Meta-Analysis the Effect of Aquatic Therapy on Functional Ability in Patients with Knee Osteoarthritis

Wita Hana Puspita\textsuperscript{1)}, Didik Gunawan Tamtomo\textsuperscript{2)}, Hanung Prasetya\textsuperscript{3)}

\textsuperscript{1)}Masters Program in Public Health, Universitas Sebelas Maret
\textsuperscript{2)}Faculty of Medicine, Universitas Sebelas Maret
\textsuperscript{3)}Department of Acupuncture, Health Polytechnics, Ministry of Health Surakarta

	extbf{ABSTRACT}

\textbf{Background:} Knee OA can affect mobility in the elderly causing pain and impaired functional ability. This study aims to analyze the effect of aquatic therapy on functional ability in knee osteoarthritis patients based on the results of a number of previous primary studies.

\textbf{Subject and Method:} This study was conducted using a meta-analysis method with articles searched using the search keywords "knee osteoarthritis" OR "osteoarthritis genu" AND "aquatic therapy" OR "hydrotherapy" OR "water exercise" AND "functional ability" OR "WOMAC" AND "Randomized Controlled Trial" OR "RCT" from PubMed, google scholar and science direct and processed using RevMan 5.3.

\textbf{Results:} 9 RCT articles that fit into the inclusion criteria, with a total of 573 samples. Knee OA patients receiving aquatic therapy had a mean WOMAC score of 1.22 units lower than those without aquatic therapy, and the effect was statistically significant (SMD = -1.22; 95\% CI -2.03 to -0.41; \(p = 0.003\)). In other words, aquatic therapy is effective in improving functional ability in knee OA patients.

\textbf{Conclusion:} Aquatic therapy has an effect on increasing functional ability in knee osteoarthritis patients.

\textbf{Keywords:} Osteoarthritis, aquatic therapy, WOMAC index

\textbf{Correspondence:} Wita Hana Puspita. Masters Program in Public Health, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Email: wita.tjo408@gmail.com. Mobile: +628164837959.

\textbf{Cite this as:} Puspita WH, Tamtomo DG, Prasetya H (2022). Meta Analysis the Effect of Aquatic Therapy on Functional Ability in Patients with Knee Osteoarthritis. Indones J Med. 07(02): 138-149. https://doi.org/10.26911/theijmed.2022.07.02.03.

\textbf{BACKGROUND}

Osteoarthritis (OA) is a chronic degenerative inflammatory disease, which is characterized by changes in articular cartilage, osteophytes and subchondral bone thickening (Alcalde, 2017). Osteoarthritis is a major cause of pain and activity limitation in the elderly. Recent studies have shown that behavioral factors, neuromuscular factors, and medical factors predict the presence of pain and activity limitations in OA (Dekker, 2014). Osteoarthritis (OA) is a serious chronic disease that affects 1 in 7 adults in the United States 32.5 million people. OA is associated with aging and is more common in people with other chronic conditions, such as heart disease, diabetes, and obesity (Albright et al., 2020). In Brazil, the number of elderly people is 16\%, surpassing the figure of 34 million in 2019. Long life brings
with chronic degenerative diseases that limit the functional capacity of the affected population. OA is a chronic degenerative disease of high incidence, a musculoskeletal disorder that usually has an insidious, progressive and slow pattern, often affecting joints such as the hands, spine, hips, and knees (Garbi et al., 2021). In Indonesia, according to Riskesdas 2018, the prevalence of joint disease based on a doctor’s diagnosis at the age of 15 years, the highest data was obtained, namely 18.9% at the age of 75+, 18.6% at the age of 65-74 years, and 15.5% at the age 55-64 years and mostly suffered by women.

Apart from aging, obesity, trauma, joint surgery, hormonal imbalance, genetics, nutrition and bone density are some of the factors that cause OA (Garbi et al., 2021). Signs and symptoms of OA experienced by the population are pain throughout the day and decrease with rest, swelling and tenderness in the joints with or without crypts, morning stiffness and reduced range of motion of the joints, with decreased aerobic capacity, and muscle weakness of the lower limbs. In addition to pain and stiffness, knee OA can affect mobility in the elderly causing impaired functional ability (Garbi et al., 2021).

The management of osteoarthritis is modified based on the updated ACR guidelines in 2000. The first stage is non-pharmacological therapy by providing education, physical activity, lifestyle changes. The second stage of pharmacological therapy (better when combined with non-pharmacological therapy) uses NSAIDs/NSAIDs. The third stage is knee replacement surgery (Albright et al., 2020). Many methods of exercise and the use of electrotherapy can be used to treat these symptoms. However, this therapy requires a long time for healing and for maintenance so that the OA condition does not get worse. The main goals of exercise therapy are to reduce pain, improve function and restore the patient’s quality of life. Physiotherapy has several methods to achieve this goal, namely kinesiotherapy, manual therapy, and electrotherapy. This training method can be given on land or in water. Several studies have reported that exercise in water (aquatic therapy) has a good effect on treating symptoms caused by OA.

The findings from several studies in the field reported that exercise in water can reduce pain, improve function, and balance in patients with knee osteoarthritis (KOA) (Lu et al., 2015; Alcalde et al., 2017; Taglietti et al., 2018; Assar et al., 2020). Aquatic therapy is a source of therapy that is widely used in the treatment of rheumatism because it promotes movement and reduces joint overload. Immersion can achieve therapeutic effects in warm water, such as muscle relaxation, pain relief, and reducing pressure on joints (Garbi et al., 2021).

Aquatic therapy uses the principles of water, known as hydrodynamics, to cause physiological changes. These principles are buoyancy, density, viscosity, thermodynamics, and hydrostatic pressure which act together to give the patient a unique sensory experience to facilitate range of motion (ROM), functional strength, and balance (Aquatic, 2016). In addition, it can also improve the patient’s quality of life with the recreational and relaxing effects of exercise activities in aquatic therapy. Aquatic therapy can be given to individuals, classes, or groups. This study aims to analyze the effect of aquatic therapy on functional ability in knee osteoarthritis patients based on the results of a number of previous primary studies using a meta-analysis.
SUBJECTS AND METHOD

1. Study Design
This research was conducted using a meta-analysis research design with PRISMA flow chart guidelines. For data search, all searchable articles published before March 2022 were examined. The databases used in this search were Google Scholar, Pubmed, and ScienceDirect. Search articles using the term Mesh with the search keywords "knee osteoarthritis" OR "osteoarthritis genu" AND "aquatic therapy OR "hydrotherapy" OR "water exercise" AND "functional ability" OR "WOMAC" AND “Randomized Controlled Trial".

2. Inclusion Criteria
Inclusion criteria 1) full paper article using a Randomized Control Trial (RCT) study design, 2) The size of the relationship used is Mean SD, 3) Research subjects are patients with knee osteoarthritis, 4) The intervention given is aquatic therapy, 5) Comparison is without therapy or other therapy, 6) The study outcome is functional ability with WOMAC score.

3. Exclusion Criteria
The exclusion criteria for this study were: 1) articles published in languages other than English and Indonesian, 2) articles before 2011.

4. Study Variables
The independent variables is aquatic therapy and the dependent variable is functional ability.

5. Variable Operation Definition
Aquatic therapy is a treatment and exercise performed in water for rehabilitation, fitness and relaxation (Ferguson, 2021). The forms of exercise are cardiovascular exercises, stretching exercises, strengthening exercises, walking.

Functional abilities are about abilities that enable people to be and do what they want to be (WHO, 2019). Measurement of functional ability using the WOMAC index.

6. Study Instrument
The results of the search for articles obtained from the database have been identified, then each study was assessed based on the eligibility criteria. The quality and design of the research analyzed in the meta-analysis is very important because it affects the results. Assessment of study quality using the Critical Appraisal Checklist for Randomized Controlled Trial.

7. Data Analysis
Research data were analyzed using the RevMan 5.3 application, to calculate the effect size and heterogeneity of the study. The results of data processing are presented in the form of forest plots and funnel plots.

RESULTS
The article selection process uses the PRISMA flow chart. A total of 883 articles consisting of 789 obtained from Google Scholar and 11 from Pubmed. A total of 146 articles were deleted because they were duplicate articles, leaving 737 articles. Then as many as 686 articles were issued on the grounds that the title was irrelevant, the article was not full text, was not an RCT study, and was not in English and Indonesian. The full text of the article that was declared worthy contained 51 articles. There were 13 articles eligible to be included in the qualitative synthesis, with 38 articles excluded because the outcome was not suitable. Finally, 9 articles were included in the meta-analysis (figure 1).

Primary research on the effect of aquatic therapy on the functional ability of knee osteoarthritis patients with a total of 9 studies located in America (USA), India, Thailand, Korea, Australia, Brazil, and Tunisia. Assessment of article quality using CASP for RCTs (Table 1). On average, the
research subjects were COA patients with middle age or >50 years, the provision of effective water exercise with 40-60 minutes per exercise session with various forms of exercise (Table 2).

![PRISMA Flowchart](image1)

**Figure 1. PRISMA Flowchart**

![Study Map Area Effect of Aquatic Therapy on Functional Ability in Patients with Knee Osteoarthritis](image2)

**Figure 2. Study Map Area Effect of Aquatic Therapy on Functional Ability in Patients with Knee Osteoarthritis**

Articles identified through database search (n= 883)

Duplicated articles removed (n= 146)

Filtered articles (n= 737)

Filtered decent articles (n= 51)

Articles included in the qualitative synthesis (n= 13)

Articles included in the meta-analysis (n= 9)

Records excluded (n= 686)
1. Irrelevant title= 303
2. Articles not in English= 59
3. Article not full text= 203
4. Not an RCT study= 121

Full text articles issued, with reasons (n= 38)
Article does not include Mean-SD =12
Outcome does not match= 26
Table 4. Description of Primary Studies included in Meta-analysis

| Author (year) | Country   | Design Studies | Number of Samples | Population                                                                 | Intervention                                                                 | Comparison                                                                 | Outcome                                      |
|---------------|-----------|----------------|-------------------|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------|----------------------------------------------|
| Fazaa et al. (2014) | Tunisia | RCT            | 116               | Male and Female COA patients, grade 2-3, age <75 years                     | Water temperature 36°C with 5 types of therapy: Underwater showers 15 minutes, massage jets showers 10 minutes, pool rehabilitation 20 minutes, application heat peloid 15 minutes, for 21 days. | Classical rehabilitation programs such as 30-minute pain relief electrotherapy and strengthening exercises. | Womac index results: p=0.001 significantly increased functional ability on day 21 |
| Kruakhorn et al. (2021) | Thailand | RCT            | 17                | Individuals with KOA male and female, age 45-75 years, grade 2-3             | Hydrotherapy: pool temperature 32-33°C, 45-60 minutes, 3x/week, 6 weeks, stretching, strengthening, cycling. | Land-based exercise: exercise on the mat 45-60 minutes, 3x/week, 6 weeks, stretching, strengthening, cycling. | Womac index results: p<0.01 significantly improve functional ability |
| Taglietti et al. (2018) | Brazil   | RCT            | 31                | COA patients grade 1-4, aged 60-85 years                                   | Aquatic program 60 minutes, 2x/week, for 8 weeks, temperature 32°C, depth 1.2 m, warm up 5 minutes (walking, patellar mob, stretching, leg muscle). Knee and hip isometric, and 15 minutes of dynamic exercise. Aerobic exercise 20 minutes, Step training and proprioceptive exercise 10 minutes, cooling down 10 minutes. | Educational group program                                                 | Womac index: p=0.04 significantly improved functional ability |
| Author (year) | Country | Design Studies | Number of Samples | Population | Intervention | Comparison | Outcome |
|--------------|---------|----------------|-------------------|------------|--------------|------------|---------|
| Hale et al. (2012) | Australia | RCT | 20 | 15 | Male and female COA patients, age 65 years or >55 years | Water-based exercise: depth of 1.3 meters, temperature 28°C 2x/week, 12 weeks 20-60 minutes. warm up (stretching, walk exercise, calf and toe raises) Balance exercises Cool down (Walking and stretching) | SeniorNet, a computer-based training program | Womac index: there is no significant difference |
| Naik et al. (2020) | India | RCT | 15 | 15 | Female, 45-55 years old, KOA | Underwater treadmill 10 minutes for 2 weeks Closed chain exercise on land | | Womac index: p<0.0001 significantly improve functional ability |
| Benkar et al. (2020) | India | RCT | 42 | 42 | COA patient | MWM under water, 10 moves, 3 sets MWM in land, 10 moves, 3 sets | | Womac index: p=0.94 not significant |
| Cardoso et al. (2017) | Brazil | RCT | 17 | 17 | KOA female, grade 1-2 | CKC Pool: 2 months, 3x/week Warm-up Mini squattingo - 300 degrees, Front step up and down, Lateral step up and down, Leg press, Float walking, Proprioceptive board, Frontal walking training, Lateral walking training, Backwards walking training CKC ground: 2 months, 3x/week Warm-up Mini squattingo - 300 degrees, Front step up and down, Lateral step up and down, Leg press, Float walking, Proprioceptive board, Frontal walking training, Lateral walking training, Backwards walking training | | Womac index: p<0.05 in pool group |
| Author (year) | Country | Design Studies | Number of Samples | Population | Intervention | Comparison | Outcome |
|--------------|---------|----------------|------------------|------------|--------------|------------|---------|
| Ha et al. (2018) | Korea | RCT | 9 | Middle-aged woman with KOA | Aquatic exercise program12 weeks, 3x/week 60 minutes. Preparation exercise 10 minutes (jumping, walking, stretching) Exercise underwater 40 minutes (swimming, walking, squat, lifting), Healing exercise | No therapy | Womac index: p<0.01 significantly improve functional ability |
| Kim et al. (2021) | USA | RCT | 20 | Primary COA patients, age >50 years | Aquatic Exercise Intervention: water temperature 32°C Warm up10 minutes. Joint ROM and strength20 minutes. Low intensity endurance 20 minutes. cool down10 minutes. Brochure about nutrition before surgery | | Womac index: p<0.0001 significantly improve functional ability |
Table 2. Assessment of research quality of Aquatic Therapy on Functional Ability in Patients with Knee Osteoarthritis

| No | Questions                                                                 | Cardoso et al 2012 | Fazaa et al 2014 | Khruak horn et al 2021 | Taglietti et al (2018) | Hale et al (2012) | Ha et al (2017) | Kim et al (2021) | Rise et al (2021) | Benkar et al (2019) |
|----|---------------------------------------------------------------------------|---------------------|------------------|------------------------|------------------------|-------------------|----------------|-----------------|------------------|---------------------|
| 1  | Does the experiment clearly address the clinical problem?                 | 1                   | 1                | 1                      | 1                      | 1                 | 1              | 1               | 1                | 1                   |
| 2  | Was the intervention given to the patient randomized?                     | 1                   | 1                | 1                      | 1                      | 1                 | 1              | 1               | 1                | 1                   |
| 3  | Were all patients included in the study properly accounted for in the conclusions? | 1                   | 1                | 1                      | 1                      | 1                 | 0              | 1               | 1                | 1                   |
| 4  | Are patients, health workers, and researchers blinded?                    | 1                   | 1                | 1                      | 1                      | 1                 | 1              | 1               | 1                | 1                   |
| 5  | Were the study groups similar at the start of the study?                  | 1                   | 1                | 1                      | 1                      | 1                 | 1              | 1               | 1                | 1                   |
| 6  | Outside of the intervention studied, were the study groups treated equally?| 1                   | 1                | 1                      | 1                      | 1                 | 1              | 1               | 1                | 1                   |
| 7  | Is the effect of the intervention large enough?                           | 0                   | 1                | 0                      | 1                      | 0                 | 1              | 1               | 1                | 1                   |
| 8  | How precise is the estimation of the effect of the intervention?          | 1                   | 0                | 1                      | 1                      | 1                 | 1              | 1               | 1                | 1                   |
| 9  | Do the benefits provided by the intervention outweigh the costs and disadvantages? | 1                   | 1                | 1                      | 1                      | 1                 | 1              | 1               | 1                | 1                   |
| 10 | Are the results applicable to the context of practice or local populations?| 1                   | 1                | 1                      | 1                      | 1                 | 1              | 1               | 1                | 1                   |
| 11 | Are all other clinically important outcomes considered in this article?   | 1                   | 1                | 1                      | 1                      | 1                 | 1              | 1               | 1                | 1                   |

Total score: 10 10 10 11 10 10 10 11 11 11

Answer: 1=Yes, 0=No.
Puspita et al./ The Effect of Aquatic Therapy on Functional Ability in Patients with Knee Osteoarthritis

Figure 2. Forest Plot

| Study or Subgroup | Aquatic Therapy | Non Aquatic Therapy | Std. Mean Difference | Std. Mean Difference |
|-------------------|-----------------|---------------------|----------------------|----------------------|
|                   | Mean            | SD                  | Mean                 | SD                  |
|                   | Total            |                     | Total                |                     |
|                   | IV, Random, 95% CI |                     | IV, Random, 95% CI   |                     |
| Hale 2012         | 35.5            | 11.57               | 35.4                 | 9.96                | 0.01 [-0.96, 0.68] | 2012 |
| Fascia 2014       | 31.5            | 20.7                | 11.6                 | 45.24               | -0.42 [-0.68, -0.16] | 2014 |
| Cardio 2017       | 26.81           | 14.95               | 17                   | 34.8                | -0.04 [-0.33, 0.71] | 2017 |
| Taglieri 2018     | 22.7            | 3.6                 | 31                   | 36.9                | -3.65 [-4.83, -3.06] | 2018 |
| Ha 2018           | 42.11           | 16.14               | 9                    | 50.38               | -0.46 [-1.43, 0.51] | 2018 |
| Berkus 2019       | 65.5            | 10.77               | 42                   | 65.52               | -0.00 [-0.43, 0.43] | 2019 |
| Naoi 2020         | 44.4            | 4.3                 | 15                   | 49.3                | -1.26 [-2.04, -0.48] | 2020 |
| Kim 2021          | 37.7            | 1.8                 | 20                   | 38.9                | -0.87 [-1.61, -0.13] | 2021 |
| Khraikham 2021    | 31.65           | 27.56               | 17                   | 35.76               | -0.11 [-0.79, 0.55] | 2021 |
| Total             | 237             |                     | 283                  |                     | -1.22 [-2.03, -0.41] |         |
| Heterogeneity: Tau^2 = 1.39; Chi^2 = 128.48; df = 8 (P < 0.00001); I^2 = 94% |
| Test for overall effect: Z = 2.94 (P = 0.003) |

Figure 3. Funnel plot

a. Forest Plot

Forest plot shows that there is an effect of aquatic therapy on functional ability in knee osteoarthritis patients. Knee OA patients receiving aquatic therapy had a mean WOMAC score of 1.22 units lower than those without aquatic therapy, and the effect was statistically significant (SMD = -1.22; 95% CI -2.03 to -0.41; p = 0.003). In other words, aquatic therapy is effective in improving functional ability in knee OA patients (Figure 2).

The forest plot also shows the heterogeneity of the estimated effect between studies in this meta-analysis (I^2 = 94%; p <0.001). Thus, the calculation of the average estimated effect of aquatic therapy from all
studies in this meta-analysis uses the random effects model (REM approach).

**b. Funnel plot**
The funnel plot in Figure 2 shows the asymmetric distribution of the effect estimates to the right and left of the mean vertical line of the effect estimates. The estimated effect is more visible to the right of the vertical line than to the left. So the funnel plot indicates that there is publication bias. Due to the tendency of the distribution of effect estimates to the right of the estimated mean vertical line in the opposite direction to the effect estimation average diamond to the left of the null hypothesis vertical line on the funnel plot, the publication's bias indicates a tendency to underestimate the effect of aquatic therapy.

**DISCUSSION**
These results are in accordance with the meta-analysis of Waller et al., (2014) showing that Therapeutic Aquatic Exercise is effective in managing symptoms associated with lower extremity OA. Another study stated that there was an effect of hydrotherapy exercise on pain intensity and functional ability in knee OA patients (Amelia et al., 2020).

Aquatic therapy interventions such as treadmill exercise in water, swimming, and other exercises have been reported in men to increase cardiovascular endurance, increase muscle strength, reduce leg swelling, increase joint range of motion, reduce mechanical stress on the extremities. King et al., (2012). The increased resistance and buoyancy inherent in aquatic exercise improve joint stability and reduce stress on muscles and joints. Immersion of the lower extremities, causes circumferential compression, which increases in proportion to the depth of the water. Increased extravascular hydrostatic pressure improves circulation and reduces edema.

Hydrotherapy can also help reduce pain through the effects of temperature. Immersion in warm water causes vasodilation, increased circulation and decreased muscle spasm, whereas cold water reduces inflammation by restricting blood flow and reducing the accumulation of inflammatory mediators. Aquatic therapy is a versatile treatment modality capable of producing a wide range of therapeutic effects and is therefore considered an effective method for the rehabilitation of individuals with OA (King et al., 2012).

Another study showing that aquatic therapy has an effect on improving function is according to Dias et al., (2017) where a structured six-week hydrotherapy program led to greater improvements in pain and function in the short term compared to an educational program alone in women with knee OA. Water exercise is usually recommended in the treatment of knee OA because of the nature of water, especially its buoyancy, which has the potential to reduce joint stress. Water pressure and temperature can also lead to increased sensory input and further relief in pain relief.

Aquatic exercise has shown a beneficial effect on joint function in patients with osteoarthritis as demonstrated in a meta-analysis. Exercise, regardless of setting, can increase joint strength and range of motion leading to improved joint function. However, the incidence of osteoarthritis is high in overweight patients, and the buoyancy of water supports body weight, thereby reducing the impact on joints, this helps reduce pain and facilitates movement (Song and Oh, 2022).

This meta-analysis shows that aquatic therapy has an effect on improving functional ability in knee osteoarthritis patients. Knee osteoarthritis patients who received aquatic therapy intervention experienced a decrease in the womac scale (function
limitation scale) thereby increasing functional ability.

**AUTHORS CONTRIBUTION**
Wita Hana Puspita is the main researcher who selects the topic, searches for, and collects research data. Didik Tamtomo and Hanung Prasetya played a role in analyzing and analyzing research data.

**FUNDING AND SPONSORSHIP**
This research was independently funded.

**ACKNOWLEDGEMENT**
We thank all those who have helped in the preparation of this article and thank the database providers Google Scholar, PubMed, Science Direct.

**CONFLICT OF INTEREST**
The study was conducted without any commercial or financial relationship that could be construed as a potential conflict of interest.

**REFERENCE**
Albright A, Ambrose K. R, Callahan L.F, Golightly Y (2020). A national public health agenda for osteoarthritis: 2020 Update. Arthritis Foundation: 124–127. doi: 10.4135/9781412973533.n19.

Alcalde GE, Fonseca AC, Boscoa TF, Goncalves MR, Bernardo GC, Piana B, Carnavale BF, et al. (2017a). Effect of aquatic physical therapy on pain perception, functional capacity and quality of life in older people with knee osteoarthritis: Study protocol for a randomized controlled trial. Trials. 18(1): 317. doi: 10.1186/s13063-017-2061-X.

Amelia AT, Fatimah N, Dwuwulantari MD (2020). The effect of hydrotherapy exercise on pain intensity and functional ability in genu osteoarthritis patients. Arc Med Res. 1(2): 26–33. doi: 10.37275/ehi.v1i2.6.

Assar S, Gandomi F, Mozafari M, Sohaili F (2020). The effect of total resistance exercise vs. aquatic training on self reported knee instability, pain, and stiffness in women with knee osteoarthritis: a randomized controlled trial. BMC Sports Sci Med Rehabilitation. 12(27): 1–13. doi: 10.1186/s13102-020-00175-y

Benkar AP, Rayjade A (2019). Study on carryover effect of mulligan’s mobilization with movement under water versus land-based mulligan’s mobilization with movement on functional mobility of knee Joint. Int J Health S. 9 (8): 181-187.

Cardoso RM, Porto PHG, Burin AF, Daitx RB, Dohnert MB (2017). Ground or swimming pool exercises for women with knee osteoarthritis? A double-blind randomized clinical trial. Br J Med Med Res. 23(10): 1-13. doi: 10.9734/JAMMR/2017/36350.

Cochrane (2014). RevMan 5.3 User Guide. Copenhagen: The Nordic Cochrane Centre: 1–105.

Dekker J (2014). Exercise and physical functioning in osteoarthritis medical, neuromuscular and behavioral perspectives, Springer. Edited by J. Dekker. London: Springer. doi: 10.1007/978-1-4614-7215-5.

Fazaa A, Souabni L, Abdelghani KB, Kassab S, Chekili S, Zouari B, Hajri R, et al (2014). Comparison of the clinical effectiveness of thermal cure and rehabilitation in knee osteoarthritis. A randomized therapeutic trial. Ann Phys Rehabil Med. 57(1-9): 561-569. doi: 10.1016/j.rehab.2014.09.007

Ferguson M (2021). The effects of thermal aquatic therapy. Gardner_Webb U. doi: 10.2522/ptj.20060006.
Garbi FP, Junior PRR, Pontes N, Oliveira A, Barduzzi G, Boas PJ (2021). Aquatic physiotherapy in the functional capacity of elderly with knee osteoarthritis. Fisi Mov. 34: 1–7. doi: 10.1590/fm.-2021.34119.

Ha GC, Yoon JR, Yoo CG, Knag SJ, Ko KJ (2018). Effects of 12-week aquatic exercise on cardiorespiratory fitness, knee isokinetic function, and Western Ontario and McMaster University osteoarthritis index in patients with knee osteoarthritis women. J Exerc Rehabil. 14(5):870-876. doi: 10.12965-jer.1836308.154.

Hale A, Waters D, Herbison P (2012). A randomized controlled trial to investigate the effects of water-based exercise to improve falls risk and physical function in older adults with lower-extremity osteoarthritis. Arch Phys Med Rehabil. 93(1): 27-34. doi: 10.1016/j.apmr.2011.08.004.

Khruakhorn S, Chiwarakranon S (2021). Effects of hydrotherapy and land-based exercise on mobility and quality of life in patients with knee osteoarthritis: a randomized control trial. J Phys Ther Sci. 33: 375–383. doi: 10.1589/jpts.33.375.

Kim S, Hsu FC, Groban L, Williamson J, Messier S (2021). A pilot study of aquatic prehabilitation in adults with knee osteoarthritis undergoing total knee arthroplasty – short term outcome. BMC Musculoskelet Disord. 22: 388. doi: 10.1186/s12891-021-04253-1.

King MR, Haussler KK, Kawcak CE, Mcllwraith, Reiser RF (2012). Review article mechanisms of aquatic therapy and its potential use in managing equine osteoarthritis. Equine vet Educ: 1–7. doi: 10.1111/j.2042-3292.2012.-00389.x.

Lu M, Su Y, Zhang Y, Zhang Z, Wang W, He Z, Liu F, et al. (2015). Effectiveness of aquatic exercise for treatment of knee osteoarthritis: Systematic review and meta-analysis. Z Rheumatol. 74(6): 543–552. doi: 10.1007/s00393-014-1559-9.

Naik RP, Rathod D, Kumar A (2020). Effects of retro-walking underwater treadmill training on pain, functional performance & functional mobility in patients with knee osteoarthritis. Int J Physiother Res. 8(5):80–85. doi: 10.16965/ijpr.2020.154.

Song J, Oh J (2022). Effects of aquatic exercises for patients with osteoarthritis: Systematic review with meta-analysis. healthcare. 10(3): 560. doi: 10.3390/HEALTHCARE10030560.

Taglietti M, Facci LM, Trelha CS, Melo FC, Silva DW, Sawczuk G, Ruivo TM, et al. (2018). Effectiveness of aquatic exercises compared to patient-education on health status in individuals with knee osteoarthritis: a randomized controlled trial. Clin Rehabil. 32(6): 766–776. doi: 10.1177/0269215517754240.

Waller B, Slodownik A.O, Vitor M, Lambeck J, Daly D, Kujala U.M, Heinonen A (2014). Effect of therapeutic aquatic exercise on symptoms and function associated with lower limb osteoarthritis: systematic review with meta-analysis. Phys Ther. 94(10): 1383–1395. doi: 10.2522/ptj.20130417.