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The Effect of Rehabilitative Exercises Using Diverse Aquatic Modalities on Athletes with Rotator Cuff Tendinitis or Tears

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Abstract: *The importance of this study stems from the premise that aquatic exercise can expedite recovery and improve the range of motion and functional strength of the injured shoulder through the use of in-water assistive implements—such as aquatic (foam) dumbbells, floatation boards, and hand paddles—while enhancing neuromuscular responsiveness in individuals with rotator cuff injuries. The study aimed (1) to design a set of rehabilitative exercises employing diverse modalities within an aquatic environment for athletes diagnosed with rotator cuff tendinitis or tears, and (2) to examine the effect of these aquatic rehabilitative exercises on this population. An experimental approach was used, employing a single-group pretest–posttest design appropriate to the study's nature and objectives. The sample comprised six athletes from various sports who had clinically diagnosed rotator cuff tendinitis or tears. Field procedures included trials and tests to measure shoulder joint range of motion (ROM) in the following movements: flexion, extension, abduction, adduction, internal rotation, and external rotation; as well as muscular strength in the same planes (flexion, extension, abduction, adduction, internal rotation, and external rotation). Based on the results obtained, the researcher concluded that rehabilitative exercises utilizing diverse aquatic modalities have a positive effect on the rehabilitation outcomes of the study participants. The findings showed statistically significant differences between pre- and post-measurements for all ROM variables, indicating the effectiveness of the aquatic program in improving the ROM of the injured shoulder. Statistically significant improvements were also recorded in all shoulder muscular strength variables, suggesting that the in-water rehabilitative exercises substantially increased rotator cuff muscle strength in the injured athletes. The researcher recommends incorporating aquatic rehabilitative exercises using varied aquatic implements into return-to-function programs for athletes with rotator cuff injuries, given their clear and significant impact on ROM and muscular strength.*

Keywords: *Rehabilitative Exercises; Diverse Modalities; Aquatic Environment; Rotator Cuff Muscles*

Introduction

A large proportion of athletes—regardless of sport, age, or sex—are exposed to various types of injuries, many of which are directly or indirectly related to the nature of the activity or the skill being performed. Management strategies differ according to the type of injury and typically proceed through several phases, such as surgical intervention (when indicated), rest or convalescence, and rehabilitation to return to activity. Among these, the rehabilitation phase is paramount, as it underpins recovery, safe return to participation, and restoration of function. These stages constitute the fundamentals of reconditioning and warrant rigorous study and scrutiny.

The aquatic environment is one of the most important settings for training and injury rehabilitation. It is generally well accepted by participants and exerts beneficial effects on both physical and psychological health. Aquatic activities have proliferated in modern communities due to the availability of suitable facilities and services, as well as qualified personnel trained to supervise such programs through well-structured exercise regimens aligned with the aims of the training or rehabilitation program. These programs leverage the unique properties of water, which afford a range of resistive forces that can be harnessed for therapeutic purposes, as employed in the present study. As defined by Isam Helmi and Osama Riyad (1987), exercises performed in water are "one of the modalities of physical therapy, comprising kinesiotherapy, electrotherapy, and hydrotherapy; they utilize the upward buoyant force of water as an external resistive force during the execution of voluntary exercises. The aim of any of the foregoing exercises is to restore the injured individual to his or her usual functional status and to enhance it. Accordingly, these exercises are administered by prescribing tasks that simulate the functions performed in daily life or the physical and sport activities practiced. Exercises in water reduce the load on painful joints because of the buoyant property of water" (Helmi & Riyad, 1987, p. 34).

Specialists in sports medicine and orthopedic surgery emphasize the value of aquatic exercise for injured patients, as it places relatively lower stress on bones, joints, and muscles. Several experts have also highlighted the importance of hydro-aerobics in reducing joint pain associated with inflammatory myopathies, restoring joint range of motion (ROM), and re-energizing overall physical function. Moreover, aquatic training contributes to performance enhancement by developing motor capacities such as endurance, coordination, strength, flexibility, balance, and proprioception. These diversified conditioning drills are carried out in swimming pools equipped with contemporary tools, devices, and equipment—many of which are now manufactured using nanotechnology.

In recent years, rapid advances in science and technology have markedly improved training efficiency and the physiology of aquatic physical rehabilitation, through the implementation of diverse conditioning programs in aquatic fitness studios (Water Gym) and aquatic exercise facilities (Aqua Gym). The success of aquatic training and rehabilitation depends to a great extent on the availability of appropriate assistive tools and devices. Incorporating such equipment into aquatic training programs can help develop all components of physical fitness. Among the most prominent modern, technology-enabled tools used for aquatic training and rehabilitation are: the aquatic stationary bicycle, aquatic cycle ergometer, aquatic ball, hand paddles, buoyant (foam) dumbbells, swim fins, kickboard, buoyant bar or flotation noodle, flotation vest, aqua step equipment, and free weights/weighted implements.

Musculoskeletal injuries remain among the most significant challenges facing athletes across disciplines, with the shoulder joint being particularly susceptible due to its complex kinematics and reliance on muscular balance and dynamic stabilization. Among the most common shoulder disorders are rotator cuff injuries (tendinitis and tears), frequently associated with repetitive overhead activities in sports such as swimming, volleyball, handball, and weightlifting. These injuries pose a direct threat to athletic performance by causing pain, restricted movement, and impaired glenohumeral stability. Because a timely and safe return to competition requires comprehensive and effective rehabilitation, interest has grown in recent years in aquatic rehabilitation, which capitalizes on the physical properties of water to reduce joint loading, promote movement without excessive mechanical stress, and provide progressive, safe resistance.

Against this backdrop, the significance of the present research lies in the premise that aquatic exercises can accelerate recovery and improve the range of motion and functional strength of the injured shoulder through the use of in-water assistive implements—such as buoyant dumbbells, kickboards, and hand paddles—while enhancing neuromuscular responsiveness in athletes with rotator cuff injuries.

Problem Statement

Despite substantial advances in sports rehabilitation, rotator cuff injuries continue to pose a major challenge for athletes and coaches, as they impede performance and prolong return-to-activity timelines. Conventional land-based rehabilitation programs may be insufficient in the early stages of recovery, particularly in cases that require minimizing mechanical load on the injured joint.

Although preliminary evidence supports the efficacy of aquatic exercises, most studies lack a comprehensive methodological framework that integrates multiple in-water modalities within a structured rehabilitation program—especially when applied to athletes who must return to high levels of functional performance. The scarcity of applied research specifically targeting athlete populations makes it difficult to recommend a standardized, practically implementable model in clubs and clinical settings.

A research gap therefore persists, reflected in the paucity of studies evaluating the effectiveness of rehabilitative exercises that employ diverse tools in the aquatic environment within a direct, athlete-focused application—particularly in Arabic-speaking contexts.

From this standpoint, the present study seeks to examine the impact of a standardized aquatic rehabilitation program that incorporates a variety of tools—such as hand paddles, buoyant (foam) dumbbells, swim fins, kickboards, and aqua-step equipment—on improving motor and functional indicators in athletes diagnosed with rotator cuff tendinitis or tears.

Drawing on the researcher's review of rehabilitative methods and observations of how patients perform post-treatment exercises, this problem is addressed through a proposed rehabilitation protocol reinforced by aquatic-based exercises.

Research Question

To what extent are rehabilitative exercises using diverse modalities within an aquatic environment effective in improving functional status and motor performance among athletes with rotator cuff tendinitis or tears?

This question underscores the need to design an integrated rehabilitation program that leverages the properties of water and relies on varied tools to restore muscle balance and range of motion (ROM) while reducing the risk of relapse or reinjury.

Objectives

1. Preparing rehabilitative exercises using diverse modalities within an aquatic environment for the study sample of athletes diagnosed with rotator cuff tendinitis or tears.
2. To determine the effect of these aquatic rehabilitative exercises—which employ varied in-water tools—on athletes with rotator cuff tendinitis or tears.

Methodology

Research Design

The researcher employed an experimental approach using a single-group pretest–posttest design, in line with the nature and objectives of the study.

Sample

The study sample consisted of six (6) athletes from various sports who had a clinically diagnosed rotator cuff tendinitis or tear. Participants were recruited from attendees of the Rehabilitation Center for Physical Therapy at Baqubah Teaching Hospital, in addition to several private clinics specializing in joint and fracture disorders.

Injuries were diagnosed by a specialist physician based on clinical examination, then confirmed by radiographic imaging (X-ray), and participants received prescribed pharmacotherapy. To ensure the accuracy of the results, statistical homogeneity testing was conducted for the following variables: age, height, weight, and injury duration, as shown in Table 1.

***Table 1. Descriptive characteristics of the study sample (age, height, weight, injury duration)* (n = 6)**

No.	Variable	Unit	Mean	Median	Standard Deviation	Skewness
1	Age	years	19.8333	19.5000	1.47196	0.418
2	Height	cm	178.0000	177.5000	2.60768	0.609
3	Weight	kg	83.5000	83.5000	3.72827	0.000
4	Injury duration	days	21.1667	20.5000	2.71416	1.179

Instruments and Equipment Used in the Study

- Digital video cameras (Sony), $n = 2$, for recording tests and exercise sessions
- Personal computers (Dell), $n = 2$
- Body-mass (weight) scale
- Stopwatches, $n = 2$
- Compact discs (CDs)
- Data extraction/recording forms
- Fabric tape measure (10 m)
- Aquatic dumbbells (Aqua Dumbbells)
- Hand paddles / resistance gloves
- Aqua bar / pool noodle stick
- Kickboard

- Aqua fins (upper-body fins)
- Small foam floats / discs
- Aquatic resistance bands (Aqua Bands)

Measurements and Tests Used in the Study

First: Measurement of Shoulder Joint Range of Motion (ROM)

Shoulder ROM was measured for the following primary movements: flexion**,** extension**,** abduction**,** adduction**,** internal rotation**,** and external rotation (aladin, Kenneth, 2015, p. 296).

1) Measurement of Shoulder Flexion ROM

Two procedures were used:

Method 1 (Seated position):

The examinee sits with the arm relaxed at the side in the starting (neutral) position. The axis of motion is identified at the inferior point of the acromion (scapula), on the lateral aspect of the arm. The stationary arm of the goniometer is aligned with the body's midline alongside the humerus, then the examinee is instructed to raise the arm anteriorly and then superiorly in the sagittal plane, maintaining the elbow in extension throughout the movement.

Method 2 (Supine position):

The examinee lies supine with the knees flexed to help maintain spinal alignment. The stationary arm of the goniometer is placed parallel to the trunk, while the moving arm is aligned with the humerus. The examinee raises the arm overhead to the maximum possible range without pain or evident resistance. The resulting angle is recorded using a goniometer**. The** normal ROM for shoulder flexion **is** 0–180°**.**

2) Measurement of Shoulder Joint ROM in Extension

(Cynthia C. Norkin, PT, EdD; Joyce White, PT, DSc, 2016, p. 80)

The range of motion of shoulder flexion is measured using a goniometer through two common procedures:

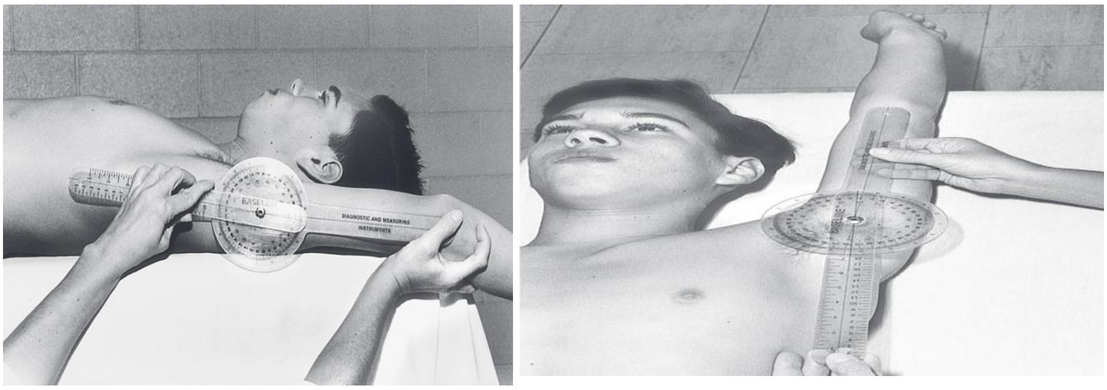
Method 1 (Seated position):

The examinee sits with the arm relaxed at the side in the starting (neutral) position (hanging downward). The axis of motion is identified at the point below the acromion (scapula) on the lateral aspect of the arm. The arm is stabilized parallel to the body's midline along the humerus, then the examinee is instructed to raise the arm anteriorly and then superiorly in the sagittal plane, maintaining elbow extension throughout the movement.

Method 2 (Supine position):

The examinee lies supine with the knees flexed to maintain spinal alignment. The stationary arm of the goniometer is fixed along the trunk, while the moving arm is aligned with the humerus. The examinee raises the arm overhead to the maximum possible range without pain or resistance.

The angle is recorded using the goniometer, and the normal ROM for shoulder



flexion is 0–180°.

Figure 1 illustrates measurement of shoulder flexion range of motion (ROM).

1) Measurement of Shoulder Abduction ROM

(Cynthia C. Norkin, PT, EdD; Joyce White, PT, DSc, 2016, p. 84)

Method 1 (Seated

The examinee sits with the arm relaxed at the side in the starting position. The axis of the goniometer is placed over the acromial process of the scapula, at the posterior aspect of the shoulder. The stationary arm is oriented toward the floor, while the moving arm follows the humerus**.** The examinee is instructed to raise the arm laterally and then upward in the frontal (coronal) plane**,** maintaining the elbow in extension throughout the motion.

Method 2 (Supine):

The examinee lies supine with both arms alongside the body. The stationary arm of the goniometer is aligned with the trunk, and the moving arm is aligned with the humerus. The examinee abducts the shoulder by lifting the arm laterally and upward away from the body until the onset of resistance or pain.

Record the angle using the goniometer. The normal ROM for shoulder abduction **is** 0–180°**.**

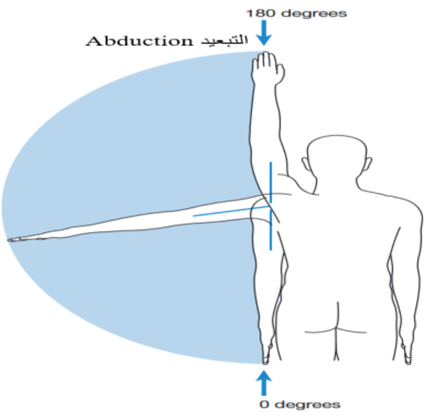


Figure 2 illustrates the measurement of shoulder abduction ROM.

Measurement of Shoulder Internal Rotation ROM

The examinee lies supine. The elbow is positioned on the table. Place the goniometer axis over the olecranon process at the elbow, aligned with the proximal ulna. The arm is stabilized along the body's midline (at the side), and the forearm is held vertical with the elbow at **90°** flexion. The examinee then rotates the shoulder internally, moving the forearm toward the feet along the long axis of the ulna. The thorax may be stabilized to prevent trunk flexion or rotation. Record the angle with the goniometer**.** The normal ROM for shoulder internal rotation, relative to the vertical**,** is 0–70°**.**

Figure 4 illustrates the measurement of shoulder internal rotation ROM.

Measurement of Shoulder External Rotation ROM

The examinee lies supine. The elbow is positioned on the table. Place the goniometer axis over the olecranon process at the elbow. The arm is stabilized along the body's midline (at the side), and the forearm is held vertical with the elbow at 90° flexion. The examinee then rotates the shoulder externally, moving the forearm toward the head along the long axis of the ulna. The thorax may be stabilized to prevent trunk flexion or rotation. Record the angle using the goniometer. The normal ROM for shoulder external rotation, relative to the vertical, is 0–80°.

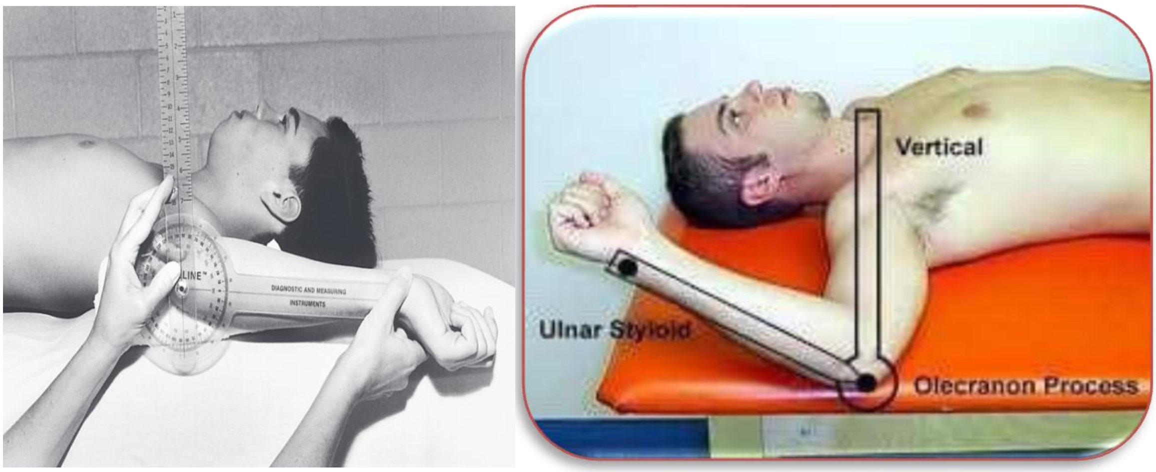


Figure 5 illustrates the measurement of shoulder external rotation ROM.

Second: Measurement of the Muscular Strength of the Shoulder Musculature

Muscular strength of the muscles acting on the shoulder joint was assessed in **five primary movements** *(Klaus Buckup, 2004, p. 108)*:

1. **Flexion strength test**

   The examinee sits on a chair; the dynamometer **is** anchored to the floor, with the trunk upright, gaze forward, and the arm **e**xtended downward**,** grasping the device's handle connected by a **cable** to the floor-fixed unit. At the agreed signal, the examinee lifts the injured arm anteriorly and upward in the sagittal plane with maximal effort.

   Outcome: record shoulder flexion maximal force for the injured arm to the nearest kilogram as displayed by the device.

2. **Extension strength test**

   Set-up as above: seated posture, dynamometer anchored to the floor, arm extended downward holding the connected handle. At the agreed signal, the examinee moves the injured arm posteriorly and upward in the sagittal plane with maximal effort.

   Outcome: record shoulder extension maximal force to the nearest kilogram**.**

3. **Abduction strength test**

   With the same seated set-up (dynamometer anchored to the floor; handle connected by cable), the examinee—at the agreed signal—abducts the injured arm laterally and upward, away from the trunk, with maximal effort.

   Outcome: record shoulder abduction maximal force to the nearest kilogram**.**

4. **Internal rotation strength test**

   The examinee lies supine with the elbow supported on a flat surface at the side of the body. The axis of motion is aligned with the olecranon in line with the proximal ulna; the arm is stabilized along the body's midline. The examinee grasps the handle attached to the wall-mounted dynamometer via a cable oriented parallel to the body in supine. At the agreed signal, the examinee performs internal rotation of the injured shoulder with maximal effort.

   Outcome: record shoulder internal-rotation maximal force to the nearest kilogram.

5. **External rotation strength test**

   From the same supine position with the elbow supported beside the body (axis aligned with the olecranon/proximal ulna, arm stabilized along the midline), the examinee grasps the handle connected to the wall-mounted device with the cable running parallel to the body. At the agreed signal, the examinee performs external rotation of the injured shoulder with maximal effort.

   Outcome: record shoulder external-rotation maximal force to the nearest kilogram**.**

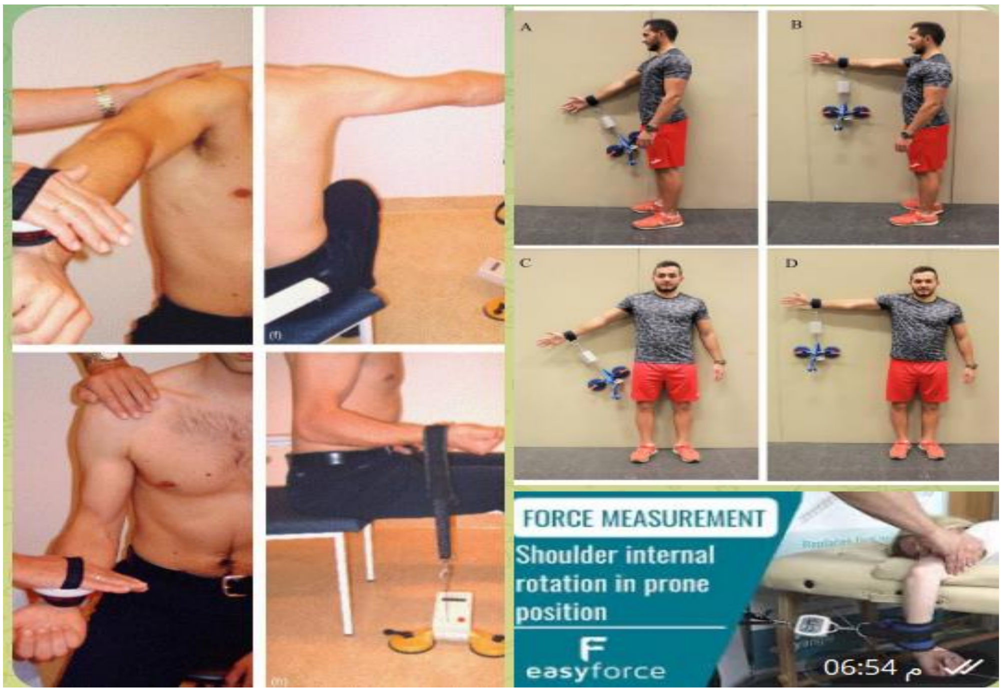


Figure 6 illustrates the measurement of shoulder-muscle strength in flexion, extension, abduction, and in external and internal rotation.

Pilot Study (Exploratory Trial):

The pilot study was conducted on Monday, May 5, 2025, in the Physiology Laboratory at the College of Physical Education and Sport Sciences. It aimed to:

1. Evaluate the suitability of the tests for the participants' level in terms of difficulty and physical capacity.
2. Verify the adequacy of the testing venue (space, equipment) and its fitness for implementing the required procedures.
3. Assess participants' understanding of the nature of the tests and the manner of their execution.
4. Evaluate the efficiency of the assisting team with respect to staffing and their ability to perform assigned tasks accurately and competently.
5. Estimate the time required to administer each test and the total duration needed to complete all tests.
6. Prepare the assisting team by briefing them on the workflow and clearly distributing tasks to ensure smooth implementation.

Pretests (Baseline Assessments)

The pretests were administered at different times for each participant, and on more than one occasion, due to the difficulty of assembling all injured participants simultaneously. The first test session for a participant commenced on Wednesday, May 7, 2025, after all research requirements had been fulfilled.

Rehabilitation Program

A therapeutic aquatic rehabilitation program employing a variety of implements and tools was designed to rehabilitate athletes diagnosed with rotator cuff tendinitis or tears, with the aim of restoring full shoulder joint range of motion (ROM) in all planes. The program was initiated 2–3 weeks after commencement of medical treatment and continued for 6 weeks, with three rehabilitation sessions per week.

Foundations for Program Design

1. Adherence to the principle of progression—from easy to difficult and from simple to complex.
2. Ensuring variety within each session to avoid boredom and enhance motivation.
3. Direct supervision by a specialist physician during exercise execution to address any complications.
4. Session duration: 35–40 minutes per session.
5. Each session comprised six rehabilitative exercises (both **isometric** and dynamic).
6. Duration allotted per exercise within the session: 10–15 minutes, depending on the participant's condition.
7. Repetitions: 10–12 repetitions × 2–3 sets.
8. Acceptable pain threshold: no more than mild discomfort; any sharp pain requires immediate cessation of the exercise.

Implementation Timeline

Due to variability in injury onset across participants, program initiation dates differed. The first participant began on Monday, May 12, 2025, and the last participant completed the program on Wednesday, July 9, 2025. Each athlete completed 18 rehabilitation sessions, each lasting 35–40 minutes.

Program Structure and Equipment

The program was divided into four rehabilitation stages, each with defined objectives and specific methods. The following tools and implements suitable for shoulder injuries were used in the aquatic environment:

1. Aquatic dumbbells (Aqua Dumbbells): provide light-to-moderate resistance depending on size and buoyancy; used for lateral raises, forward presses, and internal/external rotation drills.
2. Hand paddles / resistance gloves: increase resistance during movement; used in swimming-type or pressing actions to improve motor control.
3. Aqua bar / pool noodle stick: supports balance and is used for coordination and stability exercises; can be used bilaterally for front raises or downward presses.
4. Kickboard: provides support for the injured arm when needed or for pressing drills; assists with forward pushing strength and motor control.
5. Aqua fins (upper-body fins): offer excellent water resistance and help activate deep shoulder musculature.
6. Small foam floats / discs: used to modify resistance or provide support as required, offering additional assistance or light resistance.
7. Aqua bands (if available): provide adjustable resistance with joint support; used to strengthen internal and external rotation of the shoulder.

Rehabilitation Stages

Stage 1: ROM Restoration

Duration: 2 weeks

Objectives:

1. Reduce pain caused by tear or inflammation.
2. Initiate light muscular activation around the shoulder joint.
3. Begin early movement with minimal joint loading.

Stage 2: Muscular Balance and Motor Control

Duration: 4 weeks

Objectives:

1. Activate the prime movers of the shoulder.
2. Restore physiological ROM across all joint movements.
3. Improve intermuscular coordination and movement control.

Stage 3: Rotator Cuff Strengthening

Duration: spans the final weeks of the program

Objectives:

1. Increase strength of the deep stabilizers responsible for glenohumeral stabilization.
2. Enhance dynamic stability during movement.

Stage 4: Functional Rebalancing and Muscular Endurance

Duration: at the conclusion of the program

Objectives:

1. Develop capacity to perform daily and sport-specific functional tasks.
2. Increase muscular endurance of the joint during sustained activity.

9.2. Posttests

Post-intervention assessments were conducted on different dates across participants. The final posttest was administered on Sunday, July 13, 2025, following completion of the rehabilitation period, and replicated the same procedures and environmental conditions as the pretests.

Statistical Procedures

Data were processed using the Statistical Package for the Social Sciences (SPSS).

Result and Discussion

Presentation of the Pre–Post Test Results for the Study Variables, with Analysis and Discussion

Table 2. Means, standard deviations, and standard errors for shoulder ROM variables

Variable	Unit	Test	Mean	SD	SE
Flexion	degrees	Pre	145.0000	4.47214	1.82574
		Post	179.0000	0.89443	0.36515
Extension	degrees	Pre	38.1667	2.85774	1.16667
		Post	59.0000	1.26491	0.51640
Abduction	degrees	Pre	140.8333	3.76386	1.53659

		Post	179.0000	2.00000	0.81650
Internal rotation	degrees	Pre	37.00000	2.68328	1.09545
		Post	58.83336	1.32913	0.54263
External rotation	degrees	Pre	46.16673	3.92005	1.60035
		Post	76.83338	4.02078	1.64148

From Table 2, the mean values and standard deviations for the pre- and posttest measurements of all ROM variables are shown.

Table 3. Mean differences, SD of differences, standard errors, and calculated **t** *values for ROM variables*

Variable	Mean diff. (Pre − Post)	SD of diff.	SE	*t* value	Sig. (p)	Decision
Flexion	−34.00000	3.84708	1.57056	21.648	0.000	Significant
Extension	−20.83333	3.48807	1.42400	14.630	0.000	Significant
Abduction	−38.16667	2.48328	1.01379	37.647	0.000	Significant
Internal rotation	−21.83333	3.37145	1.37639	15.863	0.000	Significant
External rotation	−30.66667	6.97615	2.84800	10.768	0.000	Significant

(df = 5; significance assessed at α = 0.05)

Significance criterion as reported: "Significant at (Sig) … and df (5)." is Sig ≤ 0.05.

Table 4. Means, standard deviations, and standard errors for muscular strength variables

Variable	Unit	Test	Mean	SD	SE
Flexion strength	*(unit as recorded)*	Pre	6.6667	1.21106	0.49441
		Post	15.0000	1.09545	0.44721
Extension strength	*(unit as recorded)*	Pre	5.8333	0.98319	0.40139
		Post	11.1667	0.75277	0.30732
Abduction strength	*(unit as recorded)*	Pre	7.3333	1.03280	0.42164
		Post	13.1667	1.72240	0.70317
Internal-rotation strength	*(unit as recorded)*	Pre	5.6667	0.51640	0.21082
		Post	11.0000	0.89443	0.36515

External-rotation strength	*(unit as recorded)*	Pre	5.0000	0.89443	0.36515
		Post	9.6667	1.21106	0.49441

From Table 4, the mean values and standard deviations for the pre- and posttest measurements of all muscular strength variables are presented.

Table 5. Mean differences, SD of differences, standard errors, and calculated* t *values for muscular strength variables

Variable	**Mean diff. (Pre − Post)**	**SD of diff.**	**SE**	***t* value**	**Sig. (p)**	**Decision**
Flexion strength	−8.33333	2.06559	0.84327	9.882	0.000	Significant
Extension strength	−5.33333	1.21106	0.49441	10.787	0.000	Significant
Abduction strength	−5.83333	0.98319	0.40139	14.533	0.000	Significant
Internal-rotation strength	−5.33333	1.21106	0.49441	10.787	0.000	Significant
External-rotation strength	−4.66667	0.81650	0.33333	14.000	0.000	Significant

(df = 5; significance assessed at α = 0.05).

Significance criterion as reported: "Significant at (Sig) … and df (5)." Sig ≤ 0.05**.**

Comparative Analysis and Discussion

When the results are compared at the $\alpha = 0.05$ significance level, the differences are statistically significant in favor of the posttest for all shoulder ROM variables and all muscular strength variables. This provides an indicator of injury recovery and restoration of muscle function. The researcher attributes these outcomes to the aquatic exercises performed with assistive devices, which facilitated a gradual, symptom-guided return toward pre-injury status.

Hydrotherapy refers to the therapeutic use of water in all its forms and applications. It rests on the premise that water is a fundamental element for good health, and its core therapeutic function is the **de**livery of heat or cold to elicit mechanical and chemical stimulation with curative intent. Hydrotherapy is employed for preparation and warm-up and to facilitate therapeutic exercise, acting upon the body surface and internal organs, influencing circulation and core temperature, and exerting positive effects on metabolism, the nervous system, blood constituents, and endocrine secretions. It also has psychological benefits, as heat can stimulate positive energy in the body and affect the fine components of cells—electrons and ions, etc. (Haseeb & Reda, 2017, p. 156).

Hydrotherapy is considered a branch of physical therapy, and physical therapy and rehabilitation are integral components of modern sports medicine, aimed at restoring motor and skill capacities lost due to sports injuries. This field applies selected principles from the physical sciences in a regulated manner and, guided by medical examinations that determine the type of injury, the physical therapist designs a treatment plan appropriate to the nature of the condition, with the goal of restoring the functional activity of the affected limb and returning it to its normal state (Muqbil, 2015, p. 56).

According to Samia Khalil Muhammad (2010), hydrotherapy encompasses all external uses of fluids for therapeutic purposes, with water being the most suitable medium due to its ease of phase change, its efficiency in transferring heat and cold to the human body, and its strong absorptive capacity and precise thermal conduction. Hydrotherapy falls within the spectrum of complementary/alternative medical treatments that employ water to alleviate certain disease symptoms, relieve pain, or cleanse the gastrointestinal tract of toxins and food residues. It is also used in programs that include stretching, strengthening, balance training, gait training, and manual therapy to rehabilitate patients (S. Muhammad, 2010, p. 157).

Jürgen Innenmoser (2006, p. 133) notes that the mechanical effects of the aquatic environment arise when water is set in continuous motion, allowing the immersed body to benefit from mechanical actions that aid in cleansing wounds, countering inflammation, promoting recovery, and alleviating pain.

In the context of athletic rehabilitation, **Mc**anada and Lyndo Huey (1993, p. 62) report that aquatic exercises contribute to the rehabilitation of a wide range of sports injuries and the resolution of their sequelae, returning the injured athlete to pre-injury health and facilitating a gradual restoration of sports performance—thus achieving the overarching objective of the rehabilitation program.

Similarly, **Imad Sardah and Faleh Abu Eid (2013, p. 37)** concur that hydrotherapy supports rehabilitation by providing an opportunity for graded, high-quality work, fostering the development of weakened muscle groups, helping the injured person regain muscle tone lost due to injury, and promoting relaxation. Patients also tend to be more receptive to performing rehabilitative exercises in water; moreover, **sw**imming pools are widely used for convalescence and recreation.

Finally, **Lorin Thein and Paul Richley (2009, p. 48)** emphasize that rehabilitative exercises can be performed more easily in water because the laws of buoyancy reduce the body's apparent weight in water. This lessens joint loading and eases execution of movements, thereby facilitating flexibility and strength exercises in injured joints and weakened muscles. Aquatic sessions also enhance relaxation, which may reduce the risk of reinjury during rehabilitation.

Medhat Qasim (2018) states, "The aim of rehabilitation is vital for returning the injured part to its normal condition by strengthening the joints, muscles, and ligaments that have been weakened by injury; among the objectives of rehabilitation are…" (Qasim, 2018, p. 18).

This is echoed by Jamal Sabri (2011): "Muscular strength helps improve health by enhancing the stabilization of the muscles and joints, and it provides the capacity to cope with many sudden injuries." (Sabri, 2011, p. 415).

Similarly, Osama Riyadh (2002) notes that "exercise is one of the means through which the functional activity of the injured limb is restored to a state as close as possible to its condition prior to injury." (Riyadh, 2002, p. 111).

Essam Helmi (2008) affirms that exercises performed in a swimming pool and hydrotherapy have positive effects on the body: immersion increases hydrostatic pressure, which enhances the efficiency of venous circulation and the speed of venous return to the heart, thereby improving cardiac function and overall circulation. In addition, the frictional resistance of water is used therapeutically to strengthen weakened muscles following injury. (Helmi, 2008, p. 153).

Abu al-Ela Abdelfattah (1999) reports that "hydrotherapy is used for multiple purposes and in the treatment of many injuries. It relies on exposure to applications of cold and tepid water to stimulate blood circulation, strengthen the body, and alleviate pain." (Abdelfattah, 1999, p. 223).

Exercises performed in water are among the modalities of physical therapy within kinesiotherapy. Water—representing the most important of fluids in its various forms (gaseous, liquid, and solid)—is characterized by its ease of changing from one state to another and its excellent heat-transfer properties. Thus, it is an ideal medium for delivering heat or cold to the human body and has a superior capacity, compared with air for example, to absorb and systematically dissipate heat. (Riyadh & Al-Najmi, 1999, p. 47).

Emad Sardah and Faleh Abu Eid (2013) likewise agree that "hydrotherapy contributes to rehabilitation and offers an opportunity for graded, well-structured work; it promotes the development of weak muscle groups, helps the injured person regain the muscle tone lost due to injury, facilitates relaxation, and makes patients more receptive to performing rehabilitative exercises in the aquatic environment, given that swimming pools are also used for convalescence and recreation." (Sardah & Abu Eid, 2013, p. 37).

Conclusion

In light of the obtained results, the researcher concluded that rehabilitative exercises employing diverse aquatic modalities exert a positive effect on the rehabilitation outcomes of the study participants. The study demonstrated statistically significant pre–post differences across all shoulder ROM variables—flexion, extension, abduction, internal rotation, and external rotation—indicating the effectiveness of the aquatic program in improving the range of motion of the injured shoulder. Likewise, statistically significant improvements were recorded between the pretests and posttests for all shoulder muscular strength variables (flexion, extension, abduction, internal rotation, and external rotation), suggesting that in-water rehabilitative exercises contributed substantially to increasing rotator cuff muscle strength in the injured athletes. The use of varied aquatic implements (aquatic dumbbells, hand paddles, flotation bar/pool noodle, kickboard, upper-body fins, small foam floats, and aquatic resistance bands) promoted comprehensive activation of periarticular musculature and safe stimulation of deep stabilizers without imposing direct mechanical load on the injured joint.

Recommendations

The researcher recommends integrating aquatic rehabilitative exercises using varied aquatic tools into return-to-function programs for athletes with rotator cuff injuries, given their clear and statistically significant impact on ROM and muscular strength. It is essential to apply the principle of gradual progression in resistance and intensity during aquatic rehabilitation to ensure stepwise tissue adaptation and prevent excessive strain. Sports rehabilitation centers are encouraged to provide appropriate aquatic implements (aquatic dumbbells, hand paddles, upper-body fins, aquatic resistance bands) to enhance program integration and effectiveness. Future research should involve larger samples and diverse age groups and sport disciplines to verify the effectiveness of aquatic rehabilitation programs across different types of shoulder and muscular injuries.

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