



THE EFFECT OF REHABILITATION EXERCISES IN AQUATIC SETTINGS ON ENHANCING THE FUNCTIONALITY OF DAMAGED ANKLE JOINTS IN YOUNG HANDBALL ATHLETES

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ABSTRACT

Background. Sports activities serve as a significant medium for self-expression while also captivating public interest due to their inherent excitement and thrill. Consequently, these activities have experienced considerable advancement in their performance techniques and practice prerequisites. Participation in sporting activities imposes diverse stresses on muscles, joints, and ligaments, resulting in the potential for injuries of varied severity in different body regions, contingent upon the specific activity undertaken. Moreover, the direct interaction among players heightens the probability of injuries. **Objectives.** The aim of the study was to develop rehabilitative exercises by the use of an aquatic facility to enhance the efficiency of the injured ankle joint in the case of the young handball players. **Method.** The investigator applied the experimental approach that is appropriate to this issue, where the pre-test and the post-test were one-group. The sample used in the study was not random and included only young players (16-18 years old) in clubs in Maysan Governorate who were injured and performed rehabilitation exercises as a follow-up after a medical recovery period and this number constituted 8 players. **Results.** The results showed significant differences between the pre-test and post-test for the experimental group, favoring the post-test. The researcher attributes this improvement to the role of rehabilitation exercises in the aquatic environment that were designed and applied to individuals with ankle injuries. These exercises were organized, contributing to increased flexibility of the tissues surrounding the ankle joint, which led to improved elasticity of the ligaments and joints. The researcher attributes the improvement in injury levels to the aquatic environment, as it is considered an ideal place for muscle and joint injuries. **Conclusion.** The following conclusions and recommendations were the most important in the study: the use of rehabilitation exercises based on aquatic environment positively influenced the increase and the improvement of the range of motion of the ankle joint. Moreover, the use of rehabilitation exercise in water also helped in enhancing muscular strength that helps in the support of the ankle joint.

Keywords; exercises, rehabilitation, aquatic environment, injuries, ankle joint, handball, youth.



A. INTRODUCTION

In contemporary society, sports symbolize the progress taking place in nations across various socioeconomic, civilizational, and cultural dimensions. Sports activities serve as a significant medium for self-expression while also captivating public interest due to their inherent excitement and thrill. Consequently, these activities have experienced considerable advancement in their performance techniques and practice prerequisites. Participation in sporting activities imposes diverse stresses on muscles, joints, and ligaments, resulting in the potential for injuries of varied severity in different body regions, contingent upon the specific activity undertaken. Moreover, the direct interaction among players heightens the probability of injuries.

Handball is regarded as a sport with a high incidence of injuries, attributed to the competitive character and physical contact among players. The game's rapid pace and competitive nature necessitate direct and frequent contact among players, hence elevating the risk of injuries, especially to the lower extremities. The ankle joint damage is significant, particularly in handball, as it is crucial for fundamental movements, rendering it susceptible to injury.

The aquatic environment plays an important role in rehabilitation, as hydrotherapy exercises significantly contribute to injury recovery due to its unique properties that reduce body weight and provide moderate resistance, allowing exercises to be performed safely. Therefore, the importance of the study lies in preparing rehabilitation exercises in an aquatic environment, as it helps accelerate the healing process, reduce the recurrence of injuries, and return players to the field as quickly as possible. Additionally, it raises health awareness among players and coaches about the nature of ankle injuries, their mechanisms, and how to smartly deal with them based on precise scientific principles.

Research Problem

Based on the peculiarities of handball as a sport with its performance and physical skills, which are defined by the quick physical and skillful actions, and include a number of movements, such as sprinting, jumping, changing direction, and sudden stops, all of this predetermines the risk of injuries, in particular, to the ankle joint. By way of the practical experience that the researcher has had being a specialist in the field of physical therapy and also a former player, he has seen himself witness several cases of ankle injury, especially those that involve young people (youth and juniors) in high numbers. It causes deformities or complications that contribute significantly to retirement and have many players out of the fields and the games they play because there have been no specialized rehabilitation exercises to safely reintegrate the players into the fields and their sporting activities. The scientific inability to carry out proper physical preparation at the right stages of early development increases the chances of developing recurrent injuries in the future. The researcher therefore decided to come up with rehabilitation exercises that make use of water techniques, due to the unique nature of such a medium which is not similar to the earth in terms of density and gravity. These components decrease the stress on the ankle joint and provide safe resistance in the course of activity, the purpose of which is to heal the injury, reduce it, and make the recovery as quick as possible. The task is to provide a safe and effective reintegration of injured athletes into their sporting activities.

Research objectives

1. Identifying ankle joint injuries pertinent to adolescent handball athletes.

2. Developing rehabilitation exercises in an aquatic setting to enhance the functionality of the damaged ankle joint in young handball athletes.
3. Execution of rehabilitation exercises in an aquatic environment to enhance the functionality of the damaged ankle joint in young handball athletes.

Hypothesis for investigation

Statistically significant variations exist in the application of rehabilitation activities for the damaged ankle joint among young handball players in the experimental group.

B. METHOD

A fundamental aspect of the study is the selection of an acceptable methodology, which must correspond to the nature of the topic being addressed. In light of the problem's nature, the researcher employed an experimental approach appropriate for the issue, constructing a single equivalent group with pre-test and post-test assessments. This allows for the examination of the effects of rehabilitative exercises on specific ankle injuries.

Research sample

The research sample was selected intentionally, consisting of young players (16-18 years old) from the clubs of Maysan Governorate who are injured, with a total of 8 players undergoing rehabilitation exercises after medical recovery.

Research tools and devices

1. An inclinometer to measure the range of motion.
2. The multi gym device for measuring strength.
3. Stopwatch.
4. Whistle.
5. Handheld calculator.
6. A small stick.
7. Adhesive tapes.
8. A small rope.
9. Low wooden board.
10. Swedish seat (box).
11. Iron bar.
12. A wooden box with a height of 20 cm and dimensions of 50 × 50 cm.
13. Colored cones
14. Rubber bands

Methods of gathering information

1. Scientific and foreign sources.
2. Tests and measurement.
3. Scientific observation.
4. Personal interviews.
5. Questionnaire form (for experts and doctors)

Field research procedures

1. Determining the specific tests for identifying the injury

Given the importance of the subject in the field of diagnosis and injury determination, it was necessary to review the scientific sources related to the topic as well as conduct personal interviews with specialists. Based on this, the researcher prepared a set of specific tests that

can be relied upon to determine the injury. The researcher then arrived at a number of scientific methods that can be relied upon to achieve the research objectives, which are:

Radiological Examination

In order to accurately select the sample and ensure their ankle joint injury, as well as to diagnose the type and severity of the injury, radiographic examination (X-rays) was relied upon as it is an important and approved tool in diagnosing the degree of injury, in addition to indicating the extent of recovery after exercises by presenting the radiographic image to a specialist doctor in the field of joints. This method is considered successful in the field of diagnosis as the devices used are highly precise and the evaluation is conducted by an expert specialist. The results of the radiographic examination were relied upon in selecting the sample to ensure the accuracy of scientific procedures and the safety of the players. Consequently, a rehabilitation program was prepared according to the severity and degree of the injury, and radiographic examinations were conducted every two weeks for prevention and to monitor the continuous improvement of the injury.

Tests Used in the Research

1. Ankle Joint Range of Motion Test Using a Goniometer: (Al-Awadi, 2009, pages 29-30)

The range of motion test for the ankle joint is represented by measuring the joint angles as well as the degree of improvement in joint movement using a Goniometer. This device is designed to measure the required angles thru various readings that correspond to the nature of the sample individuals and the type of injury, as illustrated in Figure (1).



Figure 1. The device (Goinometer) is illustrated.

1. The purpose of the test: Measuring the angles (range of motion) of the ankle joint in different directions.
2. Possibilities and tools: A wooden box with a height of 20 cm and a top surface area of 50 × 50 cm, a Goniometer, and adhesive tapes.
3. Performance specifications: The affected person performs the test in different directions to measure the range of motion of the joint in four directions: flexion, extension, internal rotation, and external rotation, as shown in Figure (2).



Figure 2. It illustrates the method for measuring the approximation, abduction, and deviation of the ankle joint inward and outward.

The tester places the foot on the box after securing the goniometer with adhesive tapes to the box so that the angle between the leg and the foot is at a 90-degree angle. Then, the subject performs joint movements in different directions (flexion, extension, inward rotation, and outward rotation), and the values of those angles are extracted.

- Recording: The angles are recorded in all four directions after fixing the arms of the Goniometer to the maximum range of motion the joint can reach without feeling pain.
2. Test of the strength of the muscles working on the ankle joint: (Al-Awadi, 2009, pages 31-32)

The test of the strength of the muscles working on the ankle joint is represented by overcoming resistances in kilograms that the patient can push using the joint movement on the (multi gym) device.

- a. The purpose of the test: Measuring the strength of the muscles working on the ankle joint.
- b. Capabilities and tools: The multi gym device with a partner to count the repetitions and stabilize the legs.
- c. Performance specifications: From a seated position on the multi gym machine, extend the leg of the injured foot while securing it with the help of a colleague. The tester should push the iron plate attached to the machine (for two stable attempts over a suitable period) while ensuring that the knee joint is not bent, the back is not leaning backward, and the hands are in a free position.
- d. Recording method: The maximum weight that can be pushed on the device is recorded.

The exploratory experiment

The researcher conducted the pilot experiment on Saturday, April 5, 2025, on four players from the research sample suffering from (inward ankle sprain), in the large Al-Imara swimming pool and the gym hall located in the same place, inside the pool. The aim was to ensure the safety of the devices and tools, verify the accuracy and validity of the measurements and tests related to the research, avoid potential negative aspects, understand the positive aspects, assess the readiness of the injured person to perform the tests, ensure the efficiency of the supporting staff, and the ability to perform exercises in the

aquatic environment as proposed in the program. Therefore, the experiment included all measurements, tests, and the ability to perform the exercises outlined in the proposed program.

The purpose of conducting the experiment was to achieve the following results:

1. There was the possibility of conducting the tests in terms of the patient's ability to perform and the suitability of the tests.
2. The devices and tools used in the rehabilitation program operate within the normal range of motion and joint strength of the injured person.
3. Knowing the time required to implement the rehabilitation program components.
4. Identifying the field difficulties that the researcher may encounter during the implementation of the program.
5. The suitability of the prepared rehabilitation exercises and the sample's proficiency in them.
6. The suitability and adequacy of the location for conducting the main experiment.
7. Determining the appropriate time to conduct tests and exercises.

The scientific foundations of the test

The researcher sought to adopt scientific principles in the process of standardizing the tests, even to they are standardized, but for the purpose of determining the scientific validity of the selected tests, that is, determining their validity, reliability, and objectivity.

1. Test Validity

To ensure the validity of the test, the self-validity coefficient was used, "which is the validity of the experimental scores in relation to the true scores that have been purified from the impurities of random errors, and thus the true scores are the standard or criterion to which the validity of the test is attributed." (Hassanein, 2004, p. 213) and it is calculated using the following equation (self-validity coefficient = $\sqrt{\text{reliability coefficient}}$). (Farhat, 2007, page 87).

2. Test Reliability

The test-retest reliability coefficient was calculated using the test-retest method. The test was administered to four players on Saturday, April 5, 2025, with a one-week interval. The retest was conducted on the same group under the same conditions on Saturday, April 12, 2025. By processing the data obtained from the tests, the simple correlation coefficient (Pearson) between the results of the first and second tests was extracted. The results showed a high correlation between the scores of both tests, as the calculated value was compared with the maximum random correlation coefficient value of 0.67%. The random degree is accepted at this value and above. (Al-Talib and Al-Samarrai, 2009, page 43) indicating that the reliability coefficient for these tests is also high.

Objectivity of the Test

Objectivity refers to the extent to which a correct score can be obtained when two or more judges apply the test to the same sample in different situations and the first and second judges give the same score. Objectivity is "if two or more people use the same devices and procedures and obtain similar results." (Ibrahim, 1999, p. 191).

Table 1. It shows the values related to the reliability, self-validity, and objectivity coefficients for the research tests

Test	Name of test	Unit measurement	The test is valid.	Test reliability	Objectivity of the test
The range of motion of the ankle joint	The coup inward	Degree	0.97	0.95	0.94
	The coup to the outside	Degree	0.97	0.94	0.98
	The approximation	Degree	0.95	0.91	0.90
The strength of the muscles working on the ankle joint	Abstraction	Degree	0.96	0.92	0.95
	Muscle strength	Kg	0.96	0.93	0.97

The maximum random value of the Pearson correlation coefficient is (0.67) or above.

Pre-tests

Before starting the pre-tests for the studied variables, the researcher, along with the assisting team, explained and demonstrated the procedures of the tests, and then the sample members performed them. The first test conducted was the range of motion for the ankle joint, followed by the muscular strength test for the muscles working on the ankle joint. The pre-tests were conducted on Tuesday, April 15, 2025, in the gym hall of the Al-Amarah Grand Swimming Pool in Maysan.

1. Normal Distribution (Shapiro-Wilk)

After the researcher conducted the range of motion and muscle strength tests, the results were statistically processed to achieve the research objectives and verify the formulated hypotheses. Before starting the statistical treatments, the researcher performed the normality test using the Shapiro-Wilk test for the studied variables. Since the significance level (Sig) values for the muscle strength variable were greater than the accepted significance level of 0.05, this indicates that the data follow a normal distribution.

Therefore, the researcher must use parametric statistics, so he employed the paired sample T-test, and here the sample is considered equivalent in the range of motion and muscle strength tests. (Al-Qaisi, 2020, page 29). As shown in Table (2)

Table 2. Normal distribution (Shapiro-Wilk)

No	Variables	Normal distribution (Shapiro-Wilk)		
		Statistic	Degrees of freedom Df	Level of significance Sig
1	The coup inward	0.877	8	0.296
2	The coup to the outside	0.765	8	0.321
3	The approximation	0.432	8	0.829
4	Abstraction	0.865	8	0.292
5	Muscle strength	0.543	8	0.897

Water-based rehabilitation exercises

The researcher prepared the rehabilitation exercises using the aquatic environment, diversifying these exercises and adapting them to the abilities and capabilities of the injured players. Various variables were introduced, such as resistance bands and weights, to increase the intensity of the exercises, in addition to enhancing excitement and thrill. The rehabilitation exercises were implemented from Sunday, April 20, 2025, to Thursday, June 12, 2025.

1. The exercises took place over eight weeks, with three sessions each week on Sunday, Tuesday, and Thursday. There were a total of twenty-four sessions.
2. The idea of having different kinds of workouts was taken into account.
3. The change in intensity distribution throughout weeks, units, and exercises was taken into account.
4. The workouts were meant to get harder as they went along.
5. The exercises used both weighted and unweighted versions and resistance bands.
6. At first, bodyweight exercises were used in all of the training sessions. Later, weights were added to make sure that the exercises were done perfectly.
7. The application took place in the main part right after the warm-up to make sure that the player was physically ready and their muscles were working together in the way they needed to be in order to reach the goals of the exercises.
8. The approach of interval training, which included both high and low intensity, was used.

Post-tests

The researcher conducted the post-tests for his research sample on Monday, June 16, 2025, using the same method as the pre-tests, after the completion of the scheduled rehabilitation exercises. The researcher ensured to recreate the same temporal and spatial conditions and equipment to achieve the best results.

Statistical Methods

The researcher employed the statistical package (SPSS), version (23), in processing and extracting the research data.

A. RESULTS

Table 3. It shows the results of the pre-test and post-test for the experimental group in the variables of range of motion and muscular strength

Test	Unit of measurement	Pre-test		Post-test		Mean of differences	St.d differences	Value t	Value of sig	Result
		Mean	St.d	Mean	St.d					
The coup inward	Degree	14.508	1.383	10.503	3.178	3.995	4.158	2.717	0.030	Sig
The coup to the outside	Degree	7.277	1.941	4.716	2.578	2.561	1.800	4.023	0.005	Sig
The approximation	Degree	9.717	1.405	6.556	1.603	3.161	1.033	8.652	0.000	Sig
Abstraction	Degree	24.056	3.027	20.527	3.800	3.529	2.820	3.539	0.000	Sig
Muscle strength	Kg	14.828	1.797	13.095	2.530	1.733	1.120	4.376	0.003	Sig

Thru the results presented in Table (3) for the range of motion and muscle strength tests, the results showed significant differences between the pre-test and post-test for the experimental group, favoring the post-test. The researcher attributes this improvement to the role of rehabilitation exercises in the aquatic environment that were designed and applied to individuals with ankle injuries. These exercises were organized, contributing to

increased flexibility of the tissues surrounding the ankle joint, which led to improved elasticity of the ligaments and joints. The researcher attributes the improvement in injury levels to the aquatic environment, as it is considered an ideal place for muscle and joint injuries.

The buoyancy provided by water helps reduce the burden on the joints during exercise, making movement easier. If the water level is at the waist, the water supports half of the person's weight, and if the water level is at the neck, the water supports 90% of the person's weight. Therefore, the exercises used were suitable for the sample's level and degree of injury. The researcher also observes the physical properties of the aquatic medium, especially buoyancy, as it reduces the impact of body weight on the injured joint, resulting in greater angles and less pain compared to land-based exercises. This contributes to increasing the flexibility of the tissues surrounding the joint, such as ligaments, tendons, and muscles.

Gradual water resistance also allows for smooth and balanced movement in all directions, which leads to the restoration of ankle function, especially inward and outward inversion movements, as these are the most affected by common ankle injuries in handball players.

Abu Al-Ala (2012, p. 171) confirmed that "rehabilitation exercises in a water medium are among the most successful methods for restoring the range of motion of the injured joint, as they provide a safe environment and reduce external pressures on the joint."

And this result indicates the effectiveness of the proposed rehabilitation exercises to increase muscle strength, which was lost due to the injury ((as the injury leads to the inability to move, resulting in a decrease in the working strength level of the injured joint)) (Hins S., 2005, page 11).

(Riyad, 1999, p. 104) indicated that the development of strength in the injured joint is measured by comparing it to the level of strength in the healthy joint of the individual. This method is effective for ensuring the injury has healed and consequently allowing the athlete to quickly return to activity. The use of water-based exercises with additional resistances, including rubber bands and weights, by the sample members led to an improvement in the working strength of the joint. Additionally, the gradual increase in the intensity of the exercises (resistances) contributed to making the proposed exercises more effective.

The development of muscular strength working at the joint leads to the enhancement of physical fitness components such as speed and endurance, and it increases the strength of pulling and pushing. Moreover, it is closely related to the general health of the athlete, which has a significant impact on the player's psychological state, granting them a good degree of self-confidence, emotional stability, and supporting elements of courage and boldness (Mohamed A., 2008, p. 54).

As Ismail (2010, p. 212) indicates, "possessing muscular strength means preventing injuries, and flexibility is a safe factor for preventing injuries, especially to muscles, joints, and ligaments. The use of rehabilitation programs helps protect players from injuries they may encounter and treats the injured, allowing them to return to sports in an optimal and faster manner." And adherence to scientific principles when regulating intensity, applying rehabilitation exercises, considering the degree of injury during performance, and accurately measuring when using equipment will contribute to the comprehensive objectivity of the changes in ranges and strength (Banan, 2019, p. 87).

The researcher believes that using aquatic rehabilitation programs to treat ankle joint injuries in general is an effective method for restoring range of motion and muscle strength. It significantly contributes to the return of players to the field, and at that point, the player is in a better physical and biological condition.

B. CONCLUSION AND RECOMMENDATIONS

Conclusions

1. The application of rehabilitation exercises using an aquatic environment had a positive effect on increasing and improving the range of motion of the ankle joint.
2. The application of rehabilitation exercises in the aquatic environment has contributed to increasing the muscle strength that supports the ankle joint.
3. The graduated resistance of the aquatic environment has contributed to reducing pain and fear among the players.

Recommendations

1. Including aquatic rehabilitation exercises as an essential part of ankle injury rehabilitation programs for handball players.
2. The necessity of starting water exercises early in the injury.
3. Conduct future studies to compare rehabilitation exercises in water and on land, based on sound scientific principles.

C. ACKNOWLEDGMENT

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