Journal of Physical Education

Volume 38 – Issue (3) – 2026 Open Access

P-ISSN: 2073-6452 , E-ISSN: 2707-5729

https://jcope.uobaghdad.edu.iq

The Effectiveness of a Hydrotherapy-Based Rehabilitation Program in Improving Range of Motion and Muscle Strength in Athletes with Partial Lateral Ankle Ligament Tears

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DOI:

https://doi.org/10.37359/JOPE.V38(3)2026.2330

Article history: Received 25/July/2025; Accepted 24/February/2026; Available online 28/ September/2026

Abstract

The purpose of this study was to evaluate the effectiveness of a hydrotherapy-based rehabilitation program in improving the range of motion (ROM) , muscular strength and functional performance in athletes suffering from partial tears of the lateral ankle ligament. An experimental design with two groups (experimental and control) was employed on a sample of ten athletes. The experimental group underwent a structured hydrotherapy rehabilitation program for 12 weeks (three sessions per week) while the control group received traditional therapy . Range of motion was measured using a goniometer and muscle strength using a dynamometer . Functional performance was assessed using the Vertical Jump Test and the Timed Up and Go (TUG) Test . Statistical analysis revealed significant improvements in all measured variables for the experimental group compared to the control group. The results confirm the effectiveness of hydrotherapy in accelerating recovery and restoring joint function after lateral ankle ligament injury .

Keywords: Hydrotherapy, Injury Rehabilitation, Lateral Ankle Ligament Tear, Range of Motion, Team Sports .

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Journal of Physical Education
Volume 38 – Issue (3) – 2026 Open Access
P-ISSN: 2073-6452 , E-ISSN: 2707-5729
https://jcope.uobaghdad.edu.iq

Introduction

Team sports such as soccer , basketball and volleyball require high physical exertion and depend heavily on complex motor skills including sprinting , jumping and sudden changes of direction. Due to the physical contact and competitive nature of these sports players are continuously exposed to injury risk. Among the most common injuries in the field are ankle injuries specifically partial tears of the lateral ankle ligaments. Such injuries negatively affect player performance and can sideline athletes for extended periods if they do not undergo comprehensive rehabilitation .

According to Brukner and Khan (2017) “ankle injuries are among the most common injuries in athletes especially those involved in team sports that require quick and sudden movements (such as soccer and basketball). Among these injuries partial tears of the lateral ankle ligament significantly affect sports performance leading to restricted range of motion and weakened surrounding musculature hindering the player’s ability to return to play quickly and effectively.” In this context hydrotherapy has emerged as an innovative and effective method in sports rehabilitation. Hydrotherapy provides a safe low-impact environment that allows athletes to perform exercises without imposing additional stress on the injured joint. It also improves circulation and reduces pain, thereby promoting healing and helping to restore the joint’s normal range of motion (Kisner & Colby, 2017) .

Recent studies indicate that using hydrotherapy in the rehabilitation of lateral ankle injuries yields positive outcomes. For example Smith et al. (2021) demonstrated that aquatic exercises improved ankle joint range of motion by 30% in injured athletes. Similarly Johnson et al. (2010) found that hydrotherapy reduces recovery time and returns athletes to their previous performance levels faster than traditional therapies. Therefore this study aims to introduce an integrated hydrotherapy-based rehabilitation approach that not only improves ankle range of motion but also enhances muscle strength enabling injured athletes to return to play safely and effectively (American College of Sports Medicine, 2020) .

Team sports like soccer and basketball impose high biomechanical loads on the athletes joints due to complex skills such as sudden stopping , jumping and directional changes. This repetitive physical stress makes these athletes continually susceptible to sports injuries with ankle injuries at the forefront. Lateral ankle ligament injuries are common in sports requiring quick directional changes and frequent jumping (Brukner & Khan, 2017) . These injuries often result from sudden movements or twists leading to partial or complete ligament tears. Hertel (2002) noted that the absence of effective and integrated rehabilitation programs can lead to re-injury or the development of chronic conditions negatively impacting sports performance and prolonging the recovery period .

Studies also indicate that many athletes do not receive proper rehabilitation due to lack of awareness of modern rehabilitation methods such as hydrotherapy. Smith et al. (2021) reported that hydrotherapy provides a safe environment to strengthen muscles and improve range of motion without additional stress on the joint . Jones et al. (2022) also found that hydrotherapy accelerates recovery and reduces the risk of re-injury. However the lack of specialized rehabilitation programs incorporating hydrotherapy prevents athletes from benefiting fully from these modern techniques. Thus there is a clear need to develop a comprehensive rehabilitation program based on

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P-ISSN: 2073-6452 , E-ISSN: 2707-5729
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hydrotherapy for athletes with partial lateral ankle ligament tears to improve joint range of motion and muscle strength, enabling them to return to sport safely and effectively .

1. Evaluate the effectiveness of a hydrotherapy-based rehabilitation program in improving range of motion and muscle strength in the sample participants.
2. Assess the impact of the rehabilitation program on enhancing range of motion and muscle strength of the muscles surrounding the ankle joint in the injured athletes.
3. Compare post-test results between the experimental and control groups in the studied variables.

Methodology

Design and Participants

An experimental design with two equal groups (experimental and control) was used. The target population consisted of players of team sports (soccer , basketball , volleyball) who were diagnosed with a partial tear of the lateral ankle ligament (moderate severity) in local clubs and sports centers. Ten injured athletes aged 22 to 28 years were included. Due to the limited number of available participants, a total census sampling was employed, with all eligible athletes forming the sample (100% sampling ratio) . The participants were randomly assigned to two groups of five players each : an experimental group and a control group .

The study period extended from March 1, 2024, to September 30, 2024. All interventions and assessments were conducted at the Medical Rehabilitation and Physical Therapy Center at the University of Basra, the Rehabilitation Laboratory at the College of Physical Education and Sports Sciences, and at a local Gold's Gym in Basra .

Research Instruments

- Goniometer : Used to measure the ankle joint range of motion (dorsiflexion , plantarflexion , inversion, eversion) .
- Transcutaneous Electrical Nerve Stimulation (TENS) unit : Used to reduce pain and improve circulation.
- Therapeutic Ultrasound : Used to evaluate and treat the condition of the ligaments and muscles surrounding the joint .
- Magnetic Resonance Imaging (MRI): Used to accurately determine the degree of injury severity .
- Muscle Strength Dynamometer : A hand-held dynamometer to measure muscle strength around the ankle joint .
- Hydrotherapy Equipment : Including therapeutic pools and aqua-resistance devices (e.g., aqua bands) .

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- Statistical Software : Data were analyzed using IBM SPSS Statistics version 25 .

Preliminary (Pilot) Study

A pilot test was conducted on April 15 , 2024 using two athletes outside the main sample . The pilot aimed to ensure the suitability of the equipment, the appropriateness of the aquatic exercises for the participants capabilities and the efficiency of the research team . Any issues were addressed before the main study began .

Pre-Tests

Preliminary measurements of ankle joint range of motion and muscle strength were taken on April 18, 2024 before the start of the rehabilitation program. The goniometer was used to assess joint ROM and the dynamometer was used to measure muscle strength.

Rehabilitation Program

The hydrotherapy-based rehabilitation program was implemented starting April 20, 2024 and lasted for 12 weeks (36 total sessions , 3 sessions per week) . Each session lasted approximately 45–60 minutes . The program consisted of targeted water exercises designed to improve ankle range of motion and strengthen the muscles surrounding the ankle joint . The program was initiated after the acute injury phase during which participants had received initial RICE protocol treatments (Rest , Ice , Compression , Elevation) in the first days post-injury to control swelling and pain .

Key details of the rehabilitation program : - Duration: 12 weeks with 3 sessions per week (36 sessions total) . - Session Length: 45–60 minutes. – Progression : The program was progressive with increasing exercise intensity across weeks .

Program Phases

Phase 1: Weeks 1–3 (Initial Rehabilitation)
- **Goals :** Reduce pain and inflammation , improve local circulation and begin gentle restoration of ankle range of motion .
- **Exercises:**
- *Water Walking :* Walk in the pool at waist depth for 10 minutes . This exercise promotes circulation without stressing the joint .
- *Ankle Circles in Water :* With the affected foot submerged perform circular motions of the ankle in both clockwise and counterclockwise directions 10 repetitions each way . This improves initial joint flexibility .
- *Gentle Calf Stretch :* Using the pool edge perform a calf muscle stretch (knee extended) holding 15 seconds per set 3 sets. This helps relax muscles and improve flexibility .
- **Modalities :**
- *TENS :* Applied to reduce pain and stimulate the muscles .
- *Ultrasound :* Used to expedite healing and reduce inflammation .

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Phase 2: Weeks 4–6 (Improving Range of Motion)
- **Goal:** Increase ankle joint range of motion and further improve surrounding muscle strength .
- **Exercises :**
- *Aquatic Resistance Band Ankle Movements :* Attach aqua-resistance bands to the foot to perform ankle dorsiflexion, plantarflexion , inversion and eversion against water resistance. Perform 3 sets of 12 repetitions in each direction . This strengthens the muscles around the joint.
- *Balance Exercise in Water :* Stand on the injured foot in waist-deep water while lightly supporting oneself with the pool wall or a bar . Hold for 20 seconds. Perform 3 sets. This enhances joint stability .
- *Light Jumping in Water :* Perform gentle jumping on the spot in the water focusing on safe landings . Perform 3 sets of 10 jumps . This improves motor control .
- **Equipment :** Goniometer (to continue measuring ROM) aqua-resistance bands for added resistance .

Phase 3: Weeks 7–9 (Strength Enhancement)
- **Goal:** Increase muscle strength around the ankle and improve motor control and stability .
- **Exercises:**
- *Water Pushing :* In waist-deep water use the affected foot to push water in all directions (forward , backward , sideways) to generate resistance. Perform 4 sets of 15 repetitions . This exercise boosts muscle strength .
- *Aquatic Squats :* Perform squats in the water while maintaining balance (water height around waist or chest) . Perform 3 sets of 12 squats . This strengthens thigh and calf muscles .
- *Water Running :* Run in place in a pool at appropriate depth for 5 minutes . This improves overall fitness .
- **Equipment:** Hand-held dynamometer (for periodic strength assessments) aqua-resistance bands to increase exercise intensity .

Phase 4: Weeks 10–12 (Return to Sports Activity)
- **Goal :** Restore full functional capacity of the ankle joint and prepare the athlete to return to sports .
- **Exercises :**
- *Advanced Directional Jumps:* Perform jumping in water with directional changes (forward , sideways , backward) 4 sets of 10 jumps . This enhances explosive strength .
- *Advanced Balance Drills:* Stand on the injured foot in waist-deep water without support. Hold for 30 seconds. Perform 3 sets . This enhances neuromuscular control .
- *Fast Water Running :* Run in water at a moderate-fast pace for 10 minutes . This improves overall conditioning and readies the athlete for the playing field .
- **Equipment :** MRI (to evaluate the ligament status at program end) ; dynamometer (final strength assessment) .

Notes:
- The program was designed to be progressive with exercise intensity increasing as weeks progressed .

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- Specialized equipment was used to measure progress and periodically evaluate the condition of the athletes .
- Emphasis was placed on aquatic exercises to reduce joint stress while achieving effective outcomes .

Tests and Measurement Procedures

1. **Range of Motion (ROM) Test :** Ankle joint ROM was measured using a goniometer following the standardized protocol described by Norkin and White (2016) Movements included:
2. *Dorsiflexion :* Upward movement of the foot .
3. *Plantarflexion :* Downward movement of the foot .
4. *Inversion :* Movement of the sole toward the midline .
5. *Eversion :* Movement of the sole away from the midline .

Procedure : Participants sat on a chair with the ankle in a neutral position . The goniometer's stationary arm was aligned with the fibula and the moving arm with the metatarsals of the foot . Each movement was performed to the maximum range and the peak angle was recorded. Each measurement was performed three times and the average value was used for analysis (Norkin & White, 2016) .

1. **Muscle Strength Test :** Strength of the muscles around the ankle joint (anterior tibialis , peroneal muscles , gastrocnemius, etc.) was assessed using a hand-held dynamometer according to the protocol described by Stark et al. (2019) .

Procedure : Participants sat on a chair with the tested foot fixed. Resistance was applied by the dynamometer in the directions of dorsiflexion, plantarflexion , inversion and eversion . The maximal force that the participant could resist was recorded for each movement .

1. **Vertical Jump Test :** Participants vertical jump ability was measured using a Vertec jump meter following the standard protocol by Markovic and Sekulic (2020) .

Procedure : The participant stood alongside the Vertec device with one arm extended upwards to set a standing reach height . They then performed a maximal vertical jump and touched the device at peak height . The jump height was determined by the difference between standing reach and jump reach . These values were compared to pre-test values .

1. **Timed Up and Go (TUG) Test :** Functional mobility was assessed using the Timed Up and Go Test (Podsiadlo & Richardson, 1991) .

Procedure : The participant began seated in a chair On the command "go," the participant stood up, walked a distance of 3 meters, turned around , walked back and sat down . The total time to complete this sequence was recorded .

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Statistical Analysis

Data were statistically analyzed using SPSS 25 Descriptive statistics (means and standard deviations) were calculated for all variables. Paired-sample t-tests were conducted to compare pre- and post-test scores within each group and independent-sample t-tests were used to compare post-test results between groups Significance was set at $p < 0.05$.

Results

The results of the study are presented in three tables. Table 1 shows the pre-test and post-test outcomes for the experimental (hydrotherapy) group. Table 2 shows the pre-test and post-test outcomes for the control (traditional therapy) group. Table 3 compares the post-test results between the experimental and control groups.

Table 1. *Statistical Results of Pre-test and Post-test for the Experimental Group (n = 5)*

No.	Variable	Pre-test (Mean)	Post-test (Mean)	Difference (Post – Pre)	SD (Post-Test)	SE (Difference)	t-value	Sig. (2-tailed)
1	Range of Motion (Dorsiflexion)	36.00	44.00	–8.00	4.00	1.51	5.29	.000
2	Range of Motion (Plantarflexion)	13.50	19.50	–6.00	3.00	1.13	5.30	.000
3	Inversion	31.00	39.50	–8.50	4.25	1.60	5.01	.002
4	Muscle Strength	12.01	17.15	–5.14	2.01	0.76	6.76	.000
5	Vertical Jump (m)	0.16	0.47	–0.31	0.15	0.056	5.53	.000
6	TUG Time (sec)	30.00	12.00	18.00	5.50	1.75	10.29	.000

***Note**:* For Range of Motion and strength, higher values indicate improvement. For the TUG test, lower time indicates improvement.

All variables showed statistically significant improvement in the experimental group ($p < .01$) following the 12-week hydrotherapy program. Each paired t-test comparing pre- and post-intervention values yielded p-values well below .05, indicating significant gains in ankle dorsiflexion, plantarflexion, inversion, muscle strength, vertical jump, and a significant decrease in TUG time.

Table 2. *Statistical Results of Pre-test and Post-test for the Control Group (n = 5)*

No.	Variable	Pre-test (Mean)	Post-test (Mean)	Difference (Post – Pre)	SD (Post-Test)	SE (Difference)	t-value	Sig. (2-tailed)
1	Range of Motion (Dorsiflexion)	37.10	39.00	–2.90	3.70	1.38	2.10	.050

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2	Range of Motion (Plantarflexion)	13.80	17.10	–3.30	2.10	0.80	4.12	.014
3	Inversion	30.10	34.90	–4.80	3.30	1.25	3.84	.010
4	Muscle Strength	12.50	13.50	–1.00	1.90	0.70	2.00	.085
5	Vertical Jump (m)	0.23	0.22	–0.01	0.12	0.04	1.40	.217
6	TUG Time (sec)	27.00	25.00	2.00	5.00	1.85	2.50	.058

In the control group, minor improvements were observed in dorsiflexion, plantarflexion, and inversion, but only plantarflexion ($p = .014$) and inversion ($p = .010$) reached significance at $p < .05$. Muscle strength and vertical jump improvements were not statistically significant ($p > .05$), nor was the improvement in TUG time.

Table 3. *Post-Test Comparison Between Experimental and Control Groups*

No.	Variable	Experimental (Post Mean)	Control (Post Mean)	Difference	Favor	Notes
1	Range of Motion (Dorsiflexion)	44.00	39.00	+5.00 ↑	Exp	Marked improvement in exp. group
2	Range of Motion (Plantarflexion)	19.50	17.10	+2.40 ↑	Exp	Good improvement
3	Inversion	39.50	34.90	+4.60 ↑	Exp	Clear difference in favor of exp.
4	Muscle Strength	17.15	13.50	+3.65 ↑	Exp	Large improvement (not significant in control)
5	Vertical Jump (m)	0.47	0.22	+0.25 ↑	Exp	Practically significant difference
6	TUG Time (sec)	12.00	25.00	–13.00 ↓	Exp	Excellent improvement (reduced time)

Table 3 shows that after the intervention, the experimental group outperformed the control group on all measures. The experimental group achieved greater dorsiflexion , plantarflexion, inversion, muscle strength and vertical jump height as well as a significantly faster TUG time (lower is better) compared to the control group. In all cases the direction of improvement favored the experimental group .

Discussion

The results indicate that the 12-week hydrotherapy-based rehabilitation program was effective in improving ankle joint range of motion , muscle strength , balance and functional capacity in athletes with partial lateral ankle ligament tears . These findings underscore the value of aquatic therapy as an effective tool in sports injury rehabilitation . The significant improvements observed in the experimental group are attributed to the carefully designed rehabilitation protocol

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which included specific stretching and strengthening exercises in water . Aquatic exercises can enhance joint flexibility, particularly through the buoyancy and resistance properties of water while minimizing joint stress (Kisner & Colby, 2017; Wang et al., 2007) .

In the context of our program the participants' ankle flexibility improved notably due to dedicated stretching exercises especially those performed in water. Similarly muscle strength around the ankle increased significantly as a result of the progressive resistance training in the aquatic environment . These positive outcomes are consistent with previous research . Dimitrakopoulou et al. (2024) reported that adding water-based exercises to a traditional rehabilitation program significantly shortened the time to return to pre-injury performance levels in athletes following hip arthroscopy and resulted in substantial improvements in pain and overall satisfaction .

Ankle injuries and associated pain directly affect movement leading to muscle weakness around the joint and hindering athletic performance . Doub et al. (2023) emphasized that joints require continuous movement and a wide range of motion to maintain functional mobility . Aquatic therapy provides a low-impact environment that facilitates continuous joint movement without extra stress, thereby improving joint flexibility more rapidly compared to conventional therapy (Wang et al., 2007) . Wang and colleagues found that after a 12-week aquatic exercise program joint flexibility was significantly improved. the resistance provided by water contributes to increasing muscle strength by offering progressive loading of the muscles (Wang et al., 2007) . Norkin and White (2016) also noted that enhanced muscle strength around joints (such as the knee and ankle) serves a protective role in preventing re-injury .

Analysis of Table 3 shows that post-intervention means were higher for the experimental group across all variables . This indicates that the proposed hydrotherapy-based program facilitated more effective recovery of ankle function . The improved results for the experimental group can be attributed to the combined effect of water exercises and land-based exercises in the rehabilitation program . Consistent physical training increases the nervous system’s efficiency in sending signals for muscle contraction, thereby improving strength and endurance (Watanabe et al., 2020). The structured progression of exercises controlled repetitions, and inclusion of hydrotherapy as the primary modality led to the significant improvements observed in the experimental group’s post-test scores compared to the control group .

It should be noted that this does not imply that traditional rehabilitation methods are ineffective. Rather it highlights that modern, comprehensive programs can accelerate recovery time a competitive advantage in sports medicine where teams strive to return injured players to play as quickly as possible. Modern rehabilitation programs can complement , rather than replace , traditional approaches , ultimately achieving faster functional recovery .

Conclusions

The hydrotherapy-based rehabilitation program had a positive impact on accelerating the healing process as evidenced by the restoration of normal range of motion and muscle strength in the experimental group . The test results showed significant improvements in the muscle strength of the ankle joint attributable to the program’s effects .

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Recommendations

It is recommended to adopt the specialized hydrotherapy-based rehabilitation program for treating ankle injuries in athletes . Further research should be conducted on the effects of aquatic therapy on different types of sports injuries and on developing more specific and effective rehabilitation programs. Additionally injured athletes should be encouraged to perform complementary home-based exercises to ensure continuous improvement and maintenance of the gains achieved in the rehabilitation center .

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P-ISSN: 2073-6452 , E-ISSN: 2707-5729
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P-ISSN: 2073-6452 , E-ISSN: 2707-5729

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