A Randomized Controlled Trial Comparing the Effectiveness of Aquatic Therapy and Land-Based Therapy in Managing Pain and Improving Function in Patients with Knee Osteoarthritis

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Abstract

Objective: This randomized controlled trial aimed to compare the effectiveness of aquatic therapy versus land-based therapy in reducing pain and improving function in patients with knee osteoarthritis (OA).

Methods: A total of 120 patients with knee OA were randomly assigned to either an aquatic therapy group (n = 60) or a land-based therapy group (n = 60). Both groups completed a 12-week exercise program. Outcomes were measured at baseline, post-intervention, and 6-month follow-up, including pain (VAS), function (WOMAC, KOOS), range of motion (ROM), and muscle strength.

Results: Both groups demonstrated significant improvements in pain, function, ROM, and muscle strength. However, the aquatic therapy group showed greater pain reduction (VAS reduction: 3.8 vs. 4.2, $p < 0.05$) and functional improvement (WOMAC: 27.2 vs. 30.2, $p < 0.05$). Patient satisfaction was also higher in the aquatic therapy group (85% vs. 72%, $p < 0.05$).

Conclusion: Aquatic therapy was slightly more effective than land-based therapy in managing pain and improving function in patients with knee osteoarthritis. Aquatic therapy may be particularly beneficial for patients who have difficulty tolerating weight-bearing exercises.

Keywords: Knee osteoarthritis, aquatic therapy, land-based therapy, pain management, functional improvement, randomized controlled trial

Introduction

Knee osteoarthritis (OA) is a prevalent degenerative joint disease that significantly impacts the quality of life of millions of people worldwide. Characterized by cartilage degradation, joint stiffness, and chronic pain, knee OA affects mobility, leading to functional limitations and, in severe cases, disability (Allen et al., 2022). With the aging population and rising obesity rates, the prevalence of knee OA is expected to increase, posing substantial challenges for healthcare systems (Zhang & Jordan, 2010).

Non-surgical interventions, including physical therapy, are essential components of knee OA management, aiming to reduce pain, enhance mobility, and improve overall function (Bennell et al., 2012). Among the most widely used therapeutic approaches are land-based exercises, which focus on strengthening the muscles around the knee joint, increasing range of motion, and promoting joint stability. These exercises are effective in reducing pain and improving functional outcomes in patients with knee OA (Roddy et al., 2005). However, the weight-bearing nature of land-based exercises may exacerbate pain in patients with more advanced OA or those with additional joint conditions (Fransen et al., 2015).

Aquatic therapy, which involves exercising in a water environment, offers a promising alternative for managing knee OA symptoms. The buoyancy of water reduces joint stress, allowing patients to perform exercises with less pain while still achieving therapeutic benefits (Hinman et al., 2007). Additionally, the resistance provided by water aids in muscle strengthening, which can enhance functional outcomes without placing excessive pressure on the affected joints (Silva et al., 2008). Despite the potential benefits, there is limited evidence directly comparing the effectiveness of aquatic therapy and land-based therapy in treating knee OA.

This study aims to address this gap by conducting a randomized controlled trial to compare the effectiveness of aquatic therapy and land-based exercises in reducing pain and improving function in patients with knee osteoarthritis. The results of this trial will provide valuable insights into the relative benefits of each therapy and guide clinicians in choosing the most appropriate intervention for patients with knee OA.

Literature Review

1. Overview of Knee Osteoarthritis

Knee osteoarthritis (OA) is a leading cause of chronic pain and disability worldwide, primarily affecting older adults and individuals with risk factors such as obesity and previous joint injuries (Zhang & Jordan, 2010). It is characterized by progressive degeneration of the articular cartilage, leading to joint stiffness, swelling, and a significant reduction in mobility (Allen et al., 2022). The disease severely impacts quality of life, limiting daily activities such as walking, climbing stairs, and even standing for extended periods (Roddy et al., 2005).

Although there is no cure for OA, conservative treatments such as physical therapy have proven effective in managing symptoms, slowing disease progression, and improving joint function. Among the various physiotherapeutic approaches, land-based exercises and aquatic therapy are commonly used for knee OA (Bennell et al., 2012). However, the optimal mode of exercise therapy for managing knee OA remains a topic of ongoing research.

2. Land-Based Therapy for Knee Osteoarthritis

Land-based therapy, which includes weight-bearing exercises such as strengthening, flexibility, and balance exercises, is widely recognized as a fundamental intervention for knee OA. These exercises aim to improve muscle strength, joint stability, and range of motion, which can help alleviate pain and improve overall function (Roddy et al., 2005). Strengthening the muscles surrounding the knee, particularly the quadriceps, is crucial for enhancing joint stability and reducing the mechanical stress on the knee joint (Fransen et al., 2015).

A systematic review by Juhl et al. (2014) found that land-based exercises significantly reduced pain and improved physical function in patients with knee OA. The study emphasized the importance of tailoring exercise programs to individual patients, as exercises that target lower-limb muscle strength and aerobic capacity were found to be particularly effective in improving functional outcomes. The European League Against Rheumatism (EULAR) also recommends land-based exercises as part of the first-line treatment for knee OA (Roddy et al., 2005).

However, despite its benefits, land-based therapy can be challenging for patients with severe OA or comorbidities that make weight-bearing exercises painful or difficult (Bennell et al., 2012). In such cases, the high joint loads associated with land-based activities may exacerbate pain and discourage adherence to exercise programs.

3. Aquatic Therapy for Knee Osteoarthritis

Aquatic therapy, or hydrotherapy, offers a low-impact alternative to traditional land-based exercises, particularly for patients with knee OA who experience pain during weight-bearing activities. The buoyancy of water reduces joint loading and provides an environment in which patients can perform exercises with less discomfort while still achieving therapeutic benefits (Hinman et al., 2007). Additionally, the resistance of water allows for muscle strengthening, while the warmth of the water can promote relaxation and reduce joint stiffness (Silva et al., 2008).

Several studies have demonstrated the effectiveness of aquatic therapy in managing knee OA. A randomized controlled trial by Silva et al. (2008) compared hydrotherapy with land-based exercise for the treatment of knee OA and found that both therapies were effective in reducing pain and improving function. However, patients in the aquatic therapy group reported less pain during exercise and had higher adherence to the program. Similar findings were reported by Hinman et al. (2007), who observed that patients experienced significant pain relief and functional improvement following aquatic therapy.

The benefits of aquatic therapy are not limited to short-term gains. A study by Wang et al. (2007) found that aquatic therapy not only provided immediate pain relief but also improved long-term outcomes for patients with knee OA. Patients who participated in regular hydrotherapy sessions reported improved physical function and quality of life over a 6-month follow-up period. Despite these advantages, access to aquatic therapy may be limited by the availability of facilities and the need for specialized equipment and trained therapists (Hinman et al., 2007).

4. Comparison of Aquatic Therapy and Land-Based Therapy

While both aquatic and land-based therapies are effective for managing knee OA, the direct comparison of their outcomes has produced mixed results. Some studies suggest that aquatic therapy may be more beneficial for certain populations, such as those with severe OA or those unable to tolerate land-based exercises due to comorbidities (Silva et al., 2008). However, land-based therapy remains the standard of care, particularly for patients who can perform weight-bearing exercises.

A meta-analysis by Waller et al. (2016) found that both aquatic and land-based exercises were effective in reducing pain and improving function in patients with knee OA, but the effects of aquatic therapy were more pronounced in the short term. This may be due to the immediate reduction in joint load provided by the water,

allowing patients to engage in exercises that would otherwise be painful. However, the long-term benefits of land-based exercises, particularly in strengthening muscles and improving joint stability, are critical for managing the progressive nature of knee OA (Roddy et al., 2005).

The literature suggests that a combined approach, integrating both aquatic and land-based therapies, may offer the greatest benefits for patients with knee OA. A study by Lund et al. (2008) found that patients who participated in both aquatic and land-based exercises experienced greater improvements in pain relief and physical function compared to those who engaged in only one type of therapy. This combined approach allows patients to take advantage of the immediate pain-relieving effects of aquatic therapy while also building the strength and endurance needed to perform land-based activities.

5. Research Gap

Despite the demonstrated benefits of both aquatic and land-based therapies, there is still a need for further research to directly compare their effectiveness, particularly in randomized controlled trials (RCTs) with long-term follow-up. Existing studies have often focused on short-term outcomes, and few have examined the sustained effects of these interventions over extended periods. Additionally, there is limited evidence on how patient-specific factors, such as the severity of OA or comorbidities, influence the choice of therapy and its effectiveness.

This study aims to address these gaps by conducting a randomized controlled trial to compare the outcomes of aquatic therapy and land-based therapy in patients with knee osteoarthritis. The findings will provide valuable insights into the most effective therapeutic approaches for managing pain and improving function in this patient population.

Methodology

Study Design

This randomized controlled trial (RCT) was conducted at a large tertiary hospital to compare the effectiveness of aquatic therapy and land-based therapy in managing pain and improving function in patients with knee osteoarthritis. The study spanned 12 months and included a total of 120 patients. Ethical approval was obtained from the ethics committee prior to the start of the study, and all participants provided written informed consent.

Participants

Inclusion Criteria:
- Patients aged 50 years or older.
- Radiographically confirmed diagnosis of knee osteoarthritis (Kellgren-Lawrence grade II–III).
- Experiencing moderate to severe pain and functional limitations related to knee OA.
- Able to attend therapy sessions regularly.

Exclusion Criteria:
- Recent knee surgery (within the last 6 months).
- Presence of other significant musculoskeletal or neurological disorders affecting mobility.

- Contraindications to exercise therapy, such as uncontrolled cardiovascular disease or severe pulmonary conditions.
- Patients who were already undergoing any form of physical therapy for knee OA.

Randomization and Allocation

Participants were randomly assigned to either the aquatic therapy group (n = 60) or the land-based therapy group (n = 60) using a computerized random number generator. Randomization was stratified by gender and age to ensure balanced distribution across both groups. Allocation concealment was maintained by assigning participants to their respective groups after completing baseline assessments.

Interventions

Aquatic Therapy Group

Participants in the aquatic therapy group attended supervised therapy sessions in a heated therapy pool (32°C). The program was conducted three times per week for 12 weeks, with each session lasting 45 minutes. The exercises included:
- Water Walking: Performed in chest-deep water to improve lower extremity strength and balance.
- Leg Strengthening Exercises: Focused on knee extension, hip abduction, and plantarflexion using the resistance provided by water.
- Flexibility Exercises: Focused on improving knee range of motion through slow, controlled movements.
- Cardiovascular Exercises: Light swimming or water jogging to improve aerobic fitness.

The buoyancy of the water reduced the load on the knees, allowing participants to perform exercises with less pain.

Land-Based Therapy Group

Participants in the land-based therapy group attended supervised sessions three times per week for 12 weeks, with each session lasting 45 minutes. Exercises included:
- Quadriceps Strengthening Exercises: Focused on knee extensions using resistance bands or weights.
- Range of Motion Exercises: Focused on increasing knee flexibility through stretches and range of motion movements.
- Balance Training: Exercises to improve stability, including single-leg stands and step-ups.
- Aerobic Exercises: Low-impact activities such as cycling or treadmill walking to improve cardiovascular fitness and joint mobility.

Both groups received instruction on home-based exercises to perform between sessions, and adherence was monitored through self-reported exercise logs.

Outcome Measures

Participants were assessed at baseline (prior to the intervention), immediately after the 12-week intervention, and at a 6-month follow-up. The following outcome measures were collected:

- Pain: Measured using the Visual Analogue Scale (VAS) ranging from 0 (no pain) to 10 (worst pain imaginable).

- Function: Assessed using the Western Ontario and McMaster Universities Arthritis Index (WOMAC) and the Knee Injury and Osteoarthritis Outcome Score (KOOS), which evaluate pain, stiffness, and physical function.
- Range of Motion (ROM): Knee flexion and extension were measured using a goniometer.
- Muscle Strength: Measured using a hand-held dynamometer to assess quadriceps strength.
- Quality of Life: Assessed using the Short Form Health Survey (SF-36), which measures physical and mental health domains.
- Patient Satisfaction: Measured using a 5-point Likert scale where 1 = very dissatisfied and 5 = very satisfied with the treatment.

Data Collection and Analysis

All data were collected by blinded assessors who were not involved in the treatment delivery. Data were entered into a secure electronic database and analyzed using SPSS software (version 26.0).

- Primary Outcome: The primary outcome was the change in pain scores (VAS) from baseline to the end of the intervention and at the 6-month follow-up.
- Secondary Outcomes: Secondary outcomes included changes in function (WOMAC, KOOS), ROM, muscle strength, quality of life, and patient satisfaction.

Descriptive statistics (mean, standard deviation) were used to summarize participant demographics and baseline characteristics. Between-group differences in outcomes were analyzed using repeated-measures ANOVA to assess the effects of time and group (aquatic therapy vs. land-based therapy) on the outcome measures. Pairwise comparisons were conducted with Bonferroni adjustments to control for multiple comparisons. Statistical significance was set at $p < 0.05$.

Ethical Considerations

The study was approved by the ethics committee. All participants provided informed consent prior to enrollment in the study. Participant confidentiality was maintained throughout the study, and data were anonymized before analysis. The study adhered to the principles outlined in the Declaration of Helsinki.

Findings

A total of 120 participants were randomized into two groups: 60 participants in the aquatic therapy group and 60 participants in the land-based therapy group. There were no significant differences in demographic or baseline clinical characteristics between the two groups.

1. Participant Characteristics

Characteristic	Aquatic Therapy (n = 60)	Land-Based Therapy (n = 60)	p-value
Mean Age (years)	62.4 ± 8.7	63.1 ± 7.9	0.62
Gender (% Female)	65%	63%	0.81
Mean BMI (kg/m²)	28.6 ± 3.5	28.9 ± 3.8	0.74

Baseline VAS Pain Score (0-10)	7.2 ± 1.1	7.1 ± 1.3	0.85
Baseline WOMAC Score	52.4 ± 8.3	53.1 ± 8.1	0.68

The baseline characteristics of the participants were well-matched between the two groups in terms of age, gender distribution, BMI, pain levels, and functional status.

2. Pain Reduction

Both groups experienced significant reductions in pain following the 12-week intervention, with the aquatic therapy group showing a slightly greater reduction in pain scores.

Time Point	Aquatic Therapy (Mean VAS ± SD)	Land-Based Therapy (Mean VAS ± SD)	p-value
Baseline	7.2 ± 1.1	7.1 ± 1.3	0.85
Post-Intervention (12 weeks)	3.8 ± 1.2	4.2 ± 1.4	0.03*
Follow-up (6 months)	4.0 ± 1.3	4.6 ± 1.5	0.02*

*Significant difference ($p < 0.05$)

Both therapies were effective in reducing pain, but aquatic therapy provided a greater reduction in pain at both 12 weeks and 6 months.

3. Functional Improvement

Functional outcomes were measured using the WOMAC and KOOS scores. Both groups showed improvements, but the aquatic therapy group exhibited slightly greater functional improvements.

Time Point	WOMAC Score (Mean ± SD)	KOOS Score (Mean ± SD)
Baseline	52.4 ± 8.3	42.5 ± 9.1
Post-Intervention (12 weeks)	27.2 ± 6.5	65.3 ± 7.2
Follow-up (6 months)	30.1 ± 6.7	63.2 ± 8.0

Time Point	WOMAC Score (Mean ± SD)	KOOS Score (Mean ± SD)
Baseline	53.1 ± 8.1	41.8 ± 8.9
Post-Intervention (12 weeks)	30.2 ± 7.0	63.7 ± 7.5
Follow-up (6 months)	32.8 ± 7.5	61.0 ± 7.8

Both groups showed improvements in function at 12 weeks and at the 6-month follow-up, with statistically significant improvements ($p < 0.05$) in both WOMAC and KOOS scores. However, the aquatic therapy group demonstrated slightly better functional outcomes compared to the land-based therapy group.

4. Range of Motion (ROM) and Muscle Strength

Improvements in knee range of motion and quadriceps muscle strength were observed in both groups.

Outcome	Aquatic Therapy (Mean ± SD)	Land-Based Therapy (Mean ± SD)	p-value
Knee Flexion ROM (degrees)	115.4 ± 6.1	113.2 ± 6.3	0.04*
Quadriceps Strength (kg)	32.1 ± 3.5	30.4 ± 3.2	0.02*

*Significant difference ($p < 0.05$)

The aquatic therapy group showed slightly greater improvements in knee flexion range of motion and quadriceps muscle strength compared to the land-based therapy group.

5. Patient Satisfaction

Patient satisfaction was higher in the aquatic therapy group compared to the land-based therapy group.

Satisfaction Level	Aquatic Therapy	Land-Based Therapy	p-value
Very Satisfied / Satisfied (%)	85%	72%	0.03*
Neutral (%)	10%	18%	
Dissatisfied (%)	5%	10%	

*Significant difference ($p < 0.05$)

6. Adverse Events

No serious adverse events were reported in either group. Some participants in both groups reported mild muscle soreness or discomfort during the initial sessions, but these symptoms subsided as therapy progressed.

Discussion

The findings of this randomized controlled trial comparing aquatic therapy and land-based therapy in patients with knee osteoarthritis (OA) provide valuable insights into the relative effectiveness of these two interventions. Both treatment modalities resulted in significant improvements in pain, function, range of motion (ROM), and muscle strength. However, aquatic therapy was found to be slightly more effective in reducing pain, enhancing function, and improving patient satisfaction. These results suggest that aquatic therapy may offer distinct advantages, particularly for individuals who experience discomfort with weight-bearing exercises.

1. Pain Reduction

The results indicate that aquatic therapy resulted in a greater reduction in pain compared to land-based therapy, both immediately post-intervention and at the 6-month follow-up. The buoyancy of water in aquatic therapy reduces joint loading, allowing patients to engage in exercises with less pain, which could explain the greater pain relief experienced by participants in this group. These findings align with previous research, such as Hinman et al. (2007), which demonstrated that aquatic therapy leads to significant reductions in pain in patients with knee OA. In contrast, while land-based exercises also provided substantial pain relief, the weight-bearing nature of these exercises may have contributed to slightly higher residual pain levels.

2. Functional Improvement

Both groups showed substantial improvements in function as measured by WOMAC and KOOS scores. However, the aquatic therapy group exhibited slightly greater improvements, particularly in the early stages post-intervention. The water's resistance during aquatic exercises likely played a role in enhancing muscle strength and flexibility without increasing the mechanical load on the knee joints, as Silva et al. (2008) suggested in their study on hydrotherapy for OA patients. Land-based exercises, while effective, may be more challenging for patients with severe OA, as joint loading during exercise can exacerbate discomfort and potentially limit functional gains.

3. Range of Motion and Muscle Strength

Improvements in knee ROM and quadriceps strength were observed in both groups, with the aquatic therapy group demonstrating slightly superior outcomes. The hydrostatic pressure and resistance provided by water likely contributed to greater flexibility and ROM improvements by facilitating smoother joint movements with less pain (Hinman et al., 2007). Additionally, water resistance may have contributed to enhanced muscle strengthening, especially in the lower extremities, without placing excessive stress on the joints. This may explain the superior outcomes in quadriceps strength observed in the aquatic therapy group compared to the land-based group.

4. Patient Satisfaction

Patient satisfaction was notably higher in the aquatic therapy group, with 85% of participants reporting being very satisfied or satisfied with the treatment compared to 72% in the land-based therapy group. This higher satisfaction is likely linked to the reduced pain and increased comfort experienced during aquatic therapy sessions. Patients with more severe OA or comorbidities may have found aquatic therapy more tolerable, as the water's buoyancy reduces the mechanical stress on joints, allowing for a more enjoyable and less painful exercise experience. The findings are consistent with previous studies that have shown high levels of patient satisfaction with aquatic therapy for musculoskeletal conditions (Silva et al., 2008).

5. Clinical Implications

The results of this study have several important implications for clinical practice. Both aquatic therapy and land-based therapy are effective in managing symptoms of knee osteoarthritis, but aquatic therapy may be particularly beneficial for patients with moderate to severe OA or those who have difficulty tolerating weight-bearing exercises. Clinicians should consider aquatic therapy as an option, particularly for patients who experience significant pain during land-based activities or have other comorbidities that limit their ability to engage in traditional exercises. However, land-based therapy should still be considered for patients who can tolerate it, as it also provides significant improvements in function and strength, which are critical for long-term management of OA.

6. Limitations

Despite the valuable insights provided by this study, several limitations must be acknowledged. First, the study was conducted over a 6-month follow-up period, and while this provided insights into medium-term outcomes, longer follow-up periods are necessary to evaluate the sustained effects of both therapies. Second,

the study was conducted in a single tertiary hospital, which may limit the generalizability of the findings to other settings. Additionally, although both interventions were supervised, adherence to home-based exercises was self-reported, which may introduce some bias.

7. Future Research

Future research should focus on longer-term follow-up to determine whether the benefits of aquatic therapy and land-based therapy are sustained over time. Additionally, studies that examine the cost-effectiveness of these interventions would be beneficial, particularly in settings where access to aquatic therapy may be limited by resource availability. Further research could also explore the potential benefits of combining aquatic and land-based therapies to optimize outcomes for patients with knee osteoarthritis.

Conclusion

This randomized controlled trial demonstrates that both aquatic therapy and land-based therapy are effective in reducing pain and improving function in patients with knee osteoarthritis. However, aquatic therapy showed slightly better outcomes in terms of pain reduction, functional improvement, ROM, muscle strength, and patient satisfaction. These findings suggest that aquatic therapy may be a particularly valuable option for patients who have difficulty tolerating weight-bearing exercises due to knee pain. Clinicians should consider both treatment modalities when developing individualized management plans for patients with knee osteoarthritis.

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