The Effectiveness of Aquatic Exercise in Reducing Pain and Improving Muscles Strength in Knee Osteoarthritis Patient: A Systematic Review and Meta-Analysis

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Abstract

Background: Knee osteoarthritis is a degenerative joint disease as the result of wear and tear of joint and progressive loss of cartilage. It affects functional ability in the elderly who manifested with pain upon movement, morning stiffness, reduction of range of movement and joint enlargement. There are numerous conservative treatment options available such as pharmacological management, knee bracing, cryotherapy, activity modification, exercises, or interventional procedures. Of all, it was believed that conventional physical therapy with exercises by stretching and strengthening of muscles, balance training, activity modification for daily tasks are vital to reduce pain and improve joint function. However, therapeutic interventions with aquatic exercise may be helpful for OA knee patients as various evidence suggest that hydrotherapy is beneficial if the pain level is very high and analgesia is not tolerated. Moreover, it can be useful to build up strength and reduce stiffness around the knee joint in a non-weight-bearing position.

Objective: The study aims to compare the effectiveness of aquatic exercise to conventional physical therapy in reducing pain and improving muscle strength.

Methods: A systematic review of all randomised controlled trials (RCTS) articles related to aquatic exercises and subjects inflicted with knee osteoarthritis. The search covered from January 2003 to September 2022 from 10 database (i.e., CINAHL, PubMed, PubMed Central, COCHRANE Library, Google scholar, Clinical key, EMBASE, PEDro, SCIELO and LILACS). All studies contain information regarding the effectiveness of aquatic exercise towards pain and muscle strength for knee osteoarthritis subjects.

Results: After removing duplicates, there are a total of 448 studies left out of 1054 selected studies. 439 studies were left after 9 studies were eliminated for writing in languages other than English. Following the exclusion of 374 papers for failing to meet the inclusion criteria and those without complete articles, 65 studies were left after a review of the titles and abstracts. Finally, 30 studies that satisfied the required inclusion criteria for this study were chosen, and 35 studies were eliminated since they were different sorts of studies, such systematic reviews and meta analyses. Further examination resulted in the inclusion of 7 studies that satisfy the requirements, and the exclusion of 23 studies. The outcomes of the relevant studies demonstrated that aquatic exercise benefits older people with osteoarthritis of the knee. Aquatic exercise can also be utilised as an alternate strategy for older patients with knee osteoarthritis, according to the studies examined. However, there is no discernible difference between aquatic exercise and regular physical activity in terms of pain reduction and boosting muscle strength, after a thorough investigation and meta-analysis.

Conclusion: This study concluded that aquatic exercises including group aquatic physical exercise, aquatic swimming, aquatic resistance exercise and aquatic intervention in the form of foundation aquatics program (AFAP) can be used in reducing osteoarthritis pain and improving muscle strength. Overall studies have proven that aquatic exercise is effective or has similar results compared to land-based exercise, hence, can be used as an alternative intervention when dealing with knee osteoarthritis with therapeutic interventions.

Keywords: Aquatic therapy, and-based exercises, physical therapy, pain, muscle strengths.

1. Introduction

Osteoarthritis (OA) is a common joint disorder that frequently affects the joints among middle-aged and elderly people. About 10% of the global population aged over 65 years with OA present with (OA) symptoms of joint pain, tenderness, and limitation of movement (Dias et al., 2016). Knee Osteoarthritis (OA) is the most prevalent type of osteoarthritis disease affecting the knee. It is the degenerative changes of the knee due to wear-and-tear of joints and cartilage. In particular, the cartilage in the knee slowly wears and breaks and the protective gap between the bones shrinks, causing bone grinding and the formation of painful bone spurs which can be seen on X-rays. It causes alterations in the bone and connective tissue degradation, as well as inflammation of the joint lining. The anteromedial side of the knee is commonly affected. There is no cure to this degenerative disorder. However, there are numerous conservative treatment available to slow down the progression rate such as pharmacological management, physical therapy, brace or other interventional procedures including surgery. The well-known physiotherapy treatment option is exercise therapy. Of all the exercise modalities, land-based exercise therapy is highly recommended, as it can improve strength, relieve pain, reduce stiffness, and improve physical function. Nevertheless, the drawback is the pain during exercise that may discourages patients from performing extra exercise. Further, it is difficult for patients to commit to a long-term exercise program. Therefore, it is important to seek for alternative treatment options for patients with knee OA. Aquatic exercise seems to be a good alternative treatment for OA knee. It refers to exercise performed in water and has been used in the treatment of disease or maintaining health for more than 18 years. The most important physical properties of water are buoyancy, hydrostatic pressure and water resistance. Firstly, hydrostatic pressure facilitates blood circulation, relieves muscle spasm and fatigue. Secondly, water resistance acts in opposite directions to body motion, helps in enhancing muscular strengthening because greater muscle activity is needed. Thirdly, water buoyancy reduces weight bearing stress on joints, bones, and muscles. Hence, aquatic exercise allows patients to perform exercises with greater weight bearing without feeling much stress and pain. The past reviews had focus on short-term effect of hydrotherapy on pain, disability and quality of life but none were concerned about the water-based therapy in long-term muscular strengthening (Dong et al., 2018). Hence, the purpose of this systematic review and meta-analysis is to compare effectiveness of aquatic exercise versus land based conventional exercise in improving muscle strength, and relieving pain of patients with knee osteoarthritis. Exercises including stretching and strengthening of muscles, balance training, and braces are vital to reduce pain and improve joint function. Besides conventional physical therapy, other therapeutic interventions such as aquatic exercise may be helpful. Various degrees of evidence suggest that aquatic exercise is helpful if the pain level is very high and analgesia is not tolerated. Moreover, it can be useful to build up strength and reduce stiffness around the knee joint in a non-weight-bearing position

2. Methods

Systematic review and meta-analysis were performed.

2.1 Search Strategy

Three independent researchers undertook a computerised literature search through 10 electronic databases: CINAHL, PubMed, PubMed Central, COCHRANE Library, Google scholar, Clinical key, EMBASE, PEDro, SCIELO and LILACS by using different key terms that have been identified using the PICO model as shown below :

Table 1: PICO model

Patient with knee osteoarthritis	**P**	Patient with knee osteoarthritis
Aquatic exercise	**I**	Landed physical Exercise
Conventional Physical exercise	**C**	Conventional Physical exercise
Pain Intensity	**O**	Pain Intensity

2.2 Selection Criteria

2.2.1 Inclusion Criteria

- Middle aged 45 and above.
- Randomised Control Trial study
- Male and female elderly.
- Knee Osteoarthritis.
- Experiences knee pain
- Not undergone lower-limb joint replacement surgery
- No history of recent trauma in lower-limbs
- Independent ambulation

2.2.2 Exclusion Criteria

- Patients who are diagnosed other than knee osteoarthritis such as cardiovascular disease, rheumatoid arthritis, visual impairment.
- Fearful of water
- Communication impairment.
- Inability to safely enter and exit the pool

2.3 Data Extraction

Each included study's data were independently gathered by three researchers. Retrieve, synthesise, and evaluate the literature or articles you've chosen that are pertinent to your study question. For each author, the full text article was corrected, the details of the title and abstract were read, the excluded studies were compared to the included ones, and any discrepancies were handled by consensual discussion.

2.4 Data Analysis

Three researchers analysed and compared the data from each experimental investigation. Table forms were used to compare and interpret the findings and conclusions of the investigations. The conclusion of this systematic review includes a summary of the findings, and the discussion includes additional recommendations.

3. Results

A total of 1054 are screened from the following databases : CINAHL, PubMed, PubMed Central, COCHRANE Library, Google scholar, Clinical key, EMBASE, PEDro, SCIELO and LILACS. After removing duplicates, there are a total of 448 studies left. A total of 9 studies were eliminated for writing in languages other than English, such as Spanish, Arabic, and Korean. Following the exclusion of 374 papers for failing to meet the inclusion criteria and those without complete articles, 65 studies were left after a review of the titles and abstracts. Finally, 30 studies that satisfied the required inclusion criteria for this study were chosen, and 35 studies will be eliminated since they were different sorts of studies, such systematic reviews and meta analyses. Further exclusion of 23 studies after the full-text screening for reason : no primary outcome, PEDro scale less than 7/10, no intervention control group, or comparison group. Finally, 7 studies that satisfy the requirements were included upon further analysis.

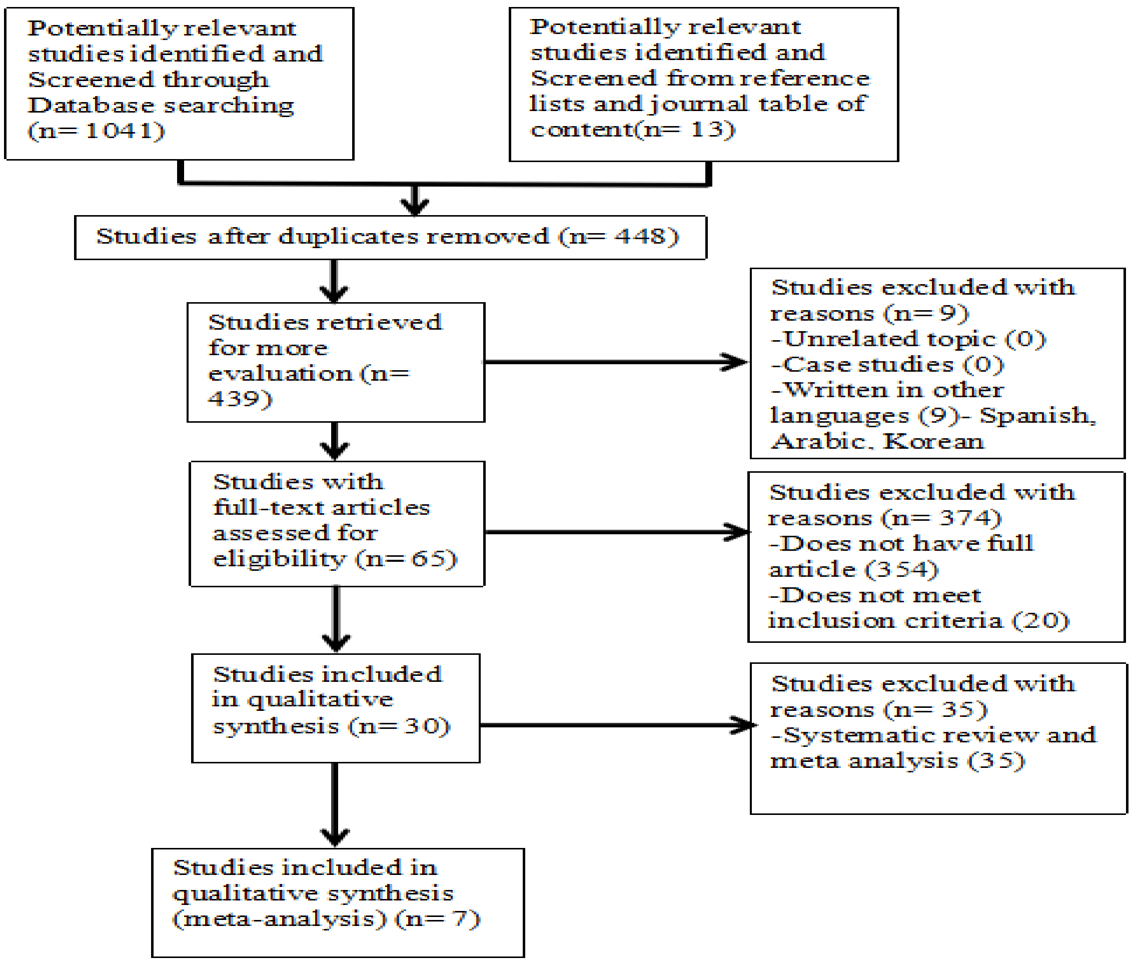


Figure 1: Prisma Flow Diagram

3.2 Qualitative Evaluation of Clinical Trials

The quality assessment of the 7 trials used in this study is shown in the table below. The magnitude of the scale was between 7 to 8, with an average score of 7.43. In 7 articles, the criterion is provided, and there is a list of criteria used to determine the participants in the study. In 5 articles, the allocation of the participants was concealed. In 7 articles, the groups are similar at baseline. In all 7 articles, the reports explain at least one outcome measurement at baseline and at least one measure of the severity of the condition being treated. All articles, subject blinding and therapist blinding do not exist. Only 1 article has more than 15 % drop out. Only one article does not have intention-to-treat analysis. Table below shows the finalised studies included in qualitative synthesis.

Table 2: Assessment of Quality study of PEDro Scale.

Author	Pedro analysis	Eligibility criteria were specified	Random allocation	Concealed allocation	Group similar at baseline	Subject blinding	Therapist blinding	Assessor blinding	Less than 15% drop out	Intention-to-treat analysis	Between group statistical comparison	Point measure and variable data
(Lund et al.,2008)	8/10	yes	yes	yes	yes	no	no	yes	yes	yes	yes	yes
(Alkatan et al., 2016)	7/10	yes	yes	yes	yes	no	no	yes	no	yes	yes	yes
(Foley, A et al.,2003)	8/10	yes	yes	yes	yes	no	no	yes	yes	yes	yes	yes
(Hinman et al., 2007)	8/10	yes	yes	yes	yes	no	no	yes	yes	yes	yes	yes

(Lim et al., 2010)	7/10	yes	yes	no	yes	no	no	yes	yes	yes	yes	yes
(Wang et al., 2011)	7/10	yes	yes	no	yes	no	no	yes	yes	yes	yes	yes
(Assar et al., 2020)	7/10	yes	yes	yes	yes	no	no	yes	yes	no	yes	yes

At first, 79 patients with knee pain and knee osteoarthritis mean aged 68 years old were studied in a randomised controlled trial by Lund et al. By using a single blinded, randomised controlled trial with blinded assessment. The patient was assigned into 3 groups: aquatic exercise (n=27), land-based exercise (n=25) or control (n=27). This article was rated 8 out of 10 on the Pedro scale. Thus it is considered a good article. Randomization, concealed allocation, baseline comparability, assessor blinding, adequate follow-up, between group statistical comparisons, intention- to-treat, reporting point of estimates, and variability are all included. Next, 48 sedentary middle-aged and older adults with OA underwent 3 months of swimming and cycling exercise training, and were studied in a randomised study design by Alkatan et al. The patients were randomly assigned into 2 groups : swimming group (n=24) or cycling exercise group (n=24). This article was rated 7 out of 10 on the Pedro scale.Thus it is considered a good article. Randomization, concealed allocation, baseline comparability, assessor blinding, between group statistical comparisons, intention-to-treat, reporting point of estimates, and variability are all included. 105 community living participants aged 50 years and over with clinical OA of hip and knee were recruited in a randomised control trial by Foley, A et al. By using a single blinded, three arm , randomised control trial. The patient was randomised into 3 groups: hydrotherapy (n=35), gym (n=35), control (n=35). This article was rated 8 out of 10 on the pedro scale. Thus, it is considered a good article. Randomization, concealed allocation, baseline comparability, assessor blinding, adequate follow-up, between group statistical comparisons, intention- to-treat, reporting point of estimates, and variability are all included. Furthermore, 71 volunteers with symptomatic hip OA or knee OA participated in this study and underwent randomised controlled trials. This study was conducted by Hinman et al. volunteers aged 50 years and older were recruited and were then randomly assigned into 2 groups : aquatic physical therapy (n=36) and control (n=35). This article is a good article due to being rated 8 out of 10 on the Pedro scale. Randomization, concealed allocation, baseline comparability, assessor blinding, adequate follow-up, between group statistical comparisons, intention- to-treat, reporting point of estimates, and variability are all included.Moreover, 75 obese participants with knee osteoarthritis were recruited to participate in this randomised controlled trial. Lim et al. conducted this study, and participants were 50 years or older and had more than 25kg/m² BMI and abdominal circumferences of more than 90 cm for men and 85 cm for women. Participants were randomly allocated into 3 groups: AQE (n=26), LBE (n=25) and the control group (n=24). This article scores 7 out of 10 on Pedro scale. Randomization, baseline comparability, assessor blinding, between group statistical comparisons, intention-to-treat, reporting point of estimates, and variability are all included. Eighty four (84) patients with knee OA were recruited from local community centres. and randomly assigned into 3 groups , which were aquatic exercise, land-based exercise or control group. Wang et al. conducted this randomised controlled trial study to compare changes over time among three study groups on the primary outcome, pain. This article scores 7 out of 10 on Pedro scale. Randomization, baseline comparability, assessor blinding, between group statistical comparisons, intention-to-treat, reporting point of estimates, and variability are all included. Thirty-six (36) patients with radiographic grading of knee OA were selected in this randomised controlled trial. Patient's age is more than 40 years. This study was conducted by Assar et al. It is a single blinded, randomised, and controlled trial. Patients were divided into three groups namely, aquatic (n=12), total resistance exercises (TRX) (n=12) and control (n=12) randomly. This article's score 7 out of 10 is a good article. Randomization, concealed allocation, baseline comparability, assessor blinding, adequate follow-up, between group statistical comparisons, reporting point of estimates, and variability are all included.

3.3 Data Presentation:

Table below summarize the findings of the finalized included studies.

Table 3: Summary of data analysis from the included studies

Summary of Data Analysis		
Study Type	**Title, Author, Year**	**Result**
Randomised Controlled Trial	1. Improved function and reduced pain after swimming and cycling training in patients with osteoarthritis. Alkatan, M., Baker, J. R., Machin, D. R., Park, W., Akkari, A. S., Pasha, E. P., & Tanaka, H.	Results: After the exercise interventions, there were significant reductions in joint pain, stiffness, and physical limitation accompanied by increases in quality of life in both groups (all $p < 0.05$). Functional capacity as assessed by maximal handgrip strength, isokinetic knee

	(2016). Improved Function and Reduced Pain after Swimming and Cycling Training in Patients with Osteoarthritis. *The Journal of Rheumatology*, *43*(3), 666–672. https://doi.org/10.3899/jrheum.151110	extension and flexion power (15–30% increases), and the distance covered in the 6-min walk test increased (all $p < 0.05$) in both exercise groups. No differences were observed in the magnitude of improvements between swimming and cycling training. Conclusion: Regular swimming exercise reduced joint pain and stiffness associated with OA and improved muscle strength and functional capacity in middle-aged and older adults with OA. Additionally, the benefits of swimming exercise were similar to the more frequently prescribed land-based cycling training.
	2. The effect of Total resistance exercise vs aquatic training on self-reported knee instability, pain, and stiffness in women with knee osteoarthritis: a randomised controlled trial. 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 randomised controlled trial. *BMC Sports Science, Medicine and Rehabilitation*, *12*(1). https://doi.org/10.1186/s13102-020-00175-y	Results : The results demonstrated that KI, VAS, BBS improved over time both in TRX and aquatic groups significantly ($p < 0.05$), but WOMAC(stiffness), knee flexion ROM, and quadriceps strength were significantly improved over time only for TRX ($p < 0.05$). Post hoc test, also, showed that there were significant differences between interventions and control groups ($p < 0.05$) for the VAS, KI, BBS, but for WOMAC(stiffness), a significant difference was observed only between TRX and control groups ($p = 0.05$) Conclusion : Although TRX and aquatic interventions had a similar effect on the patients' balance, pain and KI, TRX had more effect on WOMAC(stiffness), quadriceps strength, and knee flexion ROM than aquatic exercises.

	3. Does hydrotherapy improve strength and physical function in patients with osteoarthritis -- a randomised controlled trial comparing a gym based and a hydrotherapy based strengthening programme. Foley A, Halbert J, Hewitt T, Crotty M. (2003). Does hydrotherapy improve strength and physical function in patients with osteoarthritis--a randomised controlled trial comparing a gym based and a hydrotherapy based strengthening programme. *Annals of the Rheumatic Diseases*, *62*(12), 1162–1167. https://doi.org/10.1136/ard.2002. 005272	Results : In the gym group both left and right quadriceps significantly increased in strength compared with the control group, and right quadriceps strength was also significantly better than in the hydrotherapy group. The hydrotherapy group increased left quadriceps strength only at follow up, and this was significantly different from the control group. The hydrotherapy group was significantly different from the control group for distance walked and the physical component of the SF-12. The gym group was significantly different from the control group for walk speed and self efficacy satisfaction. Compliance rates were similar for both exercise groups, with 84% of hydrotherapy and 75% of gym sessions attended. There were no differences in drug use between groups over the study period. Conclusion : Functional gains were achieved with both exercise programmes compared with the control group.
	4. Aquatic Physical Therapy for Hip and Knee Osteoarthritis: Results of a Single-Blind Randomised Controlled Trial. Hinman, R. S., Heywood, S. E., & Day, A. R. (2007). Aquatic Physical Therapy for Hip and Knee Osteoarthritis: Results of a Single-Blind Randomised Controlled Trial. *Physical Therapy*, *87*(1), 32–43. https://doi.org/10.2522/ptj.20060	Results : The intervention resulted in less pain and joint stiffness and greater physical function, quality of life, and hip muscle strength. Totals of 72% and 75% of participants reported improvements in pain and function, respectively, compared with only 17% (each) of control participants. Benefits were maintained 6 weeks after the completion of physical therapy, with 84% of participants continuing independently. Conclusion : Compared with no

	006	intervention, a 6-week program of aquatic physical therapy resulted in significantly less pain and improved physical function, strength, and quality of life. It is unclear whether the benefits were attributable to intervention effects or a placebo response.
	5. Effectiveness of Aquatic Exercise for Obese Patients with Knee Osteoarthritis : A Randomised Controlled Trial Lim, J. Y., Tchai, E., & Jang, S. N. (2010). Effectiveness of Aquatic Exercise for Obese Patients with Knee Osteoarthritis: A Randomized Controlled Trial. *PM&R*, *2*(8), 723–731. https://doi.org/10.1016/j.pmrj.2010.04.004	Results : Although no significant difference was found in general characteristics among the 3 groups before exercise, body fat proportion in the AQE group decreased significantly (mean SD, from 34.4 4.7 to 33.3 4.7; P .031) after intervention. The body mass index was slightly reduced after intervention, but it was not statistically significant. The AQE group showed significant improvements in pain, disability, and quality of life. Notably, the change in pain interference in the AQE group (mean SD, from 25.8 15.1 to 18.8 13.1; P .009) was greater than that of the LBE group. Both exercise groups showed significant improvements in Western Ontario and McMaster Universities' osteoarthritis index disability compared with the control group. Conclusion : AQE had an advantage in controlling the interference with activity because of pain. AQE may be an effective tool for patients with obesity who have difficulties with active exercise due to knee osteoarthritis.
	6. A Randomised Controlled	Results : No effect was observed

	Trial Of Aquatic And Land-based Exercise In Patients With Knee Osteoarthritis. Lund, H., Weile, U., Christensen, R., Rostock, B., Downey, A., Bartels, E., Danneskiold-Samsøe, B., & Bliddal, H. (2008). A randomised controlled trial of aquatic and land-based exercise in patients with knee osteoarthritis. *Journal of Rehabilitation Medicine*, *40*(2), 137–144. https://doi.org/10.2340/16501977-0134	immediately after exercise cessation (8 weeks). At 3-month follow-up a reduction in pain was observed only in the land-based exercise group compared with control (–8.1 mm, (95% confidence interval –15.4 to –0.4; p = 0. 039), but no differences between groups were observed for KOOS; and no improvement following aquatic exercise. Eleven patients reported adverse events (i.e. discomfort) in land-based exercise, while only 3 reported adverse events in the aquatic exercise. Conclusion : Only land-based exercise showed some improvement in pain and muscle strength compared with the control group, while no clinical benefits were detectable after aquatic exercise compared with the control group. However, aquatic exercise has significantly less adverse effects compared with a land-based programme.
	7. Comparing the efficacy of aquatic exercises and land-based exercises for patients with knee osteoarthritis Wang, T. J., Lee, S. C., Liang, S. Y., Tung, H. H., Wu, S. F. V., & Lin, Y. P. (2011). Comparing the efficacy of aquatic exercises and land-based exercises for patients with knee osteoarthritis. *Journal of Clinical Nursing*, *20*(17–18), 2609–2622. https://doi.org/10.1111/j.1365-	Results : Results showed statistically significant group-by-time interactions in pain, symptoms, sport/recreation and knee-related quality of life dimensions of Knee Injury and Osteoarthritis Outcome Score, knee range of motions and the six-minute walk test. However, the aquatic group did not show any significant difference from the land group at both weeks 12 and 6. Conclusion : Both aquatic and land-based exercise programmes are

	2702.2010.03675.x	effective in reducing pain, improving knee range of motions, six-minute walk test and knee-related quality of life in people with knee osteoarthritis. The aquatic exercise is not superior to land-based exercise in pain reduction.

3.4 Risk of Bias in Included Studies

The outcomes of Version 2 of the Cochrane risk-of-bias tool for randomized trials (RoB 2) are displayed in Figures 2 and 3. All seven RCTs exhibited low ROBs in terms of sufficient sequence creation and addressing some partial data, and one RCT (Assar et al., 2020) had an ambiguous ROB in two dimensions. In terms of random sequence generation, allocation concealment, and participant and staff blinding, seven RCTs (Alkatan et al., 2016; Assar et al., 2020; Foley et al., 2003; Hinman et al., 2007; Lim et al., 2010; Lund et al., 2008; Wang et al., 2010) had a low ROB. Two RCTs (Alkatan et al., 2016; Assar et al., 2020) had an uncertain ROB when it comes to blinding of outcome assessment, whereas five RCTs (Foley et al., 2003; Hinman et al., 2007; Lim et al., 2010; Lund et al., 2008; Wang et al., 2010) had a low ROB. In contrast to one research (Lim et al., 2010), six RCTs (Alkatan et al., 2016, Assar et al., 2020, Foley et al., 2003, Hinman et al., 2007, Lund et al., 2008, and Wang et al., 2010) had a low ROB when it came to incomplete outcome data. Five RCTs (Alkatan et al., 2016; Assar et al., 2020; Foley et al., 2003; Hinman et al., 2007; Lund et al., 2008) showed low ROB in selective outcome reporting, one RCT (Wang et al., 2010) had uncertain bias, and one RCT (Alkatan et al., 2016) had high ROB (Lim et al., 2010). In three RCTs, ROB was not listed under other causes of bias. However, three RCTs (Assar et al., 2020; Foley et al., 2003; Lund et al., 2008) had an uncertain bias in other sources of bias, while one RCT had a low ROB in other sources of bias (Lim et al., 2010). Seven RCTs included in this analysis had blinded participants and blinded assessors (Alkatan et al., 2016; Assar et al., 2020; Foley et al., 2003; Hinman et al., 2007; Lim et al., 2010; Lund et al., 2008; Wang et al., 2010). RCTs using incorrect allocation concealment and blinding techniques appear to have a higher likelihood of displaying inflated treatment effects and may therefore be less trustworthy (Schulz, 2001). Instead of the sample size on the vertical axis for the identified trials, the effect size was shown on the horizontal axis versus the reciprocal of the estimated effect's standard error. As Sterne (2001) emphasised, factors other than sample size, such as the standard deviation of responses for continuous outcomes, affect a trial's statistical power. There was a study near the base of the pain funnel plot that was found. Three studies were located inside the plot, while four studies were located outside the plot but higher up in the contour-enhanced funnel, indicating that there was significant publication bias after the assessment of potential bias. The funnel plot for the effect size (mean difference between post- and pre-intervention knee pain in patients) of all seven articles was noticeably non-symmetrical (see Figure 4). The funnel plot for the effect size (mean difference between post- and pre-intervention muscle strength of patients' knees) of all seven articles was noticeably symmetrical (see Figure 4.1). However, there is not much significant difference due to most of the studies located near to the bottom of the line.

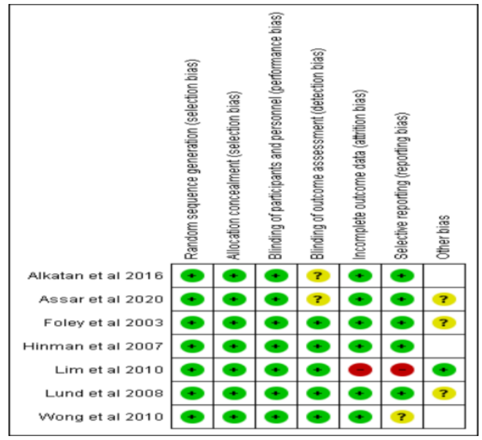


Figure 2. Risk of bias summary: review authors' judgments about each item's risk of bias for each included study

Note: +: low risk of bias; −: high risk of bias; ?: unclear.

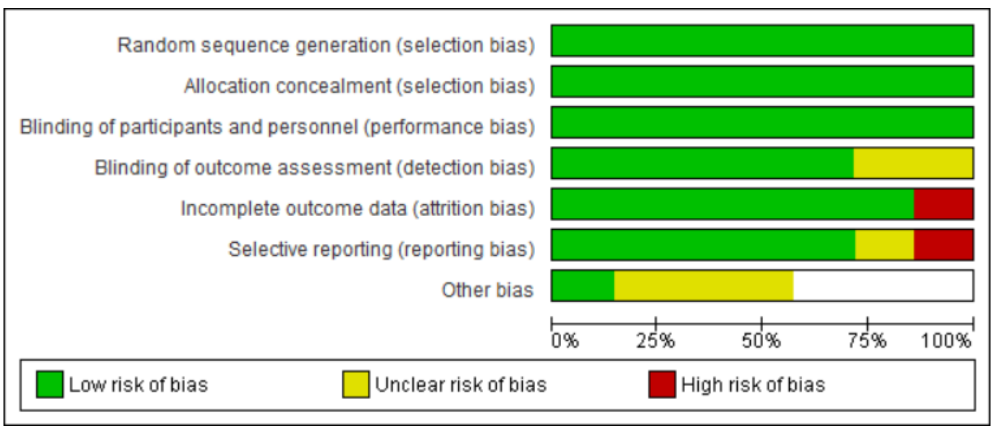


Figure 3. Risk of bias graph: review authors' judgments about each item's risk of bias presented as percentages across all included studies

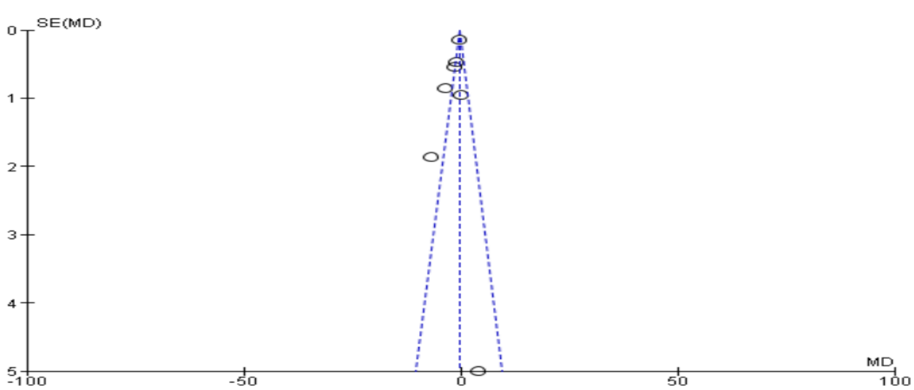
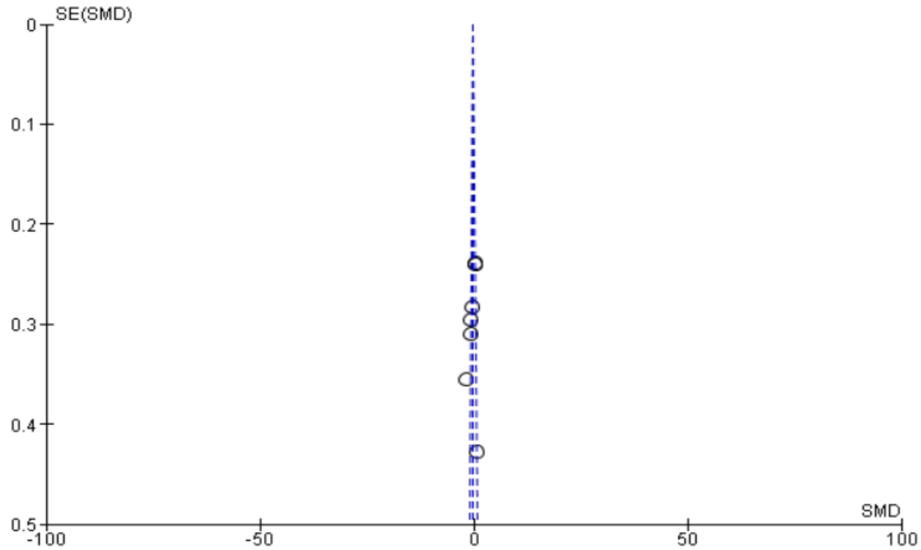


Figure 4: Funnel plot for pain as outcome measure

Figure 4.1: Funnel plot for muscle strength as outcome measure



3.5 Forest Plot Analysis

Table Forest Plot on Pain as outcome Measures

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
Alkatan et al 2016	4.2	0.5	24	4.5	0.5	24	23.4%	-0.30 [-0.58, -0.02]
Assar et al 2020	3.1	1.6	12	6.7	2.5	12	15.2%	-3.60 [-5.28, -1.92]
Foley et al 2003	10	4	35	10	4	35	14.0%	0.00 [-1.87, 1.87]
Hinman et al 2007	4	2	36	5	2	35	20.3%	-1.00 [-1.93, -0.07]
Lim et al 2010	3.27	1.67	24	4.55	1.88	20	19.4%	-1.28 [-2.34, -0.22]
Lund et al 2008	48.7	5.8	26	55.4	7.2	24	6.5%	-6.70 [-10.34, -3.06]
Wong et al 2010	72	18	26	68	18	26	1.2%	4.00 [-5.78, 13.78]
Total (95% CI)			**183**			**176**	**100.0%**	**-1.46 [-2.55, -0.37]**

Heterogeneity: Tau² = 1.30; Chi² = 30.41, df = 6 (P < 0.0001); I² = 80%
Test for overall effect: Z = 2.62 (P = 0.009)

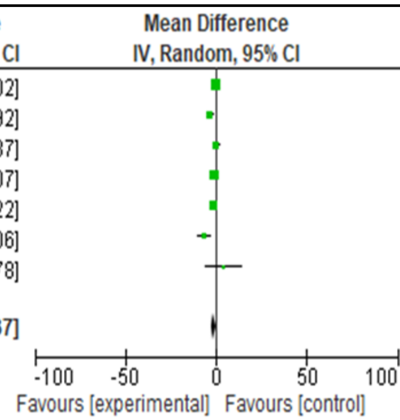


Figure 5 : forest plot results of meta-analysis of included studies on Pain as outcome measure.

Figure 5 shows the results of the meta-analysis of the included studies. The green squares in the forest plot above reflect the weight of each study, or the impact that study had on the outcome. The weight increases with sample size. Thus, Alkatan et al. (2016)'s papers received the most weight (23.4%). The 95% confidence interval is shown by a horizontal line that runs through each square; the longer the line, the broader the confidence interval, and the less dependable the conclusion. The vertical line also distinguishes between exercises performed on land and in water and serves as the line of no effect. One study that fits under this category of no effect is one by Alkatan et al. (2016). A study by Hinman et al. (2007) appears to favour the experimental group, with the square being close to the line of no impact. Only two studies (Assar et al., 2020; Lund et al., 2008), based on the forest plot, did not cross the vertical line. As a result, when compared to other treatments, the article by Lund et al. (2008) endorsed aquatic exercise as an effective treatment in lowering pain in individuals with knee OA. Despite crossing the vertical line more than half the time, Wang et al. (2010) discovered negative results, favouring land-based exercise but the square was near to the line of no effect. In four investigations, neither the interventional group nor the control group experienced any effects. However, the use of aquatic exercise was endorsed by two studies (Lund et al., 2008; Assar et al., 2020). Since those studies did not cross the vertical line, the remaining five publications (Alkatan et al., 2016; Foley et al., 2003; Hinman et al., 2007; Lim et al., 2010; Wang et al., 2010) disputed the choice of water exercise as an effective treatment. The pooled effect estimates showed that aquatic exercise was more successful than land-based exercise, which is shown by the blue diamond, and that the experimental group, which includes aquatic exercise, received more favourable results. There was no discernible effect since the diamond was so close to the vertical line (the "no effect line").

Forest Plot on Muscle Strength as Outcome Measures

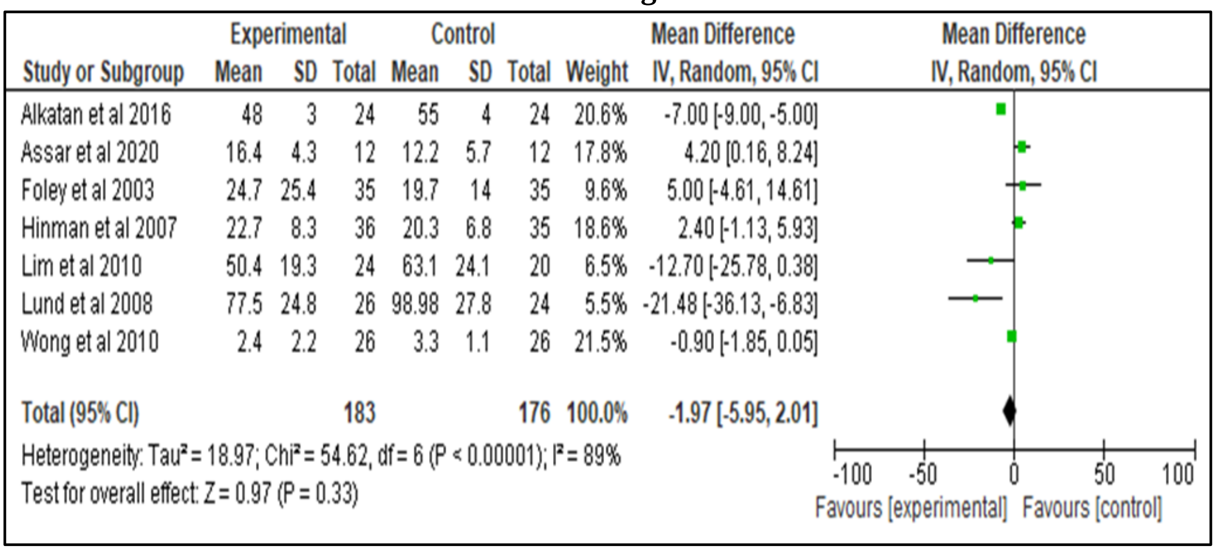


Figure 6 : forest plot results of meta-analysis of included studies on muscle strength as outcome measure.

The result of the meta-analysis of included studies are represented in Figure 6. In the forest plot above, the green squares represent the weight of each study, which is the influence of the study had on the result. The bigger the square, the larger the sample size. Thus, articles written by Wang et al. (2010) carried the largest weight. The horizontal line across each square is the 95% confidence interval, with the longer the line, the wider the confidence interval, the less precision the result is. Besides , the vertical line is the line of no effect and indicates the separation between aquatic exercise and land-based exercise. A study by Wang et al. (2010) falls into this category of no effect. However , a study by Hinman et al. (2007), with the square very near to the line of no effects, seems to favour the control group. Based on the forest plot, only 1 study crossed the vertical line, Foley et al. (2003). Meaning that this study result is not significant. The diamond pooled result favours the experimental group , and located very close to the line of no effect. Moreover, based on the study's weight, the higher the weight, the larger the sample size. Therefore, Wang et al. (2010) carries the largest sample size. The article by Lim et al. (2010), Alkatan et al (2016) and Lund et al. (2008) do not cross the line of no effect, these 3 studies are significant (P <0.05), and it supports aquatic exercise as an effective treatment in improving muscle strength when compared to other treatments. The summary effect is calculated as -1.97 , and 95% CI are -5.95 and 2.01. Since the confidence intervals do not cross the line of no effect , it can conclude that the overall effect is significant.

4. Discussions

The majority of research that was taken into account showed that exercising on land or in water had similar effects on reducing pain and increasing muscle strength in people with knee OA. The study's primary outcome measures—pain and muscle strength—were used in the 7 articles that we selected in order for the data analysis to be successful. In the study by Alkatan et al., the outcome measurements were lower body muscle strength and the self-administered pain questionnaire known as the WOMAC Index (2016). Using an isokinetic dynamometer, the lower body's isokinetic knee flexor and extensor strengths of both legs were assessed unilaterally at angular velocities of 60°/s and 120°. (Biodex Medical Systems). The Western Ontario and McMaster Universities Arthritis Index is used to assess hip and knee osteoarthritis (WOMAC). The self-administered questionnaire's 24 items are divided into 3 subscales. The WOMAC index also has 2 items for stiffness, one for it immediately after awakening and the other for it later in the day. Using stairs, rising from a chair, standing, bending, walking, getting in and out of a car, putting on and taking off socks, rising from a lying position, entering and exiting a bath, sitting, using the toilet, and carrying out both heavy and light household tasks are all included in the category of physical function, which has 17 items. The findings for each subscale are totaled up, with a possible score range of 0-20 for pain, 0-8 for stiffness, and 0-68 for physical function. The WOMAC score is normally the sum of the scores for each of the three subscales, though there are other ways to combine values. Additionally, a Biodex Medical Systems isokinetic dynamometer is used to measure muscular strength and identify any potential risks. Both groups saw significant reductions in joint pain, stiffness, and physical restriction after completing the three months of exercise therapy detailed in this article, as well as increases in quality of life (all p<0.05). Isokinetic knee extension and flexion power (15–30% increments) were used to assess functional capacity in both workout groups (all p<0.05). The rates of improvement for training in swimming and cycling were identical. Body weight, BMI, Lean body mass, Body fat mass, Body fat percentage, Abdominal fat, BPI mean pain, BPI pain interference, WOMAC, SF-36 PCS, SF-36 MCS, Peak torque, knee extensor (Nm), and Peak torque, knee flexor were the outcome measures used in the article by Lim et al., (2010). (Nm). However, the main areas of emphasis in this systematic review will be pain and muscle strength. The results of the study showed that whereas AQE had better pain management, LBE and AQE had nearly comparable effects on knee function.Three participants in the LBE group discontinued the research due to complaints of pain and discomfort, as opposed to one in the AQE group who did so due to chest pain but did not experience symptoms of arthritis. The data evaluation for muscle strength was unreliable due to a number of limitations in this study, including the exercise program's 8-week duration being unlikely to be long enough to evaluate its benefits. They found that the difference in pain interference between the AQE and LBE groups was greater (mean +/- SD, from 25.8 +/- 15.1 to 18.8 +/- 13.1; P= 0.009). At Western Ontario and McMaster Universities, both exercise groups significantly decreased the osteoarthritis index disability as compared to the control group. Even though the study by Wang et al. (2011) contained a number of outcome measures (symptoms, ADL, Sport/Recreation, QOL, ROM- knee flexion and extension, and 6MWT), the only one that gained greater attention was pain, which was measured using KOOS. To evaluate the quality of life related to knee OA, the KOOS was employed. For usage with those who experienced knee OA or injuries, the scale was developed and validated. The 42-item survey measures five facets of health: QOL (14 questions), ADL function (17 questions), sport/recreation function (5 questions), and pain (9 questions) (4 items). Each response is scored on a Likert scale of 0 (no problems) to 4 (very many problems) (severe problems). Each of the five dimensions' components is added up to create a score, which is then transformed to a scale from 0 to 100, with 100 denoting no knee issues and 0 denoting very severe knee troubles. The aquatic group's pain reduction did not substantially differ from that of the land group at weeks 6 (P=0.389) or 12 (P=0.801). However, when compared to the control group, they found that after 12 weeks of exercise, pain decreased in both groups. For the aquatic and land groups, respectively, the mean changes in the KOOS's pain dimension were 8.8 (95% CI = 4.8-12.8) and 9.1 (95% CI = 5.1-13.2). The results of the study show that both land-based and aquatic exercise programmes can reduce pain in individuals with knee OA, enhance knee ROMs and 6MWT, and subsequently improve quality of life. Water exercise is not more effective at relieving pain than land-based exercise. Although TRX and aquatic therapies had a similar impact on patients' balance, pain, and KI, Assar et al. (2020) found that TRX had a greater impact on WOMAC (stiffness), quadriceps strength, and knee flexion range of motion than aquatic exercises. The WOMAC stiffness subscale, balance, pain, KI, quadriceps strength, and knee flexion range of motion were investigated as the outcome measures in the study. Using a 10-cm visual analogue scale (VAS) with a scoring range of 0 to 10, where "0" represented no pain, "1" minor discomfort, and "10" intense or intolerable discomfort, the level of knee pain was determined. Using the Baseline PullPush Dynamometer, the knee extensors' maximum isometric strength (quadriceps muscle) was determined (Model 12–0343, Fabrication Enterprises Inc., NY, USA). The greatest force that can be measured by this digital dynamometer is 199.9 kg. At a knee flexion range of 80° to 90°, measurements were taken.

In the TRX and aquatic groups, VAS scores for pain considerably decreased over time (P 0.0001) with 8 weeks compared to the baseline (t0 vs. t1, P = 0.0001 in TRX; t0 vs. t1, P = 0.0001 in aquatic activities), while this was not significant in the control group (t0 vs. t1, P = 0.13). TRX and aquatic activities did not significantly differ from one another, though (P = 0.63). There was no significant improvement for the aquatic and control groups (t0 vs. t1, P = 0.21 and t0 vs. t1, P = 0.88), but there was a significant improvement for quadriceps strength scores after 8 weeks compared to the baseline in TRX (t0 vs. t1, P = 0.001). Additionally, there is no statistically significant difference between the aquatic group and the TRX group (P = 0.80). Lund et al,. (2008) 's study states that the end measures employed were pain level at rest and during walking by VAS, physical function via KOOS, and quadriceps and hamstring strength via isokinetic dynamometry. None of the groups' post-exercise pain was different, but at the 3-month follow-up, the land-based exercise group's resting pain was significantly lower than the control group's (group mean difference: -8.1 mm (95% CI: -15.8 to -0.4 mm; p = 0.039). The land-based exercise programme significantly increased overall muscle strength as compared to the control group (SMD 0.20; 95% CI 0.02-0.38), whereas the aquatic exercise programme significantly decreased it (SMD -0.22; 95% CI -0.38 to -0.05). According to the study's findings, only land-based exercise improved pain and muscle strength when compared to the control group; aquatic exercise had no clinically significant advantages over the control group. However, compared to a land-based regimen, water training has substantially fewer drawbacks. Pain, strength, and function are the outcome measures in the study by Foley et al., (2003). WOMAC pain score (0–20) and Arthritis Self-Efficacy Score were used to assess pain (10–100). A hydraulic leg extension machine that had been modified to only allow leg extension at an angle of 110 degrees was used to evaluate the isometric quadriceps strength. This study demonstrated that resistance exercise programmes that used the water or a gym effectively enhanced physical function. It was discovered that the gym-based intervention was more successful at boosting muscle strength. Between baseline and follow-up, the gym group significantly increased both left and right quadriceps strength (p = 0.001), but the hydrotherapy group only significantly increased left quadriceps strength (p = 0.010). At baseline, the hydrotherapy group had significantly greater WOMAC pain scores than the gym group (p = 0.015). The Arthritis Self-Efficacy Scale, which measures self-reported pain, did not show any differences across groups. Therefore, we conclude that individuals with OA benefit functionally from both hydrotherapy and gym therapies. However, it appears that gym-based exercise is more suited for strengthening programmes, whereas hydrotherapy may be better suited for aerobic-based exercise regimens.

Last but not least, pain, physical function, levels of physical activity, quality of life, and muscle strength were among the end indicators of the Hinman et al., 2007 study. A VAS with 1-cm increments was used to quantify pain during movement. On 5-point Likert scales ranging from 1 (far worse) to 5, subject perceptions of overall changes in pain and physical function (since the start of the study) were recorded (much better). Participants were categorised as demonstrating improvement if they scored their overall changes at 4 or 5, while participants who evaluated their changes at 1, 2, or 3 were categorised as not improving. The 24-item Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), which is disease-specific, was utilised to gauge the primary OA joint's pain, stiffness, and physical function over the past 48 hours. Using a Nicholas Manual Muscle Tester (model 01160)*, isometric hip abduction and knee extension strength (force-generating capability) were evaluated bilaterally in accordance with Bohannon's methodology. Participants in aquatic physical therapy reported experiencing 33% less pain on movement on average from baseline, which was significantly less discomfort at 6 weeks than control participants (P 0.01). This result showed a negligible effect size (0.24) for this result. Only 17% (6 of 35) of the control group participants reported an overall improvement in pain, compared to 72% (26 of 36) in the intervention group (P 0.001). At 6 weeks, the aquatic group had considerably more hip muscular strength and higher quality of life than the control group. Quadriceps femoris muscular strength was one of the outcomes that did not change significantly after the intervention. Based on the study's data, we can draw the conclusion that, despite statistically significant differences between the aquatic and control groups, aquatic physical therapy has only marginally positive effects on pain, stiffness, right hip abductor strength, and quality of life, and questionable clinical effects on left hip abductor strength. In summary, we can say that all 7 publications have similar findings regarding the effects of land-based exercise and aquatic exercise on patients with knee OA, but that aquatic exercise is not better than land-based exercise. Aquatic exercise can be a different choice for people with knee OA because there is no discernible difference between it and land-based exercise as a result. This is owing to the fact that aquatic exercise can lessen joint shock and the weight that comes with moving underwater due to the buoyancy of the water. As a result, patients will experience less pain and be more motivated to exercise in the pool than they would on land. Additionally, because of the warm pool temperature, exercising in the water can lower knee stiffness and fall risk. A safe and efficient form of exercise for patients with obesity and degenerative knee OA is aquatic exercise programme. This is so that individuals with balance issues can exercise without being concerned about falling, thanks to hydrostatic pressure's ability to support and stabilise the patients. Next, consider the resistance or viscosity of the water, which can be particularly useful for strengthening rehabilitation progressions and muscle retraining. However, there are several restrictions, such as the lack of swimming pools in hospitals or community centres and the high cost of maintenance.

4.1 Strengths

This study is a systematic review of randomised controlled trials (RCTS), ranked at the highest level in the hierarchy of evidence. It provides a comprehensive and unbiased pooling of the information from similar research articles to answer a particular research question. This systematic review involves transparency throughout the conduction of each phase so that readers can have a clear-cut understanding or better practical decision-making based on the evidence. Furthermore, discussions were being conducted by four researchers (three students and a supervisor) throughout the process until it reached a consensus. Besides, it has undergone peer or professional review along with the approval of the proposal to validate the idea. This systematic review has evaluated all the relevant articles in the available electronic databases, yielding a more reliable result than a single study.It is considered one of the substantial designs to evaluate the affecting relations. This systematic review was conducted efficiently by investigating the efficacy of different aquatic exercises in reducing phantom limb pain among amputees. Only a few similar reviews or research was discovered in the published or registered articles. Moreover, the team had done meta-analysis. Meta-analysis increased extrapolation to a larger population and statistical power. Meta-analysis is evidenced-based. Due to the consolidation of smaller research into one larger study, it is more probable to detect an effect. Meta-analysis also increased accuracy as a result of the pooling and analysis of smaller studies. Besides, researchers can collect a large amount of data without spending a lot of time, money and resources since the bulk of the data collection work has already been completed. In addition to providing a summary and integration of various findings and essential suggestions for future research, meta-analysis offers a view of the research that has been conducted in a certain topic. Another benefit of a meta-analysis is that it makes it easier for other academics and decision-makers to conduct study on a subject. People can gain a more accurate picture of what might be happening in a population by looking at the results of the meta-analysis rather than having to look at the findings of numerous smaller research.

4.2 Limitations

The main challenge in conducting this systematic review is the lack of standardisation between the included studies. There are varieties of intervention for aquatic therapy and are broadly used for different conditions or disorders. Despite the significant findings, different characteristics vary among the studies that cannot be directly compared, thus causing difficulties in retrieving the results. For instance, all analysed studies used various assessment tools for the evaluation of pain. Other than that all 7 articles did not blind the participants, and therapists, this may affect the result of the studies as a placebo effect may occur among participants causing publication bias to merge. Besides that, systematic bias may arise in our studies because there were 2 articles, in which the concealed allocation does not apply. Some articles like Lim et al.,2010 and Hinman 2007 have lacked detailed investigation of aquatic therapy into the long term effects of improving knee strength and pain. Besides that, systematic bias may arise in our study because there was one article in which Lim et al.,2010 has incomplete complete data and lack of selective reporting which the attrition bias and reporting bias arise. Other than that, 5 articles have unclear risk of bias after using RoB2 tool. Despite being an effective research method, meta-analysis has certain drawbacks. Finding all the relevant research to review can be challenging and time-consuming. Meta-analyses also call for sophisticated statistical knowledge and methods. This might be scary and demanding for researchers who may lack experience with this type of research.

4.3 Recommendations

Based on apparent increasing use of aquatic therapy intervention in various fields or areas, better guidelines with evidence-based support should be figured out. Hence, there is an urgent need for high-quality, well reported research. Further research with larger sample sizes and longer follow-up is needed. It is also essential to incorporate health related quality of life measures to detect improvements in participants' activity limitation in community settings. These measures can also provide meaningful results to the participants and may aid in engaging participants to continue the long-term exercise programme after the intervention.

5. Conclusion

Referring to the 7 included articles, some of the studies conclude that aquatic exercises have similar effects as land-based exercise. Some studies conclude that hydrotherapy brings better effects compared to land-based exercise. All in all, the outcome of the studies are expected to benefit practitioners and patients. This study concluded that hydrotherapy or aquatic exercises including group aquatic physical exercise, aquatic swimming, aquatic resistance exercise and other types of intervention such as foundation aquatics program (AFAP) can be used in reducing osteoarthritis pain and improving muscle strength. Overall studies have proven that hydrotherapy is effective or has similar results compared to land-based exercise, thus can be used as an alternative intervention when dealing with Knee osteoarthritis.

References

1. Alkatan, M., Baker, J. R., Machin, D. R., Park, W., Akkari, A. S., Pasha, E. P., & Tanaka, H. (2016). Improved Function and Reduced Pain after Swimming and Cycling Training in Patients with Osteoarthritis. The Journal of Rheumatology, 43(3), 666–672. https://doi.org/10.3899/jrheum.151110
2. Ansari, S. (2014, July 10). Effects of Aquatic Exercise Training on Pain, Symptoms, Motor Performance, and Quality Of Life of Older Males with Knee Osteoarthritis. Http://Aassjournal.Com/Article-1-101-En.Html. http://aassjournal.com/article-1-101-en.html
3. Arnold, C. M., & Faulkner, R. A. (2010). The Effect of Aquatic Exercise and Education on Lowering Fall Risk in Older Adults With Hip Osteoarthritis. Journal of Aging and Physical Activity, 18(3), 245–260. https://doi.org/10.1123/japa.18.3.245
4. 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 Science, Medicine and Rehabilitation, 12(1). https://doi.org/10.1186/s13102-020-00175-y

5.Azizi, S., Dadarkhah, A., Rezasoltani, Z., Raeissadat, S. A., Mofrad, R. K., & Najafi, S. (2020). Randomized controlled trial of aquatic exercise for treatment of knee osteoarthritis in elderly people. Interventional Medicine and Applied Science, 11(3), 161–167. https://doi.org/10.1556/1646.11.2019.19

6.Bannuru, R.R., Schmid. C.H., Kent. D.M., Vaysbrot. E.E., Wong. J.B., Mcalindon. T.E. (2015). Comparative effectiveness of pharmacologic interventions for knee osteoarthritis: a systematic review and network meta-analysis. Ann Intern Med., 162(1), 46–54.

7.Barduzzi, G. D. O., Rocha Júnior, P. R., Souza Neto, J. C. D., & Aveiro, M. C. (2013). Capacidade funcional de idosos com osteoartrite submetidos a fisioterapia aquática e terrestre. Fisioterapia Em Movimento, 26(2), 349–360. https://doi.org/10.1590/s0103-51502013000200012

8.Bartels, E. M., Juhl, C. B., Christensen, R., Hagen, K. B., Danneskiold-Samsøe, B., Dagfinrud, H., & Lund, H. (2016). Aquatic exercise for the treatment of knee and hip osteoarthritis. Cochrane Database of Systematic Reviews. https://doi.org/10.1002/14651858.cd005523.pub3

9.hatia, D., Bejarano, T., & Novo, M. (2013). Current interventions in the management of knee osteoarthritis. Journal of Pharmacy and Bioallied Sciences, 5(1), 30. https://doi.org/10.4103/0975-7406.106561

10.Bocalini, D. S., Serra, A. J., Murad, N., & Levy, R. F. (2008). Water- versus land-based exercise effects on physical fitness in older women. Geriatrics & Gerontology International, 8(4), 265–271. https://doi.org/10.1111/j.1447-0594.2008.00485.x

11.Bressel, E., Wing, J. E., Miller, A. I., & Dolny, D. G. (2014). High-Intensity Interval Training on an Aquatic Treadmill in Adults With Osteoarthritis. Journal of Strength and Conditioning Research, 28(8), 2088–2096. https://doi.org/10.1519/jsc.0000000000000258

12.CADMUS, L., PATRICK, M. B., MACIEJEWSKI, M. L., TOPOLSKI, T., BELZA, B., & PATRICK, D. L. (2010). Community-Based Aquatic Exercise and Quality of Life in Persons with Osteoarthritis. Medicine & Science in Sports & Exercise, 42(1), 8–15. https://doi.org/10.1249/mss.0b013e3181ae96a9

13.Cesar Barauce Bento, P., Pereira, G., Ugrinowitsch, C., & Rodacki, A. L. (2012). The Effects of a Water-Based Exercise Program on Strength and Functionality of Older Adults. Journal of Aging and Physical Activity, 20(4), 469–470. https://doi.org/10.1123/japa.20.4.469

14.Cochrane, T., Davey, R., & Matthes Edwards, S. (2005). Randomised controlled trial of the cost-effectiveness of water-based therapy for lower limb osteoarthritis. Health Technology Assessment, 9(31). https://doi.org/10.3310/hta9310

15.Dias, J. M., Cisneros, L., Dias, R., Fritsch, C., Gomes, W., Pereira, L., Santos, M. L., & Ferreira, P. H. (2017). Hydrotherapy improves pain and function in older women with knee osteoarthritis: a randomized controlled trial. Brazilian Journal of Physical Therapy, 21(6), 449–456. https://doi.org/10.1016/j.bjpt.2017.06.012

16. Edris, B. M. (2017, January 1). SID.ir | The Effect Of Aquatic Training And Compare It With Traband Training On The Most Widely Used Functional Tests In Old Men With Knee Osteoarthritis. Scientific Information Database. https://www.sid.ir/en/journal/ViewPaper.aspx?id=568827
17. The effectiveness of hydrotherapy in patients with osteoarthritis of the knee. (2018). International Journal of Pain Research and Treatment. https://doi.org/10.28933/ajpr-2018-06-1802
18. Etesami, A. S. (2015, October 10). Effectiveness of Aquatic Exercise Therapy on the Quality of Life in Women With Knee Osteoarthritis. Iranian Journal of Ageing. http://salmandj.uswr.ac.ir/article-1-734-en.html
19. European Journal of Physical and Rehabilitation Medicine 2016 August;52(4):422–30. (n.d.). EDIZIONI MINERVA MEDICA. https://www.minervamedica.it/en/journals/europa-medicophysica/article.php?cod=R33Y2016N04A0422
20. Fisken, A. L., Waters, D. L., Hing, W. A., & Keogh, J. W. (2015). Perceptions towards aqua-based exercise among older adults with osteoarthritis who have discontinued participation in this exercise mode. Australasian Journal on Ageing, 35(1), 12–17. https://doi.org/10.1111/ajag.12167
21. Fisken, A. L., Waters, D. L., Hing, W. A., Steele, M., & Keogh, J. W. (2015). Comparative Effects of 2 Aqua Exercise Programs on Physical Function, Balance, and Perceived Quality of Life in Older Adults With Osteoarthritis. Journal of Geriatric Physical Therapy, 38(1), 17–27. https://doi.org/10.1519/jpt.0000000000000019
22. Foley A, Halbert J, Hewitt T, Crotty M. (2003). Does hydrotherapy improve strength and physical function in patients with osteoarthritis--a randomised controlled trial comparing a gym based and a hydrotherapy based strengthening programme. Annals of the Rheumatic Diseases, 62(12), 1162–1167. https://doi.org/10.1136/ard.2002.005272
23. Franco, M. R., Morelhão, P. K., de Carvalho, A., & Pinto, R. Z. (2017). Aquatic Exercise for the Treatment of Hip and Knee Osteoarthritis. Physical Therapy, 97(7), 693–697. https://doi.org/10.1093/ptj/pzx043
24. Fransen, M., Nairn, L., Winstanley, J., Lam, P., & Edmonds, J. (2007). Physical activity for osteoarthritis management: A randomized controlled clinical trial evaluating hydrotherapy or Tai Chi classes. Arthritis & Rheumatism, 57(3), 407–414. https://doi.org/10.1002/art.22621
25. Garbi, F. P., Rocha Júnior, P. R., Pontes, N. D. S., Oliveira, A. D., Barduzzi, G. D. O., & Boas, P. J. F. V. (2021). Aquatic physiotherapy in the functional capacity

of elderly with knee osteoarthritis. Fisioterapia Em Movimento, 34. https://doi.org/10.1590/fm.2021.34119

26. Ha, G. C., Yoon, J. R., Yoo, C. G., Kang, S. J., & Ko, K. J. (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. Journal of Exercise Rehabilitation, 14(5), 870–876. https://doi.org/10.12965/jer.1836308.154

27. Hajmohammadi, F., Hosseinifar, M., Akbari, A., Ghiasi, F., Namvar, H., & Askari Ashtiani, A. (2021). The Effect of Aquatic and Non-aquatic Balance Training on the Fall Risk of Patients With Grade 2 and 3 Knee Osteoarthritis: A Randomized Clinical Trial. Iranian Rehabilitation Journal, 19(4), 343–350. https://doi.org/10.32598/irj.19.4.1166.1

28. Hale, L. 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. Archives of Physical Medicine and Rehabilitation, 93(1), 27–34. https://doi.org/10.1016/j.apmr.2011.08.004

29. Hall, J., Swinkels, A., Briddon, J., & McCabe, C. S. (2008). Does Aquatic Exercise Relieve Pain in Adults With Neurologic or Musculoskeletal Disease? A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Archives of Physical Medicine and Rehabilitation, 89(5), 873–883. https://doi.org/10.1016/j.apmr.2007.09.054

30. Hinman, R. S., Heywood, S. E., & Day, A. R. (2007). Aquatic Physical Therapy for Hip and Knee Osteoarthritis: Results of a Single-Blind Randomized Controlled Trial. Physical Therapy, 87(1), 32–43. https://doi.org/10.2522/ptj.20060006