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RESEARCH ARTICLE

The Effect of Rehabilitative Exercises in Improving (the range of motion, muscle strength, and the degree of pain) for Football Players After ACL Surgery

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Abstract
Objective: This study aims to prepare rehabilitative exercises for football players following anterior cruciate ligament surgery and to determine the impact of such exercises on the functional ability of the anterior cruciate ligament (muscle strength, range of motion, and level of pain) in advanced football players following surgery. Method: A sample of (6) injured, from Al-Kut club, (age = 27.33 ± 1.98 years, height = 174.7 ± 2.99 cm, mass 60.6 0.68 kg) participated in the study. The participants in the experimental group (n=6) completed pre-tests and post-tests. Results: The results of the experimental sample show that there was a significant improvement in the mean scores for Muscular strength on the post-test compared to the pre-test. The mean score for muscular strength increased from 18.50 to 33.33, $p<0.001$), the mean score for the range of motion increased (extension) from 163.50 to 177.33, (flexion) 68.83 to 21, $p<0.001$), and the mean score for pain decreased from 7.125 to 1.12, $p<0.001$). conclusion: following surgery, rehabilitation exercises improve the strength of the muscles that operate on the knee joint, increase the range of motion of the knee joint, and decrease pain degree.

Keywords
Rehabilitative Exercises, Football Players, ACL Surgery

INTRODUCTION

Modern football is characterized by the speed in play and skill in technical and tactical performance, and this is what requires the player to enjoy high physical fitness, which can be developed through sports training, sports training has a strategy that reflects the general goal far from it, which is to achieve access to the highest levels of sports for players, which generates tremendous pressure that leads to illness or injury in a member of the body.

It is recognized that football depends more on the lower extremities, and this is what makes the majority of possible injuries concentrated in this extremity. Among the most important and most common injuries of the lower extremity are knee joint injuries. This injury has received great attention from sports medicine specialists, and extensive research and studies have been conducted to provide the best possible means of treatment. One of the body's most vital and intricate joints is the knee, because its anatomical structure determines its function, as it is responsible for many different movements, which places a great burden on this joint and exposes it continuously to injury, as the knee injury represents about 70% of the injuries that affect athletes in sports stadiums (Awadi, 2004). The anterior cruciate ligament (ACL) injury is one of

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the most widespread knee joint injuries worldwide, with a total of about 250,000 cases per year (Leininger et al, 2019), so, the typical approach to anterior cruciate ligament rehabilitation has shifted from complete immobilization after surgery too early recovery of strength and range of motion and increased muscle activation because most of the patients undergoing anterior cruciate ligament surgery and subsequent restoration often suffer from atrophy of the large thigh muscles her survival is impaired for a long time after the operation, therefore, specialists are faced with the task of finding means and tools Alternative rehabilitation (Norte et al, 2018).

During competitions or training units, players are exposed to cutting the cruciate ligament, as a result of strong friction between the players or as a result of performing some movements imposed by the match situations, in addition to the great muscle effort and weakness of the ligaments in the knee joint, as well as the poor physical preparation of the player before the performance in a disproportionate manner, and so on. The effort, as well as a large number of cases of friction in which the weight of the body largely rests on this joint, leads to them stopping training for quite a while, leading to an extent that may prevent them from playing the game, and this is what prompted researchers and those interested in this field to use various means and modern techniques. To speed up the rehabilitation of the injured anterior cruciate ligament cut, the researchers attempted to prepare specific exercises to restore the functional ability of the muscles and ligaments working on this joint to its best levels and in the shortest possible period. The main research problem in this study is the prevalence of anterior cruciate ligament injuries and surgical operations to restore the ligament between football players, some of them completely moved away from playing and reinjured each other again, and most of the athletes were late in returning to the stadiums because they underwent long stages of treatment. Because some of them are influential players in their teams, whose absence affects the results and causes material, moral, and technical losses to their teams, the researchers sought to solve this problem by developing a set of rehabilitative exercises in a scientific way to rehabilitate this injury by strengthening the muscles surrounding the joint and increasing the range of motion and preserving the muscles from atrophy and reduce the degree of pain, As well as speeding up the rehabilitation process by restoring full functional capabilities to facilitate the return of the injured player to the field as soon as possible.

Hence, the importance of this study is that it resorted, t to preparing special rehabilitative exercises that work on the knee joint, aiming at rehabilitating the injured and returning them to practicing their normal lives and returning to the stadiums at maximum speed while restoring their functional efficiency to avoid complications and health problems that the athlete is exposed to as a result of undergoing surgery. The research aims to identify the effect of rehabilitative exercises in restoring the functional ability of the anterior cruciate ligament (range of motion, muscle strength, degree of pain) after surgery for advanced football players.

MATERIALS AND METHODS

Participants

The participants were composed of 6 volunteers who had undergone anterior cruciate ligament surgery, aged (23-30 years). All six patients attend regular physical therapy sessions for their rehabilitation. However, all of them had quadriceps and/or hamstring weakness and pain at least 2 weeks to 1 month after their last surgical procedure.

The lower extremities of all individuals were measured for comparison purposes. All patients underwent measurements of the affected lower extremity at least twice during the treatment period, pretest and posttest, and had been using rehabilitative exercise therapy as part of their rehabilitation routine for at least 12 weeks.

One participant with a hip fracture (6 males; see Table 1 for participant characteristics) volunteered to participate in the study and gave written informed consent for the experimental procedures. Participants had no known history of other disorders or diseases. In addition, none of the participants had engaged in any resistance training within the past 2 months. This study followed ethical standards and received approval from the Wasit University with reference number (No. 22/162 and dated 02/12/2023). Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the

Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

Table 1. Group characteristics

Variables	Measuring unit	Mean	Std. Deviations	Median	Skewness
Length	Cm	165.0	3.67	166	0.817
Hight	Cm	74.67	1.63	74	0.38
Mass	Kg	60.60	5.412	67	0.886
Age	Year	27.33	1.92	29	0.312
Training age	**Year**	8.60	1.82	7	0.989

Data Collection Tools

Form for each player to record the sequence measurements

Goniometer to measure the range of motion of the knee joint

Measurements of joint range of motion (ROM) are part of a physical therapist's daily work. Activities of daily living and exercises can be complicated to perform when ROM is limited, and depending on the demands of daily living, the knee joint requires different ROM. In sports, a few degrees in ROM may make the difference between getting injured or not. The goals of physical therapists are to help patients to regain full ROM, mobility, strength, and function after sustaining an injury. To measure joints with the manual universal goniometer is considered time-consuming and difficult with respect to repeated measurements.

Initial position

The patient takes a prone position on the abdomen and installs the device on the outer side of the knee joint along the thigh bone. The knee joint is flexed to the maximum extent it can reach. The difference in reading the device is between zero degrees and the angle of maximum flexion of the knee joint (Pereira et al, 2017).

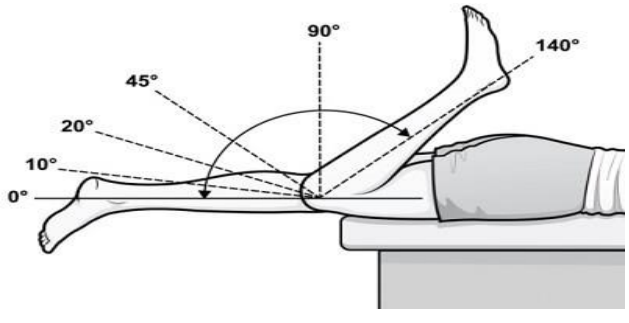

Figure 1. Measurement of knee joint range of motion

Hamstring muscle strength measurement with dynamometer

The Hamstring muscle strength of the individuals participating in the study was assessed using a hand dynamometer (Medical Commander Power Track 2, USA). The measurements were repeated three times for the right and left sides. The highest value was recorded as Newton (N) (Hasan, 2018)

Performance specifications

Person stands erect on base of the device in appropriate place on middle of the base, hands in front of the thighs, and the fingers of the hands are pointing down. The tester grips the tension column tightly so that the palm of one hand is directed forward and the other is directed to the body. When the tester is ready to pull, he bends his knees forward, forming an angle of 90°.

Figure 2**.** Measurement of the hamstring muscles strength

It must be noted that the back is not bent, as well as the straightening of the arms without any bending in the elbows. At the end of the test, the legs must be fully extended.

Quadriceps muscle strength measurement with dynamometer

The quadriceps muscle strength of the individuals participating in the study was assessed

using a hand dynamometer (Medical Commander Power Track 2, USA). The measurements were repeated three times for the right and left sides. The highest value was recorded as Newton (N) (Bandinelli et al, 1999).

Figure 3. Measurement of the Quadra muscles strength

Experimental Design

Participants were familiar with all testing and exercise protocols before starting the study. Rehabilitation exercises were done before and after. Therefore, the total duration of the experimental study was 12 weeks. During the rehabilitation exercises withdrawal period, the participants were asked to maintain their normal diet and physical activity levels.

Pre- measurements Measurements and pre-tests were performed on a group of members of the experimental research sample consisting of (6) injured, at the Specialized Center for Physiotherapy and Physical Rehabilitation in Al-Kut Sports Club on Sunday corresponding to 22/1/2023.

Rehabilitation exercises

The proposed rehabilitation exercises were prepared in three stages, where each stage lasted four weeks, and the total time required to implement the program in practice was three months. The rehabilitation stages contain different exercises to suit the stage that the injured player goes through. The training took place at the rate of (5) rehabilitation units per week, and the number of rehabilitation units for the injured over the course of twelve weeks was (60) rehabilitation units, and the time of the rehabilitation unit in the first stage was (45) minutes about the injury. This stage aims to activate muscle tissue, gradually move the joints near the site of the injury, and stimulate blood and lymphatic circulation at the site of the injury. The researchers used forced exercises and assisted exercises, and the number of exercises in one qualifying unit at this stage ranged between (8-10) exercises. One of the most important goals of the first stage was to stimulate blood circulation in the area of injury and prevent muscle atrophy and joint stiffness in the area of injury.

In the second stage, the time of the rehabilitation unit was (60) minutes, and the exercises of this stage begin when the healing is activated and the functions are gradually restored in the injured parts, where the patient has adapted to the physical effort and allowed him to move the injured part. It included static exercises for the muscles in the injured and healthy areas, and moving exercises for the injured muscles, starting with free exercises without resistance, followed by exercises against resistance, starting with the weight of the limb to resist the muscular work. Then we got to practice exercises in which the static and moving muscular work overlapped. (Hassan, 2019)

In the third stage, the time of the rehabilitation unit increased to (75) minutes, in which the researchers used simple strength and resistance exercises, in which the researchers took into account the use of gradation in their weights from easy to difficult, as well as kinetic exercises, taking into account the gradient load in the exercise. Resistance exercises aim to maintain the efficiency of the neuromuscular work of the muscles operating on the thigh by strengthening them as a result of the surgery period. Resistance exercises vary by either body weight resistance, gravity, rubber bands, or moderate external weight. These exercises must be performed slowly at the beginning. In addition, with full muscle control until the movement reaches its last range.

Post-measurements

Post-measurements and tests were carried out on a group of experimental research sample members on 25/4/2023 in the same order as the tribal measurements, under the same conditions, and for each patient separately.

Statistical Analysis

SPSS package program was used in the statistical analysis of our research. It was determined by the normality distribution and skewness coefficients of the data. Significance level was determined as P 0.05 and all data were presented as mean standard deviation (SD) unless stated otherwise. Independent samples t-test was

used to compare the scores obtained from the measurements according to categorical variables.

RESULTS

For patients participating in rehabilitation exercises at 12 weeks, no injury was recorded at any stage of the exercises, and no adverse events (both acute and chronic) were reported for anyone doing the exercise.

Table (2) Mean scores and standard deviations of the experimental group on the Pre-Test and Post-Test.

Variables		Measuring unit	Pre-test		Post-test	
			M	SD	M	**SD**
Muscular strength	Injured	Kg	18.50	1.048	33.33	**4.546**
	Uninjured	Kg	32.60	2.07	35.80	**0.83**
Range of motion (injured)	Extension	Degrees	163.50	3.27	177.33	**1.63**
	Flexion	Degrees	68.83	2.786	21	**4.656**
Degree of pain for the injured leg		**Degrees**	**7.125**	**0.478**	**1.12**	**0.629**

As Table (2) illustrates,

Strengthening of the damaged leg: The pre-test arithmetic mean was 18.50 with a standard deviation of 1.048, and the post-test arithmetic mean was 33.33 with a standard deviation of 4.546. The arithmetic mean for the muscular strength of a healthy leg was (32.60) with a standard deviation of (2.07) in the pre-test and (35.80) with a standard deviation of (0.83) in the post-test, respectively.

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The injured leg's range of motion was measured in pre- and post-tests. The arithmetic mean for the former was 68.83 with a standard deviation of 2.786, while the latter was 21% with a standard deviation of 4.656. Regarding the injured leg's range of motion (flexion), the pre-test arithmetic mean was 163.50 with a standard deviation of 3.27, and the post-test arithmetic mean was 177.33 with a standard deviation of 1.63. Arithmetic mean for the harmed leg: 7.125 with a standard deviation of 0.478 in the pre-test and 1.12 with a standard deviation of 0.629 in the post-test, respectively, representing the degree of discomfort.

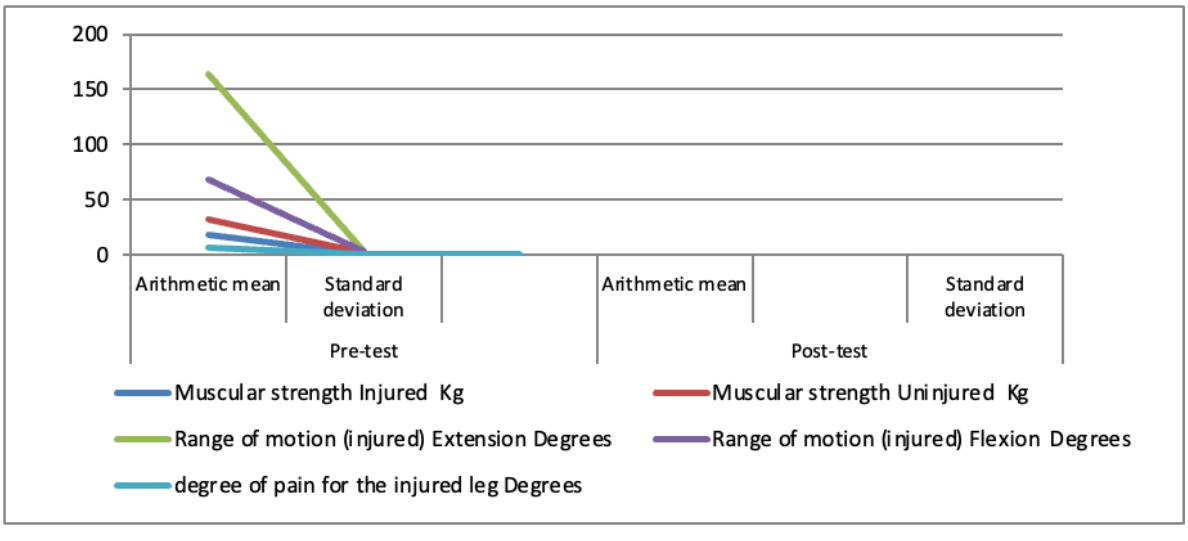

Figure 2. Statistical characterization of the variables examined before and after the Rehabilitation exercises with BFR program of the participant patients.

Table 3. Significant differences between the pre- and post-test in the variables under study for the study sample

Variables		Measuring unit	Difference between arithmetic mean	Difference between standard deviations	T value calculated	Level Sig	Type Sig
Muscular strength	Injured	Kg	14.833	5.036	6.241	0.002	**Sig**
	Uninjured	Kg	3.20	2.38	2.997	0.04	**Sig**
Range of motion (injured)	Extension	Degrees	47.83	5.98	19.591	0.000	**Sig**
	Flexion	Degrees	13.83	2.63	6.83	.0010	**Sig**
Degree of pain for the injured leg		**Degrees**	**6**	**1.08**	**7.407**	**0.005**	**Sig**

* Significant if the error level is ≤ or = (0.05) at the significance level (0.05).

It can be seen from Table (3)

The pre- and post-test findings showed a substantial difference in the injured leg's muscle strength, according to the study. With a standard deviation of 5.036, the arithmetic mean difference between the pre- and post-test values was 12.833. The post-test result outperformed the pre-test by a degree of freedom of (5), according to the computed (T) value of 6.241 and the confidence level of 0.002.

The results of a muscle strength test conducted on an uninjured leg showed an arithmetic mean difference of 3.20 and a standard deviation of 2.38. Significant differences were seen between the pre- and post-tests at the significance level of 0.05, with the post-test being favoured in front of the degree of freedom (5). With a confidence level of (0.04), the computed (T) value was (2.997).

Range of motion (extension) of the injured leg: A significant difference was observed between the pre- and post-test findings at the significance level (0.05) in front of the degree of freedom (5), favouring the post-test. With a confidence level of (0.000), the computed (T) value was (19.591). Between the pre- and post-test findings, there was an arithmetic mean difference of (47.83), with a standard deviation of the differences of (5.98). Regarding the injured leg's range of motion (flexion), the computed (T) value was 6.83, the confidence level was 0.001, and the arithmetic mean difference between the pre- and post-test values was 13.83, with a 2.63 standard deviation of the differences. This suggests that, at the level of significance (0.05) in front of the degree of freedom (5), there were noteworthy changes between the pre and posttest findings in favour of the posttest. Discomfort level in the injured leg: The difference in the arithmetic mean between the pre- and post-test findings was (6), with a standard deviation of the differences of 1.08. The computed (T) value was (7.407), the confidence level was (0.005). In front of the degree of freedom (5), these results demonstrate substantial differences between the pre- and post-tests at the significance level (0.05), favouring the post-test.

DISCUSSION

The outcomes of the muscular strength test's pre- and post-tests

Tables (2) and (3) make it evident that there are statistically significant differences in favour of the post-test between the pre and post-tests for the variable of muscle strength of the injured and healthy legs**.** The researcher attributes the appearance of these results to the rehabilitative exercises prepared by the researcher, as they included strength, lengthening and balance exercises. With rationing and organizing the exercises according to accurate scientific foundations and methods in determining the rehabilitative loads for the importance of this stage in the process of rehabilitating the injured joint after the restoration of the anterior cruciate ligament, where these exercises were developed on scientific bases that suit the ranges of motion, strength and the nature of the muscles working on the joint, this is consistent with what was stated by (Tarfa, 2004) “One of the most important foundations in preparing rehabilitative curricula is determining the ideal load for rehabilitative exercises, where the ideal load is defined as the specific amount of impact on the various organs and systems of the individual when practicing physical activity, as well as the effort or physical burden And the nervous system that affects the organs and systems of the body and the reaction to the physical performance performed.” Through this, the rehabilitative exercises worked on the development of muscle strength since the first

weeks after the operation, as the exercises contributed to avoiding a large part of the muscular atrophy of the muscles. This was confirmed by (Shephard, & Astrand, 1994). That people who stay in bed due to injury can avoid muscular atrophy by contracting their muscles for a period of seconds so that they are proportional to one-third of the maximum strength of the muscle, and it is not required here that the contraction be maximal, and this means that most injured athletes can exercise enough training to prevent muscular atrophy (Hasan, 2024).

The outcomes of the motor range test's pre- and post-tests (flexion, extension)

Tables (2) and (3) make it evident that the posttest significantly outperformed the pretest in terms of the motor range variable (extension, flexion) of the injured leg**.** The researchers attribute, through reviewing the results, that the improvement in the motor ranges in the stretching and flexion tests is due to the positive effect of the rehabilitative exercises, which included different types of methods for developing the range of motion, such as fixed and mobile flexibility exercises, and performing these exercises slowly and with a wide range of motion helped to obtain these results. The researchers refer This improvement of the motor range variable in flexing and extending the joint, which may approach 100% in the post measurement, indicates the efficacy of the rehabilitation exercises in its three stages, as the first and second stages included various stretching exercises that increase the degree of flexibility in the joints, and the third stage contained exercises of higher intensity and time Longer and more exercises than the first and second phases, which had a positive impact on increasing and developing the range of motion of the joint and in extending and flexing in a way that is almost like a healthy joint. And (Atheer Al-Jumaili, 2010) believes that the movement of the knee is determined by the pain and swelling that occurs in it, which leads to a loss of its efficiency, and this develops if the injured person does not receive appropriate treatment and rehabilitation for the injury, which in turn works to restore the mechanical movement in the knee.

This agrees with what was indicated by (Talha et al, 1997; Al-Khatib and Al-Nimr, 1997), and (Hasan, 2022), that flexibility exercises work to develop the muscle elongation component and increase the elastic property of the muscles and ligaments together, which leads to an increase in the range of motion of the joint. The researchers believe that the development occurred as a result of the effectiveness of the vocabulary of rehabilitative exercises, which was prepared according to the correct scientific foundations and based on the efficiency of the exercises used in strengthening the muscle groups surrounding the injured knee joint.

The outcomes of the degree of pain test's pre- and post-tests

Tables (2) and (3) show that there are significant differences between the pre-test and the post-test in the variable (degree of pain) of the injured leg, in favor of the post-test. The researchers attribute these differences in the research sample to the rehabilitative exercises prepared by the researchers, and this was confirmed by (Fox. B. 1997) that flexibility exercises complement the rehabilitative program as the player feels comfortable and relieves many of the pains he suffers from, and this comes through Increasing the speed and quantity of blood pumped into the circulatory system, which worked to get rid of the products of injury gradually, as well as the possibility of movement with the disappearance of pain and an increase in the strength of muscles and ligaments, and this is confirmed by Baker, (Baker, A.G., Webright, W.G., & Perrin, D.H. 1998). In rubber band exercises, it is characterized by the exchange of contraction and relaxation, and this results in an increase in blood flow flowing to the muscles, which leads to an increase in the disposal of work products during training and the outcome of sports injuries.

Conclusion

The available data strongly support the use of Rehabilitation exercises that have a positive effect on improving the muscle strength of the muscles working on the knee joint after surgery. Rehabilitation exercises that have a positive effect on increasing the range of motion of the knee joint after surgery. Rehabilitation exercises contributed to reducing the degree of pain eliminating it, and improving the muscular lengthening of the muscles and ligaments surrounding the knee joint.

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Disclosure Statement

The author have no conflicts of interest that are directly relevant to the content of this manuscript.

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Conflict of interest

No conflict of interest is declared by the authors. In addition, no financial support was received.

Ethics Committee

This study followed ethical standards and received approval from the Wasit University with reference number (No. 22/162 and dated 02/12/2023).

Author Contributions

Study Design, BB, LS; Data Collection, BB; Statistical Analysis, BB, LS; Data Interpretation, BB, LS; Manuscript Preparation, BB, LS; Literature Search, BB, LS. All authors have read and agreed to the published version of the manuscript.

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