, one of which is in the form of aquatic therapy (Khruakhorn & Chiwarakranon, 2021). Aquatic therapy is an exercise therapy performed in water, utilizing the physical properties of water, such as resistance, temperature, buoyancy, viscosity, and hydrostatic pressure. These physical properties of water can reduce pressure on the joints and facilitate body movement without exacerbating pain (Slouma et al., 2024).

According to earlier research, water therapy helps lessen pain and stiffness in the joints, thereby increasing the range of motion of the joints and enabling joints to operate at their best (Assar et al., 2020b; Munukka et al., 2020a). However, the findings of these studies differ, necessitating further research to systematically evaluate the effectiveness of aquatic therapy on key clinical parameters, namely pain, joint stiffness, and range of motion. This meta-analysis and systematic review are essential for obtaining robust scientific evidence as a basis for developing more effective, efficient, and evidence-based rehabilitation programs for OA patients.

## Method

### Participants

The PICO model framework was utilized in the formulation of this meta-analysis and comprehensive review study. Population (P) refers to patients with osteoarthritis. Intervention (I) refers to aquatic therapy. Comparison (C) refers to physical therapy in the form of land-based exercises. Outcome (O) refers to physical function, range of motion, joint stiffness, and pain.

### Procedure

Articles were retrieved from the ScienceDirect and PubMed databases using the keywords “aquatic therapy” OR “water exercises” OR “hydrotherapy” AND ‘osteoarthritis’ AND “randomized controlled trial”. Full-text publications, English-language publications, and randomized controlled trial (RCT) study designs are requirements for inclusion, publications from 2011 to 2025, and reporting of mean values and standard deviation (SD). Exclusion criteria: articles where the control group didn't perform exercises.

The use of water therapy is the independent variable. Pain is one of the dependent variables, along with joint stiffness and physical function, which affect range of motion in people with knee osteoarthritis. Water exercise at temperatures between 32°C and 34°C, with an intensity of exercise 3 times a week, for 20-45 minutes, with a focus on strengthening movements, increasing joint range of motion, and water walking, which utilizes water quality to improve body function and quality of life, is known as water therapy. Pain is an unpleasant emotional and sensory experience brought on by OA that happens when joints are used for activities or when they are at rest. Joint stiffness is a condition in which joints feel stiff and difficult to move as a result of OA. The greatest range of motion a joint can achieve in a single movement cycle is known as joint range of motion, influenced by the bone structure and surrounding

tissues of the joint. Physical function is the body's ability to perform daily physical activities with osteoarthritis.

This meta-analysis study began by formulating the PICO as a reference for searching for primary study articles from the Science Direct and PubMed databases. Using a critical assessment checklist, the research quality in the primary studies was then evaluated. The assessment of primary study quality indicators was conducted using the criteria for evaluating randomized controlled trials developed by JBI (Joanna Briggs Institute).

### Data analysis

After identifying articles that met the PICO and inclusion criteria, the Review Manager 5.3 application was used to evaluate the data, which were gathered in compliance with the Preferred Reporting Items for Meta-Analyses and Systematic Reviews (PRISMA) diagram. The synthesized data results, including the standardized mean difference (SMD) and heterogeneity consensus (I2) values, were translated and summarized as the findings of this meta-analysis.

## Results

This meta-analysis study consisted of nine articles with a total sample size of 423. The primary study articles came from various continents, namely Asia, consisting of South Korea, Turkey, Iran, and Thailand; Europe, consisting of Germany and Finland; North America, consisting of the United States; South America, consisting of Brazil; and Africa, consisting of Tunisia.

Figure 1. Identification of studies via databases

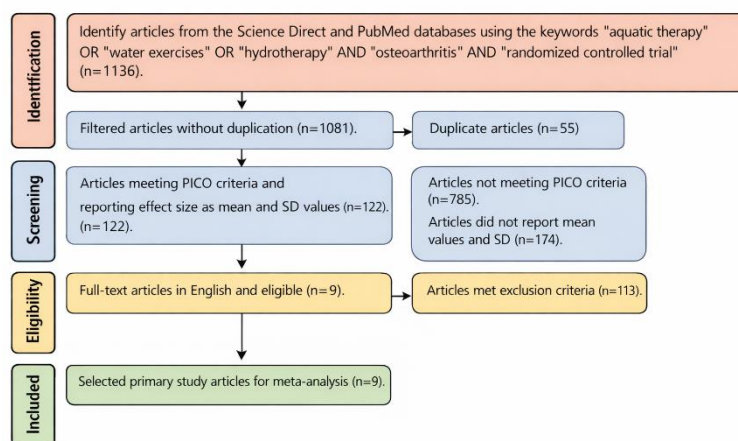


Table 1. Description of PICO Primary Study (n= 423)

Author (Year)	Country (Sample Size)	Population	Intervention	Comparison	Outcome			
					Pain	Joint Stiffness	ROM	Physical Function
Kim et al., (2012)	South Korea (n= 70)	OA	Aquaerobic; 60 minutes/session; 3 sessions/week for a duration of 12 weeks.	Aerobic exercises: 60 minutes/session; 3 sessions every week for a total of twelve weeks.	VAS			
Roper et al. (2013)	United State (n= 14)	OA	Treadmill in water; 3 sessions/week for 3 weeks.	Treadmill on land 3 sessions/week for 3 weeks.	VAS			
Schencking et al. (2013)	Jerman (n= 20)	OA Hip Joint dan OA Knee Joint	Hydrotherapy: 30 minutes/session, 3 sessions/week for ten weeks.	Land-based exercises: 30 minutes/session; 3 weekly sessions for ten weeks.	VAS		ISOM	SF-36



Dias et al. (2017)	Brazil (n= 65)	OA Knee Joint	Hydrotherapy: 2 sessions/week for six weeks.	Land-based exercises; 2 sessions per week for six weeks.	WOMAC			WOMAC
Kunduracilar et al. (2018)	Turkey (n= 89)	OA Knee Joint	Aquatic exercise 45-60 minutes/session; 5 sessions/week for 3 weeks	Land-based exercises: 45-60 minutes/session, 5 sessions/week for 3 weeks.	VAS and WOMAC	WOMAC		WOMAC
Assar et al. (2020)	Iran (n= 24)	OA Knee Joint	Aquatic exercise: 3 sessions/week for eight weeks.	Land-based exercises: 3 sessions per week for eight weeks.	VAS		ISOM	
Munukka et al., (2020)	Finland (n= 47)	OA Knee Joint	Resistance training in water: 1 hour/session; 3 sessions/week for 16 weeks.	Resistance training on land: 1 hour/session; 3 sessions/week for 16 weeks.	WOMAC	WOMAC		WOMAC dan SF-36
Khruakhorn and Chiwarakranon (2021)	Thailand (n= 34)	OA Knee Joint	Hydrotherapy: 45-60 minutes/session; 3 sessions/week for six weeks.	Land-based exercises: 45-60 minutes/session; 3 sessions per week for six weeks.	WOMAC	WOMAC		WOMAC
Slouma et al., (2024)	Tunisia (n= 60)	OA Knee Joint	Aquatic exercise: 3 sessions/week for eight weeks.	Land-based exercises: 3 sessions per week for eight weeks.	WOMAC dan VAS	WOMAC	ISOM	WOMAC dan SF-12

WOMAC= Western Ontario and McMaster Universities Osteoarthritis Index; VAS = Visual analogue Scale; ISOM= International Society of Osteoarthritis Management; SF = short form; ROM= range of motion

Figure 2. Primary study distribution map



### ***Aquatic Therapy for Pain in Osteoarthritis***

The findings of this RCT study's meta-analysis indicate a reduction in pain among OA patients following aquatic therapy of 0,61 units compared to those undergoing land-based physical therapy (SMD = -0,61; Statistical significance was achieved by both of these outcomes ( $p < 0,001$ ), with a 95% CI of -0,85 to -0,36. Data heterogeneity analyzed using a random-effects model yielded an I-squared ( $I^2$ ) value of 60%.

The funnel plot suggests that there may be publication bias because the meta-analysis's distribution of impact estimates from the main RCT studies is concentrated further to the right of the vertical average estimate line than to the left. Unlike where the diamond form is located in the forest plot, this publication bias typically lies on the right side of the vertical average line; hence, it is referred to as overestimation. The real impact of aquatic therapy on OA patients' pain tends to be amplified by this publication bias.

### ***Aquatic Therapy for Joint Stiffness in Osteoarthritis***

This RCT study's meta-analysis revealed that OA patients' joint stiffness has decreased. After aquatic therapy of 0.39 units compared to those who underwent physical therapy with land-based exercises (95% CI = -0,77 to -0,01; SMD = -0,39), and  $p = 0,05$  indicated that the findings were statistically significant. Data heterogeneity analyzed using a random-effects model showed an I-squared ( $I^2$ ) value of 64%.

The funnel plot suggests that there may be publication bias because the RCT meta-analysis's impact estimate distribution from the primary studies is concentrated further to the right of the vertical average estimate line than to the left. In contrast to the orientation of the diamond shape in the forest plot, this publishing bias typically lies to the right of the vertical average line, thus indicating an overestimate.

The true impact of water therapy on OA patients' decreased joint stiffness is often overestimated due to publication bias.

### ***Aquatic Therapy for Osteoarthritis Joint Range of Motion***

The meta-analysis of this RCT study's results indicates that OA patients' joint range of motion has increased following aquatic therapy of 0,26 units compared to those undergoing land-based physical therapy (SMD = 0,26;  $p = 0,25$ ). Nevertheless, this outcome lacked statistical significance (95% CI = -0,19 to 0,72). Data heterogeneity using the random-effects model showed an I-squared ( $I^2$ ) value of 63%.

The funnel plot indicates that there appears to be publication bias, as in this RCT meta-analysis, the distribution of impact estimates from the primary studies is concentrated further to the right of the vertical average estimate line than to the left. Similar to the diamond shape in the forest plot, this publishing bias typically lies on the right side of the vertical average line and is therefore considered an underestimate. The true impact of water therapy on increasing the range of motion in OA patients is often understated by this publication bias.

### ***Aquatic Therapy for Physical Function in Osteoarthritis***

The findings of this RCT study's meta-analysis show an improvement in physical function in OA patients following aquatic therapy of 0,23 units compared to those undergoing land-based physical therapy (SMD = -0,23). Nevertheless, this result was not significant in terms of statistics ( $p = 0,42$ ; 95% CI = -0,78 to -0,33). Data heterogeneity analyzed using a random-effects model showed an I-squared ( $I^2$ ) value of 90%.

The funnel plot indicates there may be publication bias present because in this RCT meta-analysis, the impact estimates from the primary studies are distributed more to the right of the vertical average estimate line than to the left. In contrast to the forest plot's diamond shape's location, this publication bias typically lies on the right side of the vertical average line, thus indicating an overestimate. The true impact of water therapy on enhancing physical function in OA patients is often overestimated due to publication bias.

Table 2. Effect Size of Aquatic Therapy on Osteoarthritis

Aquatic Therapy	SMD	95% Confidence Interval		Z	$I^2$	p-value
		Lower	Upper			
Pain	-0.61	-0.85	-0.36	4.27	60%	<0.001*
Joint Stiffness	-0.39	-0.77	-0.01	1.99	64%	0.05*
Range of Motion	0.26	-0.19	0.72	1.14	63%	0.25
Physical Function	-0.23	-0.78	0.33	0.80	90%	0.42

## **Discussion**

### ***Aquatic Therapy for Pain in Osteoarthritis***

There was a significant difference in pain reduction between OA patients who received aquatic therapy and land-based physical therapy. Compared to land-based workouts, aquatic therapy has been shown to help OA patients experience less pain. The buoyancy of water can reduce the load and compressive pressure on joints (Azizi et al., 2020). Warm water temperature can provide a relaxing effect, reduce muscle tension, improve local blood flow, and reduce pain perception through nervous system modulation. Hydrostatic pressure applies even pressure to the body, helping to reduce inflammatory symptoms and edema around the joints. Water viscosity and resistance provide a safe environment and prevent the risk of injury from exercise (Ferreira et al., 2024; Kunduracilar et al., 2018). The outcomes of this meta-analysis are consistent with earlier research that showed a substantial variation in the intervention and control groups' mean pain scores. The intervention group experienced a significant decrease in pain and participated in water exercise three times a week for eight weeks, in contrast to the control group, which just got lifestyle recommendations (Azizi et al., 2020; Dias et al., 2017).

### ***Aquatic Therapy for Joint Stiffness in Osteoarthritis***



Aquatic therapy has been proven to reduce joint stiffness in OA patients compared to land-based exercises. The warm water temperature, ranging from 32-34°C, provides a relaxing effect on the tissues and muscles around the stiff joints, thereby increasing the elasticity of collagen tissues and joint capsules. Warm water also promotes optimal blood flow, enhancing oxygenation of the muscles (Alonso-Rodríguez et al., 2021). Because water is buoyant, less body weight presses against the joints, enabling OA patients to move their joints without pain. Consistent exercise movements help lubricate the joints through synovial fluid circulation, thereby improving stiffness. The viscosity and resistance of water stimulate joint mobility, improve flexibility, and reduce excessive muscle tone that causes joint stiffness. Hydrostatic pressure makes water a confident environment for OA patients to perform movements, enabling more effective joint exercises and accelerating the reduction of stiffness (Augusto Teixeira et al., 2024).

This meta-analysis supports earlier studies that found the aquatic group experienced more clinical improvement than the exercise group. The variation in joint stiffness was statistically significant. Following the second phase of rehabilitation, which covered 115 patients, the evaluation was carried out (Alonso-Rodríguez et al., 2021).

### ***Aquatic Therapy for Range of Motion of the Joint in Osteoarthritis***

The results of the analysis showed that there was no significant difference in the increase in range of motion between OA patients who received aquatic therapy and land-based physical therapy. Aquatic therapy has been proven to improve OA patients' joint range of motion compared to land-based exercises. Water's physical characteristics produce a warm, weightless, and supportive environment that facilitates optimal joint movement. Water buoyancy can reduce gravitational pressure on joints by 80–90%, depending on water depth, allowing joint movements to be performed freely, pain-free, and with minimal load, thereby helping to gradually improve flexibility and ROM (Lee & Kim, 2021). Warm water temperature can increase the elasticity of connective tissue, relax muscles, and loosen joint capsules, allowing stretching movements to be performed more optimally. Water viscosity provides balanced and safe resistance during joint movements, allowing OA patients to perform repetitive movements without overloading the joints and improving active ROM through controlled and dynamic exercises (Tedeschi et al., 2024). However, other studies have shown that the buoyancy of water causes less pressure on the joints to move, and light to moderate exercise designs to reduce pain do not provide maximum effect on increasing ROM and physical function (Augusto Teixeira et al., 2024).

This meta-analysis supports other studies that showed notable variations in range of motion scores prior to and during aquatic exercise. In contrast to exercise on land, changes in knee range of motion were dramatically lessened following a 2-week water exercise intervention (Lee & Kim, 2021).

### ***Aquatic Therapy for Physical Function in Osteoarthritis***

The results of the analysis showed that there was no significant difference in the improvement of Physical Function between OA patients who received aquatic therapy and land-based physical therapy. Aquatic therapy has been demonstrated to enhance bodily function in OA patients compared to land-based exercises. The physical properties of water allow functional exercises to be performed safely and comfortably (Ma et al., 2022). Water buoyancy reduces joint load. Water resistance enhances muscle strength and endurance, thereby improving joint function. Hydrostatic pressure facilitates body posture and improves body stability, thereby reducing the risk of injury and enhancing mobility in OA patients (Garzón Mosquera & Aragón Vargas, 2021; Lee & Kim, 2021).

The findings of this meta-analysis are consistent with research showing that aquatic therapy had a major effect on OA patients' physical function as determined by the Arthritis Index (WOMAC) of Western Ontario and McMaster Universities, and SF-36 measures. Using the SF-36, there was no discernible difference in physical function, according to the study, but a significant difference between the aquatic and non-aquatic physical treatment groups (Ma et al., 2022).

The findings of this meta-analysis indicate that aquatic therapy has a significant impact on pain, physical function, range of motion, and joint stiffness in OA patients. However, various factors play a role, including frequency, intensity, duration of therapy, and OA severity. Aquatic therapy has a reduced load impact, thus not effectively training the strength and coordination components that are crucial for improving physical function. Variability in individual response is also an important consideration in designing



more personalized and adaptive therapy programs. This study did not analyze exercise dosage, as the type, frequency, duration, and intensity of exercise will influence the effectiveness of therapy. These limitations of this meta-analysis are expected to be considered for future research (Montoya Gonzalez et al., 2022).

## Conclusions

A meta-analysis of nine trials with 423 individuals in total from various countries concluded that the reduction of joint pain and stiffness by water therapy is statistically significant in osteoarthritis patients, compared to land-based physiotherapy exercises. Aquatic therapy also showed potential in improving joint range of motion and physical function compared to land-based physiotherapy exercises, although these differences were not statistically significant.

Therefore, aquatic therapy can be considered a beneficial non-pharmacological intervention in the management of osteoarthritis. Furthermore, aquatic therapy can also be used as an alternative to physiotherapy interventions for OA.

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