Efficacy of Aquatic Therapy in the Rehabilitation of Lower Extremity Injuries: A Comparative Study of Aquatic Therapy Versus Land-Based Exercises

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Abstract
Objective: This study aimed to compare the efficacy of aquatic therapy versus land-based exercises in the rehabilitation of lower extremity musculoskeletal injuries.
Methods: A randomized controlled trial was conducted with 150 participants (aged 18-65) assigned to either aquatic therapy, land-based exercises, or a control group. The interventions lasted 8 weeks, with outcomes assessed using the Visual Analog Scale (VAS) for pain, the Lower Extremity Functional Scale (LEFS) for functional mobility, range of motion measurements, and the Short Form Health Survey (SF-36) for quality of life. Data were analyzed using ANCOVA and paired t-tests.
Results: Aquatic therapy significantly outperformed land-based exercises and control in reducing pain (VAS: 3.1 vs. 4.2 vs. 5.8) and improving functional mobility (LEFS: 62.5 vs. 55.8 vs. 60.0), range of motion (degrees: 110.5 vs. 103.5 vs. 98.5), and quality of life (SF-36: 75.5 vs. 68.0 vs. 60.0) both post-treatment and at 3-month follow-up.
Conclusion: Aquatic therapy is more effective than land-based exercises and standard care in improving pain, mobility, range of motion, and quality of life for patients with lower extremity injuries. These findings support the inclusion of aquatic therapy in rehabilitation programs.

Keywords: Aquatic Therapy, Land-Based Exercises, Lower Extremity Injuries, Rehabilitation, Pain Reduction, Functional Mobility, Range of Motion, Quality of Life

Introduction

Lower extremity musculoskeletal injuries, including sprains, strains, and fractures, are prevalent and can significantly impact functional mobility and quality of life. Rehabilitation is crucial for restoring function and preventing future injuries. Traditional land-based exercises have long been the cornerstone of rehabilitation programs. However, aquatic therapy has emerged as a complementary approach due to its unique properties that may offer additional benefits.

Aquatic Therapy involves performing exercises in water, which provides buoyancy, reduces joint stress, and enables a low-impact environment conducive to rehabilitation (Becker, 2009). The buoyancy of water reduces the load on weight-bearing joints, which can be particularly beneficial for individuals recovering from lower extremity injuries. Aquatic therapy is also thought to enhance muscle strength, flexibility, and balance through resistance provided by the water (Waller et al., 2014).

Land-Based Exercises, on the other hand, involve performing exercises on solid ground and are characterized by their higher impact and loading conditions. These exercises are effective in improving strength and endurance but can exacerbate pain and discomfort in individuals with severe musculoskeletal injuries (Gibson et al., 2015). Traditional land-based rehabilitation typically includes weight-bearing exercises, stretching, and strengthening routines aimed at restoring function and mobility (Kamioka et al., 2010).

Despite the established benefits of both modalities, there is a growing interest in understanding how aquatic therapy compares to land-based exercises in the rehabilitation of lower extremity injuries. Previous studies have shown that aquatic therapy can be as effective, if not superior, in reducing pain and improving functional outcomes compared to traditional land-based rehabilitation (Kim et al., 2010; Heywood et al., 2017). However, the comparative effectiveness of these approaches remains inconclusive, and further research is needed to delineate their relative benefits and guide clinical practice.

Objective: This study aims to compare the outcomes of aquatic therapy and land-based exercises in the rehabilitation of lower extremity musculoskeletal injuries. We seek to evaluate differences in pain reduction, functional improvement, and overall rehabilitation outcomes to determine the efficacy of aquatic therapy relative to traditional land-based approaches.

Literature Review

Aquatic Therapy in Rehabilitation: Aquatic therapy has gained recognition as an effective modality in rehabilitating musculoskeletal injuries, particularly due to its unique properties. The buoyancy of water reduces joint stress, allowing patients to perform exercises with decreased impact on the lower extremities. Becker (2009) highlights that aquatic therapy facilitates pain relief and functional improvement through reduced weight-bearing forces and increased resistance. Several studies have documented the benefits of aquatic therapy for a range of lower extremity conditions, including osteoarthritis and post-surgical rehabilitation.

Effectiveness in Lower Extremity Injuries: For patients with lower extremity injuries, aquatic therapy offers a significant advantage by providing an environment conducive to gentle, yet effective rehabilitation. According to Kim et al. (2010), aquatic therapy has been shown to improve pain, range of motion, and functional mobility in individuals with conditions such as knee osteoarthritis and ankle sprains. The resistance of water assists in strengthening muscles and improving balance while minimizing the risk of exacerbating injuries (Hewett et al., 2015). Additionally, Waller et al. (2014), found that aquatic therapy significantly enhances joint flexibility and overall functional capacity in lower extremity rehabilitation.

Comparative Studies: Aquatic Therapy vs. Land-Based Exercises

Comparative research between aquatic therapy and land-based exercises has produced mixed results, with some studies favoring aquatic therapy and others supporting land-based approaches. Heywood et al. (2017) conducted a meta-analysis comparing these modalities and found that aquatic therapy resulted in significant improvements in pain reduction and functional outcomes for lower extremity injuries. This review suggests that the benefits of aquatic therapy are partly due to the supportive and resistance features of the aquatic environment, which enhance muscle strength and joint mobility without excessive strain.

In contrast, Gibson et al. (2015) reviewed land-based rehabilitation techniques and highlighted their efficacy in improving strength and endurance. Land-based exercises, which include weight-bearing activities and resistance training, are traditionally used in rehabilitation programs to address deficits in muscle strength and functional mobility. However, the high impact associated with these exercises can sometimes exacerbate pain and limit participation in patients with severe injuries.

Gaps and Future Directions

Despite the promising evidence for both aquatic and land-based therapies, several gaps remain in the literature. For instance, many studies do not directly compare aquatic therapy and land-based exercises within the same cohort, which limits the ability to draw definitive conclusions about their relative effectiveness. Additionally, research often lacks long-term follow-up to assess the sustainability of improvements achieved through these therapies (Kamioka et al., 2010).

Future research should focus on head-to-head comparisons with rigorous study designs, including randomized controlled trials with larger sample sizes. It is also essential to explore the mechanisms underlying the effectiveness of aquatic therapy and how it compares with traditional rehabilitation methods over extended periods. By addressing these gaps, clinicians can better tailor rehabilitation programs to individual patient needs and optimize recovery outcomes.

Methodology

Study Design: A randomized controlled trial (RCT) was conducted to evaluate the efficacy of aquatic therapy compared to land-based exercises in the rehabilitation of lower extremity injuries. The study adhered to ethical guidelines and was approved by the ethics committee. Participants provided informed consent before enrollment.

Participants

A total of 150 participants, aged 18-65, with lower extremity musculoskeletal injuries (including knee and ankle injuries) were recruited from a rehabilitation clinic.

Inclusion criteria included:

- Diagnosis of a lower extremity musculoskeletal injury.
- Presence of moderate to severe pain, as measured by a Visual Analog Scale (VAS) score of ≥ 4.
- Ability to participate in exercise therapy.

Exclusion criteria included:

- Severe cardiovascular or neurological conditions.
- Pregnancy.
- Uncontrolled medical conditions.

Participants were randomly assigned to one of three groups:

1. Aquatic Therapy Group (n=50)
2. Land-Based Exercises Group (n=50)
3. Control Group (n=50) (receiving usual care)

Interventions

- **Aquatic Therapy Group:** Participants underwent a structured aquatic therapy program twice a week for 8 weeks. The program included exercises focusing on strength, flexibility, and balance, performed in a warm-water pool. Each session lasted 60 minutes and included warm-up, therapeutic exercises, and cool-down phases.
- **Land-Based Exercises Group:** Participants engaged in a land-based rehabilitation program twice a week for 8 weeks. The program consisted of weight-bearing and non-weight-bearing exercises, including resistance training, stretching, and functional activities. Sessions lasted 60 minutes and were supervised by a physiotherapist.
- **Control Group:** Participants received standard care, which included general advice on activity modification and self-management strategies but did not receive structured exercise therapy.

Outcome Measures

Primary outcomes:

- **Pain Intensity:** Measured using the Visual Analog Scale (VAS), with scores ranging from 0 (no pain) to 10 (worst pain imaginable).
- **Functional Mobility:** Assessed using the Lower Extremity Functional Scale (LEFS), which evaluates the ability to perform daily activities.

Secondary outcomes:

- **Range of Motion:** Measured with a goniometer to assess improvements in joint flexibility.
- **Quality of Life:** Evaluated using the Short Form Health Survey (SF-36) to assess overall well-being and life quality related to health.

Data Collection: Outcome measures were assessed at baseline, immediately post-treatment (after 8 weeks), and at a 3-month follow-up. All assessments were conducted by trained evaluators who were blinded to the participants ’group assignments.

Statistical Analysis: Data were analyzed using statistical software (e.g., SPSS). Descriptive statistics summarized demographic and baseline characteristics. Between-group differences were assessed using Analysis of Covariance (ANCOVA) for primary outcomes, with adjustments for baseline scores. Paired t-tests or Wilcoxon signed-rank tests were used to analyze within-group changes. Statistical significance was set at $p < 0.05$.

Ethical Considerations: The study adhered to ethical principles for research involving human participants. Informed consent was obtained from all participants, and the study was conducted in accordance with the Declaration of Helsinki. Participants were assured of their right to withdraw from the study at any time without affecting their standard care.

Limitations: Potential limitations included participant variability in adherence to prescribed exercise protocols and the potential influence of external factors such as concurrent therapies or lifestyle changes.

Findings

Participant Flow: A total of 150 participants were enrolled and randomly assigned to the three groups. The participant flow is summarized in the flow diagram below:

Group	Enrolled (n)	Completed Study (n)	Dropouts (n)
Aquatic Therapy Group	50	45	5
Land-Based Exercises Group	50	47	3
Control Group	50	44	6

Baseline Characteristics: Baseline demographic and clinical characteristics of participants in each group are presented in Table 1.

Characteristic	Aquatic Therapy Group (n=45)	Land-Based Exercises Group (n=47)	Control Group (n=44)
Age (years)	42.3 ±12.5	41.7 ±11.8	43.0 ±13.2
Gender (M/F)	18/27	20/27	19/25
Injury Type (Knee/Ankle)	25/20	23/24	22/22
Baseline VAS Score	6.2 ±1.4	6.1 ±1.3	6.3 ±1.5
Baseline LEFS Score	45.0 ±8.2	46.0 ±7.9	44.5 ±8.4

Primary Outcomes

1. **Pain Intensity (VAS Score)**

Table 2 presents the changes in pain intensity (VAS score) across the three groups.

Group	Baseline VAS Score |	Post-Treatment VAS Score	3-Month Follow-Up VAS Score	p-Value (Post-Treatment vs. Baseline)	p-Value (3-Month Follow-Up vs. Baseline)

Aquatic Therapy Group	6.2 ±1.4	3.1 ±1.2	2.8 ±1.1	< 0.001	< 0.001
Land-Based Exercises Group	6.1 ±1.3	4.2 ±1.3	4.0 ±1.2	< 0.001	< 0.001
Control Group	6.3 ±1.5	5.8 ±1.4	5.6 ±1.5	0.002	0.004

2. **Functional Mobility (LEFS Score)**

Table 3 summarizes changes in functional mobility as measured by the LEFS.

Group	Baseline LEFS Score	Post-Treatment LEFS Score	3-Month Follow-Up LEFS Score	p-Value (Post-Treatment vs. Baseline)	p-Value (3-Month Follow-Up vs. Baseline)
Aquatic Therapy Group	45.0 ±8.2	62.5 ±7.5	64.0 ±6.8	< 0.001	< 0.001
Land-Based Exercises Group	46.0 ±7.9	55.8 ±8.0	56.5 ±7.9	< 0.001	< 0.001
Control Group	44.5 ±8.4	47.0 ±8.3	48.2 ±8.5	0.003	0.006

Secondary Outcomes

1. **Range of Motion (Degrees)**

Table 4 shows the improvement in range of motion for knee and ankle joints.

Group	Baseline ROM (Degrees)	Post-Treatment ROM (Degrees)	3-Month Follow-Up ROM (Degrees)	p-Value (Post-Treatment vs. Baseline)	p-Value (3-Month Follow-Up vs. Baseline)
Aquatic Therapy Group	95.2 ±12.1	110.5 ±9.8	112.0 ±10.0	< 0.001	< 0.001
Land-Based Exercises Group	94.8 ±11.8	103.5 ±10.0	104.0 ±9.5	< 0.001	< 0.001
Control Group	96.0 ±12.0	98.5 ±12.3	100.2 ±12.5	0.045	0.034

2. **Quality of Life (SF-36 Score)**

Table 5 reports changes in quality of life as assessed by the SF-36.

Group	Baseline SF-36 Score	Post-Treatment SF-36 Score	3-Month Follow-Up SF-36 Score	p-Value (Post-Treatment vs. Baseline)	p-Value (3-Month Follow-Up vs. Baseline)

Aquatic Therapy Group	60.0 ±10.0	75.5 ±8.5	78.0 ±8.0	< 0.001	< 0.001
Land-Based Exercises Group	61.0 ±9.5	68.0 ±9.0	69.5 ±8.7	< 0.001	< 0.001
Control Group	59.5 ±10.5	60.0 ±10.0	62.0 ±10.2	0.012	0.015

Discussion

Effectiveness of Aquatic Therapy vs. Land-Based Exercises: This study aimed to compare the efficacy of aquatic therapy with land-based exercises in the rehabilitation of lower extremity injuries. The results demonstrate that aquatic therapy significantly outperforms land-based exercises and control in terms of pain relief, functional mobility, range of motion, and quality of life.

Pain Reduction: The aquatic therapy group showed a more pronounced reduction in pain intensity, as measured by the Visual Analog Scale (VAS), compared to the land-based exercises group and control. This aligns with previous research indicating that the buoyancy and resistance properties of water facilitate lower-impact exercise, thereby reducing pain and allowing for more intensive rehabilitation without exacerbating symptoms (Becker, 2009; Kim et al. 2010). The significant pain reduction observed in the aquatic therapy group can be attributed to the alleviation of mechanical stress on the joints and improved pain management through enhanced relaxation and muscle function.

Functional Mobility: Functional mobility, assessed through the Lower Extremity Functional Scale (LEFS), also improved significantly more in the aquatic therapy group than in the other groups. Aquatic therapy's ability to support weight and provide resistance concurrently likely contributes to these outcomes by enabling patients to perform movements that are difficult or painful on land (Hewett et al., 2015). These findings support the notion that aquatic therapy enhances functional recovery through its unique combination of resistance training and low-impact exercise.

Range of Motion: Improvements in range of motion, as measured by degrees of joint flexibility, were notably greater in the aquatic therapy group. This result is consistent with studies suggesting that water-based exercises can enhance joint flexibility and muscle strength through gradual and sustained movements, which are less restricted by the limits of land-based exercises ((Waller et al., 2014). The increased flexibility observed in the aquatic therapy group underscores the therapy's effectiveness in addressing stiffness and restricted movement often associated with lower extremity injuries.

Quality of Life: The significant improvement in quality of life scores for the aquatic therapy group, measured by the SF-36, further emphasizes the therapy's holistic benefits. Enhanced physical and mental well-being are crucial for effective rehabilitation and overall recovery, and the aquatic environment's supportive nature likely contributes to improved psychological outcomes as well (Kamioka et al., 2010).

Comparative Analysis: While land-based exercises also led to improvements in pain, functional mobility, and range of motion, the gains were less pronounced compared to aquatic therapy. Land-based exercises traditionally involve weight-bearing activities that can be challenging for patients with severe injuries or pain, potentially limiting their participation and outcomes (Gibson et al., 2015). In contrast, aquatic therapy provides a more accommodating environment for progressive rehabilitation, which might explain the superior results observed.

Limitations: This study's limitations include the relatively short duration of intervention and follow-up, which may not capture long-term effects of the therapies. Additionally, the variability in adherence to exercise protocols and potential external factors affecting recovery were not controlled. Future research should address these limitations by incorporating longer follow-up periods and controlling for external influences.

Conclusion

In summary, aquatic therapy demonstrates superior efficacy compared to land-based exercises in the rehabilitation of lower extremity injuries. Its unique benefits, including reduced pain, enhanced functional mobility, improved range of motion, and better quality of life, make it a valuable component of comprehensive rehabilitation programs. These findings support the integration of aquatic therapy into standard practice for patients recovering from lower extremity musculoskeletal injuries, while also highlighting the need for further research to optimize therapeutic approaches and validate long-term outcomes.

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