Comparative Analysis of Aquatic versus Land-Based Exercise in Post-Surgical Rehabilitation of ACL Reconstruction: Functional and Biomechanical Outcomes

Mahima Alexander[1], Neelu Pawar[2], Shadma Siddiqui[3]

[1]*PG SAM Global University, Raisen, India*

[2]*Assistant Professor, SAM Global University, Raisen, India*

[3]*Dean/Head of Paramedical Sciences, SAM Global University, Raisen, India*

Abstract

Introduction: The anterior cruciate ligament (ACL) of the knee is crucial for controlling the movement of the tibia relative to the femur and guiding knee extension. ACL injuries, often resulting from both contact and non-contact mechanisms, are prevalent and can significantly impair knee function. Rehabilitation post-ACL reconstruction is essential for recovery, with both land-based and aquatic exercises being common approaches. This study aims to compare the effectiveness of these two rehabilitation methods.

Objectives: To determine whether aquatic exercises lead to less difficulty with activities of daily living and better outcomes in terms of joint effusion and lower-extremity function compared to land-based exercises in patients after intra-articular ACL reconstruction.

Method: A randomized controlled trial was conducted with 30 subjects who underwent intra-articular ACL reconstruction. Subjects were randomly assigned to two groups (n=15 each). Group A performed aquatic exercises, while Group B performed land-based exercises. Both groups followed identical exercise programs initially, with progressive adjustments from the second week onwards. The Lysholm scale was used to measure outcomes at 2, 4, and 8 weeks postoperatively. Data analysis was performed using the unpaired t-test and ANOVA.

Results: Both rehabilitation programs were found to be equally effective in improving overall knee function. However, Group A (aquatic exercises) showed significantly less joint effusion and facilitated recovery of lower-extremity function more effectively than Group B (land exercises), as indicated by higher Lysholm scores.

Conclusion: The study concludes that while both aquatic and land-based exercise programs are effective for post-ACL reconstruction rehabilitation, aquatic exercises offer additional benefits in reducing joint effusion and enhancing lower-extremity functional recovery. Therefore, the alternate hypothesis (H_1) is supported, indicating a significant difference between the effects of aquatic and land-based exercises in the rehabilitation of intra-articular ACL reconstruction patients.

Keywords: *ACL reconstruction, aquatic exercises, land-based exercises, rehabilitation, joint effusion, functional outcomes, Lysholm scale, knee injury, postoperative recovery, comparative study.*

Introduction

The anterior cruciate ligament (ACL) plays a critical role in knee stability by preventing anterior translation of the tibia relative to the femur, guiding the screw-home mechanism during knee extension, preventing hyperextension, and assisting in the prevention of varus and valgus movements, especially in an extended knee. ACL injuries are common, particularly among individuals aged 20-40, and can be classified as partial or complete ruptures. These injuries often result from both contact and non-contact mechanisms, with the latter, involving

rotational forces on a planted foot, being particularly prevalent. Women are notably three times more likely than men to suffer ACL injuries through non-contact mechanisms.

Following an ACL injury, pain, effusion, and inflammation often lead to muscle inhibition and impaired activation of the thigh muscles, necessitating either conservative treatment or, in cases of knee instability, reconstruction surgery. ACL reconstruction typically involves using a tissue graft to replicate the damaged ligament, with bone-patellar tendon-bone autografts being the gold standard due to their reliability and efficacy. Advances in surgical techniques, such as arthroscopically assisted procedures and improved graft fixation methods, have significantly influenced rehabilitation protocols.

Rehabilitation post-ACL reconstruction has evolved from lengthy immobilization and non-weight-bearing protocols to accelerated programs that encourage immediate weight-bearing and early return to activity, typically within six months. The primary goals of rehabilitation include achieving full passive knee extension, restoring patellar mobility, reducing postoperative inflammation, re-establishing voluntary quadriceps control, and progressing strengthening exercises. Early phases focus on minimizing the adverse effects of surgery through range of motion (ROM) and muscle strengthening exercises, ensuring activities do not overstress the ACL graft.

Closed-chain (CKC) exercises are advocated as safer alternatives to open-chain exercises (OCK) because they apply resistance through the terminal joint of a limb segment, reducing stress on the ACL graft. Aquatic exercises, particularly beneficial in the initial rehabilitation phase, offer decreased joint stress, improved circulation, and facilitated movement due to the buoyancy and resistance properties of water. These exercises can lead to less joint effusion and greater self-reports of functional improvement.

Research indicates that aquatic exercises expedite rehabilitation by decreasing pain, increasing ROM and flexibility, restoring joint mobility, reducing edema, and enhancing blood flow to muscles. Studies have demonstrated that accelerated CKC and OKC exercises in water do not harm the healing ACL graft, as the impact forces are significantly reduced. Hydrotherapy enables early full weight-bearing, facilitating gait re-education and potentially increasing patients' tolerance to rehabilitation programs.

While land-based rehabilitation programs are extensively documented, the combination of accelerated land and hydrotherapy programs remains underexplored. A combined program may benefit sports participants by allowing more joint loading, aggressive rehabilitation, and earlier return to function. This study aims to determine whether aquatic exercises result in less joint effusion, less thigh atrophy, and less difficulty with activities of daily living compared to land exercises post-ACL reconstruction. The modified Lysholm scale, a widely used scoring system focusing on patients' perception of function, will be employed to assess outcomes.

Method

This study is a randomized clinical trial (RCT) focused on post-operative day one patients who have undergone ACL reconstruction. The sample consists of 30 subject’s selected using simple random sampling from the population of ACL reconstruction patients at Rajeev Gandhi Physiotherapy College, Bhopal, and Trauma Center Bhopal GAM Ortho, Nagpur. The inclusion criteria for the study are males and females aged 20-40 years who have had ACL reconstruction using a patellar tendon graft, are in their first post-operative day, and have no post-operative complications. The exclusion criteria include patients with other ligament injuries, a prior history of ACL reconstruction, early osteoarthritis changes, limb length discrepancies, or prior muscle weakness. The aim is to ensure a homogenous sample, thereby allowing a clear assessment of the outcomes of the intervention under study.

Procedure

Thirty subjects who underwent intra-articular ACL reconstruction were randomly divided into two groups (n=15) using the lottery method. All subjects provided informed consent and completed a Lysholm scale questionnaire at 2, 4, and 8 weeks post-operatively.

Group A (Aquatic Exercises): Performed exercises in waist-deep water.

Group B (Land Exercises): Performed exercises on land.

First Week Rehabilitation Program:

- Stretching of hamstring and calf muscles

- Ankle pumps, toe movements, quadriceps muscle setting

- Active-assisted knee flexion/extension ROM exercises (10 minutes)

- Heel drags, assisted straight leg raises (3 sets x 10 repetitions)

- Gait training with crutches and a hinged knee brace

From the second week onwards, both groups followed their respective exercise programs, with progression in intensity and repetitions over time. Post-exercise readings were recorded at 8 weeks. Data were analyzed using tables and graphs.

Outcome Measures

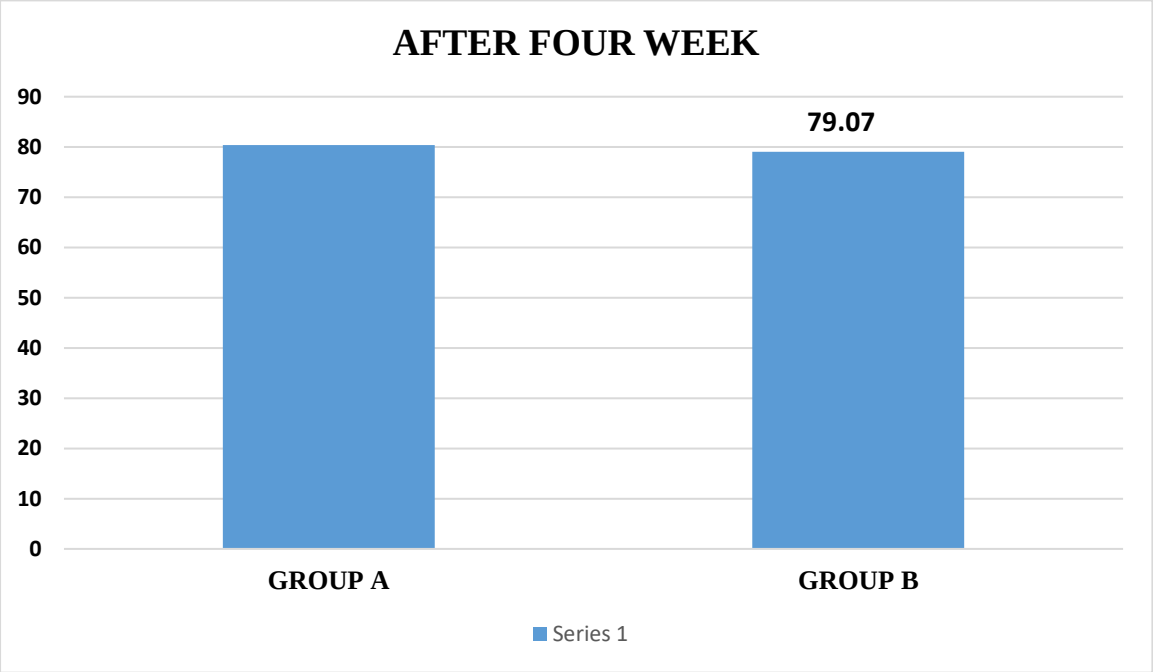
- Primary Measure: Lysholm Scale score

Variables

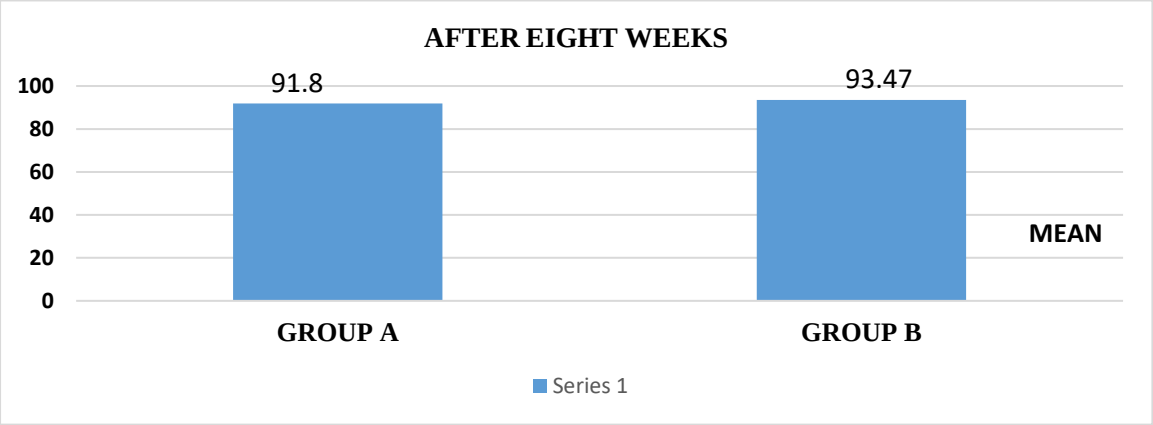
- Dependent: Pain, swelling, instability

- Independent: Aquatic exercises, land exercises

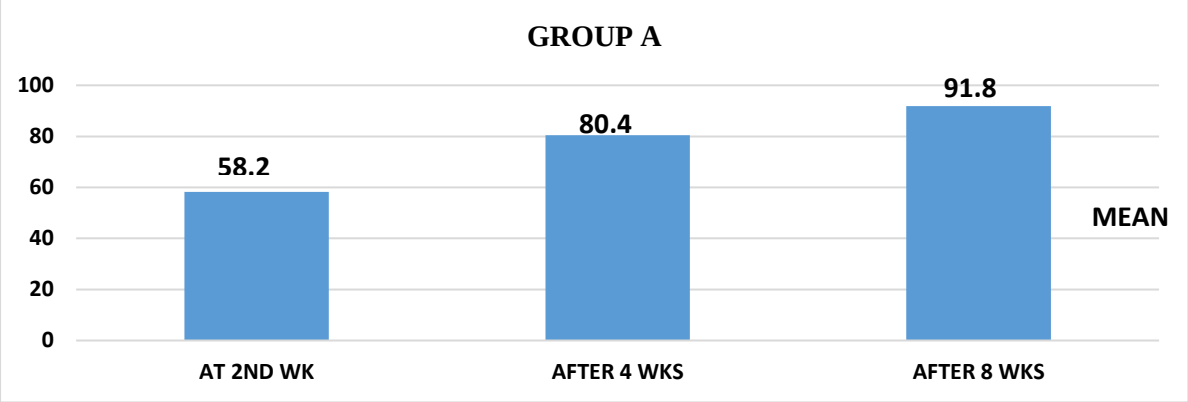
GRAPH NO. 1 GRAPHICAL PRESENTATION OF MEAN LYSHOLM SCORE OF GROUP A AND GROUP B AFTER 4 WKS



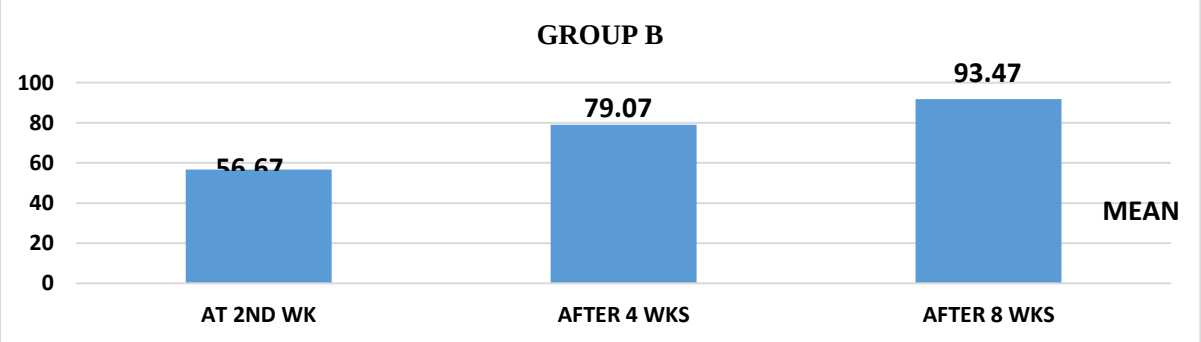
GRAPH NO. 2 GRAPHICAL PRESENTATION OF LYSHOLM SCORE MEAN OF GROUP A AND GROUP B AFTER EIGHT WEEKS



GRAPH NO. 3 THE MEAN OF LYSHOLM SCORE IN GROUP A (AQUATIC EXERCISE GROUP) AT 2, 4 AND AT 8 WEEKS



GRAPH NO. 4-THE MEAN OF LYSHOLM SCORE IN GROUP B (LAND EXERCISE GROUP) AT 2nd, 4th AND AT 8 WEEKS



Discussion

The present study aimed to compare the efficacy of aquatic exercises versus land-based exercises in patients undergoing rehabilitation after intra-articular ACL reconstruction. The key findings indicate that while both rehabilitation programs are effective in improving functional outcomes, aquatic exercises offer additional benefits in terms of reducing joint effusion.

Effectiveness of Rehabilitation Programs

Both groups, aquatic (Group A) and land-based (Group B), showed significant improvements in function as measured by the Lysholm scale over the 8-week period. This finding aligns with existing literature that supports the effectiveness of structured rehabilitation programs in restoring knee function following ACL reconstruction. The improvement observed in both groups underscores the importance of early and consistent rehabilitation post-surgery.

Aquatic Exercises and Joint Effusion

One notable difference between the two groups was the reduction in joint effusion observed in the aquatic exercise group. This finding is consistent with studies suggesting that aquatic therapy can be beneficial in reducing inflammation and swelling due to the hydrostatic pressure exerted by water. Reduced joint effusion can enhance comfort and potentially expedite the recovery process by allowing greater range of motion and less pain during exercises.

Functional Outcomes and Patient Perception

While the primary outcome measures indicated similar functional improvements in both groups, patients in the aquatic exercise group reported greater ease in performing activities of daily living. This subjective improvement suggests that aquatic exercises might offer psychological benefits and greater patient satisfaction, potentially due to the reduced pain and discomfort associated with lower joint effusion.

Limitations and Future Research

The study's sample size was relatively small (n=30), and the duration of the follow-up was limited to 8 weeks. Future studies should include larger sample sizes and longer follow-up periods to better understand the long-term effects of both rehabilitation programs. Additionally, integrating a strengthening program for the quadriceps and hamstring muscles and evaluating its impact over a more extended period could provide more comprehensive insights into the optimal rehabilitation strategy for ACL reconstruction patients.

Clinical Implications

The findings of this study suggest that incorporating aquatic exercises into rehabilitation protocols can be particularly beneficial for reducing joint effusion and enhancing patient comfort without compromising functional recovery. Clinicians should consider the individual needs and preferences of patients when designing post-ACL reconstruction rehabilitation programs. For patients experiencing significant joint effusion or discomfort with land-based exercises, aquatic therapy may offer a viable alternative that promotes better compliance and outcomes.

Conclusion

In conclusion, while both aquatic and land-based exercises are effective in improving functional outcomes after ACL reconstruction, aquatic exercises provide the added benefit of reducing joint effusion. This reduction in effusion may facilitate a more comfortable and potentially quicker recovery process. Future research should focus on larger and more diverse patient populations, longer follow-up periods, and the inclusion of comprehensive strengthening programs to further elucidate the comparative benefits of these rehabilitation approaches.

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