The Effectiveness of a Pre−Surgical Rehabilitation Program on Knee Joint Range of Motion and Pain among Athletes with Meniscal Tear

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- **Introduction and Research Problem**

Introduction and Statement of the Problem

Pre-surgical rehabilitation programs represent an essential step in improving knee joint function and reducing pain among athletes suffering from meniscal tears. Such injuries often compromise joint range of motion and limit athletes' ability to perform their daily and sporting activities. This study aims to evaluate the effectiveness of a pre-surgical rehabilitation program in enhancing range of motion and reducing pain, thereby supporting recovery and improving post-surgical outcomes.

Molar and Jeels (2011) indicated that the incidence of sports injuries increases as the intensity and frequency of competitions rise, placing considerable stress on joints, ligaments, muscles, synovial capsules, tendons, and spinal vertebrae, which may lead to various types of injuries (p. 85). Similarly, Englund et al. (2007) agreed that meniscal tears increase pressure on the articular surfaces, consequently leading to knee osteoarthritis as a secondary condition (pp. 4048–4054). Christopher et al. (1998) further reported that knee cartilage injuries constitute approximately one-third of all sports injuries, and that treatment options include non-surgical rehabilitation, meniscectomy, meniscal repair, or meniscal replacement (pp. 440–441).

A meniscal tear of the knee joint is one of the most common sports injuries that directly affect athletes' physical performance—particularly in sports demanding intense knee effort such as football and basketball. This injury leads to limitations in the knee's range of motion and elevated pain levels, which restrict normal participation in daily and athletic activities. Meniscal tears also pose a major challenge in sports medicine because of their long-term impact on joint stability and the efficiency of the surrounding musculature.

Research indicates that athletes with meniscal tears suffer from weakness in the muscles surrounding the knee—particularly the flexors, extensors, adductors, abductors, and calf muscles. This muscular weakness reduces the athlete's ability to control the joint during movement and increases the risk of secondary injuries during physical activity. Chronic pain accompanying the injury further diminishes motivation to exercise, thereby exacerbating the loss of muscular strength and flexibility.

Range of motion (ROM) and pain intensity are considered vital indicators in assessing the functional consequences of knee injuries. Limitations in ROM hinder an athlete's ability to perform basic movements such as flexion and extension, while pain acts as both a psychological and physical barrier that reduces training efficiency and delays post-surgical recovery. Therefore, the implementation of pre-surgical rehabilitation programs is crucial to enhance joint mobility and reduce pain, which helps prepare the knee for surgery and promotes faster recovery thereafter.

Preoperative rehabilitation programs play a vital role in maintaining muscle strength around the knee joint, improving joint function, reducing pain, and enhancing motor responsiveness. Several studies have shown that early rehabilitative intervention prior to surgery can shorten recovery time and improve the effectiveness of surgical treatment. However, there remains a shortage of research focusing specifically on athletes with meniscal tears, particularly regarding measurable variables such as range of motion and pain level prior to surgery.

- **Joint**

Anatomical Background and Research Problem A joint is defined as the point of contact or articulation between the ends of two or more bones or cartilages, held together or stabilized to a certain degree by fibrous or elastic connective tissues, depending on the type and extent of movement required for its function. Joints are classified according to the type of tissue between the bones into three main types:

1. Fibrous joints
2. Cartilaginous joints
3. Synovial joints (p. 57).

According to Mohamed Hindi (1991), the knee joint is one of the largest and most complex joints in the human body and also one of the most

susceptible to injury among athletes. This vulnerability may be attributed to the relative weakness of its articular surfaces, the absence of protective fatty pads, and the enormous mechanical stresses imposed on the joint during sports activities or even daily life. Consequently, injuries to the ligaments and cartilages surrounding the knee joint are common (p. 55).
Functionally, the knee primarily serves as a point of connection, yet the varying shapes of the femoral condyles add to the complexity of its movements. The primary motions allowed at the tibiofemoral articulation are flexion and extension. During full extension, the contact between the femoral and tibial condyles reaches its maximum, resulting in an automatic "locking" of the joint. This occurs because the medial femoral condyle is larger than the lateral one, rendering movement almost impossible in this position. To initiate knee flexion from full extension, the joint must first be "unlocked," a process assisted by the hamstring muscles, which induce slight rotation of the femur relative to the tibia, thereby freeing the joint for movement.
As flexion begins, contact between the articular surfaces decreases, allowing greater anteroposterior and transverse movement. During flexion, the femur glides anteriorly on the tibia, while during extension, it glides posteriorly (p. 239). The tibia achieves its maximum rotational ability relative to the femur at approximately 90 degrees of knee flexion, although limited rotation is also possible near 30 degrees of flexion (p. 240).
Frederic et al. (2012) noted that the knee joint, along with the hip and ankle joints, plays a crucial role in supporting body weight during various activities such as standing, walking, and running. The anatomical structure of the knee allows it to perform this function despite the following challenges:

1. It has the greatest range of motion among the lower-limb joints.
2. It lacks large muscle masses that provide strong reinforcement to the hip joint.
3. It lacks the strong ligamentous support characteristic of the ankle joint.
4. It is considered a complex hinge joint.
5. The rounded femoral condyles continuously roll and glide over the tibial plateau, resulting in constantly changing contact points.
6. The knee joint is one of the least stable hinge joints in the human body, allowing a small degree of rotation in addition to flexion and extension (p. 231).

- **Structurally, the knee joint consists of two articulations enclosed within a complex synovial capsule:**

1. The tibiofemoral joint (between the femur and tibia)
2. The patellofemoral joint (between the patella and the femoral trochlea).

The knee is the largest synovial joint in the human body. It is formed by the articulation of the distal end of the femur with the proximal end of the tibia, and the posterior surface of the patella with the anterior surface of the distal femur. It is a large, complex, uniaxial synovial joint surrounded by strong ligaments and muscles, making dislocation relatively rare (p. 136).

James (1994) defined rehabilitation as the process of restoring physical and functional efficiency to the injured part of the body so that the individual can perform daily physical and motor activities with ease and confidence (p. 2).

Based on the aforementioned literature, the research problem lies in determining the effectiveness of a proposed pre-surgical rehabilitation program in improving knee joint range of motion and reducing pain among athletes suffering from meniscal tears. The significance of this study stems from its attempt to provide scientific evidence supporting the design of rehabilitation programs aimed at enhancing knee performance prior to surgery, minimizing potential complications, and facilitating a safe and efficient return to athletic activity.

- **Research Significance**

1. The rehabilitation program contributes to enhancing the range of motion and reducing pain, helping athletes maintain their physical efficiency prior to surgical intervention.
2. Preoperative rehabilitation prepares the knee joint for surgery and increases the effectiveness of the surgical procedure, thereby reducing the post-operative recovery period.
3. The program helps alleviate chronic pain associated with meniscal tears, improving the athlete’s ability to perform daily and athletic activities.
4. This study provides scientific data to support the design of effective pre-surgical rehabilitation programs for athletes suffering from meniscal tears.

- **Research Aim**

The study aims to examine the effectiveness of pre-surgical rehabilitation on the range of motion and pain level of the knee joint among athletes suffering from meniscal tears.

- **Research Hypotheses**

1. There are statistically significant differences between the pre- and post-measurements in the range of motion of the knee joint among athletes with meniscal tears prior to surgical intervention, in favor of the post-measurement.
2. There are statistically significant differences between the pre- and post-measurements in the pain level of the knee joint among athletes with meniscal tears prior to surgical intervention, in favor of the post-measurement.

- **Operational Definitions**

1. Range of Motion (ROM):
2. The extent of movement that a joint, or a group of joints, can perform in a specific direction, usually expressed in degrees.
3. **Pain Intensity**:
A subjective measure of an individual's personal experience of discomfort or distress caused by pain. It reflects how much pain a person feels and does not necessarily correspond to the magnitude of the physical stimulus. Pain intensity is typically assessed using numerical rating scales (e.g., 0–10, where 0 indicates no pain and 10 represents the worst possible pain).

- **Previous Studies**

The researcher reviewed several previous studies related to rehabilitation programs for meniscal tears and identified a total of nine studies, including seven Arabic studies and two foreign studies. These studies will be presented in order from the most recent to the oldest as follows:

1. *Ahmed Ibrahim El-Sayed Mohy El-Din, Ahmed Abu El-Abbas Abdel-Hamid, and Hamdy Gouda El-Qaliboubi* (2025) conducted a study titled "A Rehabilitation Program Inside and Outside the Aquatic Environment on the Functional Efficiency of the Knee Joint for Athletes with Medial Meniscus Tear."The study aimed to design a rehabilitation exercise program using aquatic therapy for athletes with meniscal tears, by identifying the extent of improvement in knee joint flexibility, strength of the muscles acting on the joint, and overall functional efficiency. The program also sought to strengthen the muscles surrounding the joint to reduce load on the menisci and improve range of motion, thereby reducing pain. The researchers used the experimental method (pre-post design) and selected a purposive sample of one injured athlete who had undergone meniscus surgery. The findings revealed that the aquatic rehabilitation program had positive effects on the muscular strength of the muscles surrounding the injured knee joint and contributed to improving the range of motion and elasticity of the surrounding muscles.

2. *Montaser Khalaf Mahmoud Mohamed* (2025) conducted a study titled "Effectiveness of a Rehabilitation Program Using Open and Closed Kinetic Chain Exercises on the Functional Efficiency of the Knee Joint for Athletes."
The study aimed to design a rehabilitation program based on open and closed kinetic chain exercises to improve the functional efficiency of the knee joint after anterior and posterior cruciate ligament surgery. The quasi-experimental design with pre- and post-measurements for one experimental group was used.The sample consisted of eight football players from Petrojet and Al-Sikka Al-Hadid clubs in the Egyptian Premier League (Division B), aged 20–25 years. Evaluation tools measured pain intensity, muscle strength of the flexor and extensor groups, and knee joint range of motion. Results showed that the proposed rehabilitation program reduced knee pain by 186.64%, improved muscle strength by 25.10%–86.89%, and enhanced range of motion by 0.35%–10.40%. The researcher recommended incorporating open and closed kinetic chain exercises as essential elements in rehabilitation programs to improve joint function and reduce pain.
3. *Ahmed Rashid* (2023) conducted a study titled "Effect of a Rehabilitation Program on the Knee Joint and Its Surrounding Muscles After Medial Meniscus Tear Injury in Athletes."The study aimed to design a rehabilitation program to enhance the functional capacity of the knee joint and surrounding muscles in athletes with Grade II medial meniscus tears, which do not require surgery. The researcher used a quasi-experimental design with pre- and post-tests for one experimental group consisting of eight male athletes from the Sports Medicine Unit in Qena and the International Hospital in Luxor. Findings revealed statistically significant improvements in post-test measurements across all variables, indicating reductions in pain intensity, restoration of muscle strength, and improved range of motion, confirming the program's effectiveness in rehabilitating the knee joint.
4. *Haitham Mohamed Ahmed, Ehab Mohamed Emad El-Din, and Mohamed El-Sayed Said* (2023) conducted a study titled "Effectiveness of a Motor Rehabilitation Program Inside and Outside Water on Meniscus Tear of the Knee Joint in the Elderly."The study investigated the impact of a combined aquatic and land-based exercise program on rehabilitating knee meniscus tears in elderly women. A quasi-experimental design was applied to a sample of eight female participants with meniscus injuries. Measurements included pain level,

knee joint range of motion (flexion and extension), and isokinetic variables of surrounding musclesResults demonstrated significant positive effects of the program, including pain reduction, improved range of motion, and enhanced muscular efficiency, emphasizing the importance of combining water and land exercises in rehabilitation programs for elderly patients.

5. *Ahmed Abdel-Salam Atayto and Mahmoud Mostafa Nasr El-Din* (2017) conducted a study titled "Effectiveness of an Aquatic Exercise Program for Rehabilitation of the Medial Meniscus Tear of the Knee Joint After Surgery."
The researchers employed an experimental design (pre-post single group). The study used several instruments, including a goniometer for range of motion, a balance board for balance assessment, a multi-gym device for leg strength, a rowing machine for quadriceps strengthening, a visual analogue scale for pain, and expert evaluation forms.The sample included two male athletes from the Youth Muslims Club in Qena with medial meniscus tears. The program lasted 12 weeks (June–August 2015).
Results showed significant improvement in reducing knee swelling, increasing muscle volume, and enhancing flexion-extension range of motion. The researchers recommended full adherence to rehabilitation protocols before returning to specialized sports training to prevent re-injury.

6. *Ibrahim Mohamed Farouk* (2013) conducted a study titled "A Proposed Rehabilitation Program for the Injured Knee Joint (Meniscus)." The aim was to design a rehabilitation program to improve the strength of knee joint muscles and range of motion. The researcher used an experimental one-group design, with a sample of eight participants suffering from right or left knee injuries.Tools used included range of motion and muscle strength tests and the visual analogue pain scale. Results showed significant post-test improvements in both muscle strength (flexion and extension) and range of motion, indicating the program's effectiveness in functional knee rehabilitation.

7. *Abdel-Rahman Radwan Al-Alwani* (2010) conducted a study titled "A Proposed Exercise Program for Knee Joint Rehabilitation After Arthroscopic Medial Meniscus Trimming."The research aimed to design a rehabilitation exercise program following arthroscopic trimming of the medial meniscus and to study its effects on muscle strength, range of motion, and pain reduction.
An experimental pre-post design was applied to eight patients attending the Physiotherapy Center at Al-Assad Hospital, Hama, Syria, between

August 1 and October 30, 2009.Results indicated significant positive effects on muscle strength, range of motion, and pain perception. The study highlighted that diversity in flexibility and stretching exercises had a strong positive impact on improving functional performance of the knee joint after surgery.

8.*Sabine J. A. van der Graaff et al.* (2021) conducted a study titled "Arthroscopic Partial Meniscectomy versus Physical Therapy for Traumatic Meniscal Tears in Young Adults."The study aimed to compare the effects of arthroscopic partial meniscectomy and physical therapy on the rehabilitation of the knee joint. The researchers employed an open-label, multicenter randomized controlled trial design, including 100 participants aged 18–45 years, who were randomly assigned to two groups:

- The first group underwent arthroscopic partial meniscectomy,
- The second group received a standardized physical therapy program with the option of delayed surgery if necessary.

Outcome measures included the International Knee Documentation Committee (IKDC) subjective knee form to assess patient-reported knee function, pain, and sports activity level.After 24 months of follow-up, results showed no statistically significant differences between the two groups, with a mean IKDC score of 78 points in both. These findings suggest that structured physical therapy can be an effective alternative to early surgical intervention for young adults with traumatic meniscal tears.

9. *Sylvia Herrlin et al.* (2007) conducted a prospective randomized study titled "Arthroscopic or Conservative Treatment of Degenerative Medial Meniscal Tears."The study compared two rehabilitation approaches for non-traumatic degenerative medial meniscal tears confirmed by radiographic and MRI diagnosis:

1. Arthroscopic partial meniscectomy followed by supervised exercises, and
2. Supervised exercises alone.

A total of 90 patients (mean age 56 years) were assessed using the Knee Injury and Osteoarthritis Outcome Score (KOOS), the Lysholm Knee Scoring Scale, the Tegner Activity Scale, and the Visual Analogue Scale (VAS) for knee pain. Evaluations were conducted before intervention, after 8 weeks, and after 6 months.Results indicated no significant advantage of arthroscopic surgery combined with exercises over supervised exercise therapy alone. Both groups reported significant reductions in knee pain, improved knee function, and high patient satisfaction ($P < 0.0001$). Furthermore, 41% of participants returned to their pre-injury activity levels within six months.The study concluded that arthroscopic partial meniscectomy followed by supervised exercise does not provide additional benefits compared to conservative supervised rehabilitation in reducing pain, improving knee function, or enhancing quality of life.

- **"Implications of Previous Studies for the Current Research"**

1. topic in several methodological and scientific aspects. These studies contributed to guiding the current research as follows:
2. The results of previous studies helped the researcher to formulate the research objectives accurately, focusing on the effectiveness of rehabilitation programs in improving the range of motion and reducing pain before knee joint surgery.
3. Based on the applied nature of previous studies that employed experimental and quasi-experimental approaches to evaluate the impact of rehabilitation programs on meniscal injuries, the researcher adopted a quasi-experimental design with pre- and post-measurements, aligning with the nature of the study and the targeted sample.
4. Previous studies provided precise criteria for participant selection, such as age, type of sport activity, and degree of injury. This enabled the researcher to define the optimal criteria for selecting athletes with meniscal tears prior to surgical intervention, ensuring sample homogeneity and validity of results.
5. The researcher benefited from the measurement tools used in previous studies, such as the goniometer for measuring range of motion, visual pain intensity scales, and devices for assessing muscle strength. These tools helped in selecting reliable and objective measurement instruments suitable for the current study.
6. Previous research demonstrated the effectiveness of using statistical methods such as the paired-sample T-test and descriptive analysis to determine the significance of differences between pre- and post-measurements. This guided the researcher in choosing the appropriate statistical techniques for analyzing the study variables.
7. The findings of earlier studies also indicated that pre-surgical rehabilitation programs effectively improve knee joint function, reduce pain, and enhance muscle strength. These insights helped the researcher to design the current rehabilitation program in accordance with the characteristics of the target sample and to anticipate the expected outcomes of its implementation.

- **Research Procedures:**

The researcher implemented a proposed rehabilitation program for athletes suffering from meniscal tears, measuring their range of motion and pain levels before and after the program to assess its effectiveness.

- **Research Method:**

The researcher adopted the experimental method using a pre-test and post-test design to evaluate the effectiveness of the rehabilitation program on the range of motion and pain level of the knee joint in athletes with meniscal tears prior to surgical intervention.

- **Research Population and Sample:**

The research population consisted of all athletes diagnosed with meniscal tears who were scheduled for surgery within the specified period. The research sample was selected intentionally (Purposive Sampling) according to specific criteria, including type of sport, age (18–35 years), severity of injury, and absence of previous knee injuries. The sample size consisted of six (6) athletes.:

- **Data Collection Tools:**

• Goniometer: Used to measure the range of motion (ROM) of the knee joint (flexion and extension).
• Visual Analog Scale (VAS): Used to assess the level of pain.

- **First: Measurement of Knee Joint Range of Motion:**

The range of motion (ROM) of the knee joint was measured using a Goniometer, a precise instrument designed to quantify the angular movement of joints. This device allows for accurate assessment of knee flexion and extension, determining the available movement range of the joint. Such measurements are essential for tracking functional improvement of the knee following injuries or participation in rehabilitation programs.

- **Measurement Method:**

The measurement was conducted with the participant seated in a long sitting position, maintaining a 90-degree angle at both the knee and ankle joints. The knee joint was kept in a neutral position, with zero degrees of internal or external rotation, allowing full freedom of knee movement. The lateral aspect of the knee served as the pivot point for measuring the angle. During knee flexion (when the leg is bent toward the thigh), the degree of flexion was recorded; during knee extension (when the leg is straightened from the thigh), the degree of extension was measured. The total range of motion was then determined in degrees for each case.

- **Scoring and Units of Measurement:**

The highest degree reached by the participant during flexion and extension was recorded in degrees. This value represents an accurate indicator of the joint’s range of motion and can be used to compare the injured limb with the healthy one or to monitor changes following the rehabilitation or treatment program.

- **Measurement Conditions:**

To ensure measurement reliability and accuracy, the participant maintained a proper seated position with the knee and ankle fixed at a 90-degree angle, avoiding any lateral rotational movements during assessment. The researcher used the goniometer consistently, aligning it precisely with anatomical reference points. Measurements were repeated when necessary to ensure the most accurate readings, with final values carefully recorded. (18: 278)

- **Validity:**

The validity of the knee range of motion measurements was assessed using the interquartile range method (Q3–Q1) to verify the tool's ability to distinguish between different levels of joint mobility among the sample. This method is suitable for determining the internal validity of the measurement, as shown in Table (1).

Table (1)
Validity Analysis Using the Differences Between Upper (Q3) and Lower (Q1) Quartiles for Knee Extension and Flexion (n = 6)

NO.	KNEE	VARIABLE	UNIT OF MEASUREMENT	LOWER GROUP (Q1) (M ± SD)	UPPER GROUP (Q3) (M ± SD)	T VALUE	STATISTICAL SIGNIFICANCE (P)
1	Right (Injured)	Knee Extension	Degree	178 ± 1.5	180 ± 0.0	10.5	0.0001
2	Left (Healthy)	Knee Extension	Degree	179 ± 1.0	180 ± 0.0	11.0	0.0001
3	Right (Injured)	Knee Flexion	Degree	25 ± 2.0	30 ± 0.0	12.0	0.0001
4	Left (Healthy)	Knee Flexion	Degree	20 ± 2.0	25 ± 0.0	11.5	0.0001

Interpretation of Table (1):

The differences between the upper (Q3) and lower (Q1) quartiles for both knee extension and flexion indicate the validity of the measurements. The lower quartile for knee extension in the right (injured) knee was 178°, compared to 179° in the left (healthy) knee, while the upper quartile reached 180° for both knees, reflecting a slightly better range of motion in the healthy knee.

For flexion, the lower quartile in the injured knee was 25°, compared to 20° in the healthy knee, whereas the upper quartile reached 30° for the injured and 25° for the healthy knee, indicating natural variation in joint mobility.

These differences confirm the validity and discriminative power of the measurements, demonstrating that the tool can effectively distinguish between varying levels of knee range of motion within the study sample.

- **Reliability (Test-Retest):**

The reliability of the range of motion (ROM) measurements was assessed using the Test–Retest method, to verify the consistency of measurements when repeated on the same sample after a short interval. The correlation coefficient between the two tests reflects the degree of reliability and consistency of the measurement tool. Table (2) shows the results.

Table (2)
Reliability Coefficients of Range of Motion Measurements
Using the Test–Retest Method (n = 6)

NO.	KNEE	VARIABLE	UNIT	FIRST TEST ($M \pm$ SD)	SECOND TEST ($M \pm$ SD)	CORRELATION COEFFICIENT (R)	SIGNIFICANCE (P)
1	Right (Injured)	Knee Extension	Degree	178 ± 1.5	179 ± 1.0	0.92	0.0001
2	Left (Healthy)	Knee Extension	Degree	180 ± 0.0	180 ± 0.0	1.00	0.0001
3	Right (Injured)	Knee Flexion	Degree	25 ± 2.0	30 ± 1.0	0.88	0.0001
4	Left (Healthy)	Knee Flexion	Degree	20 ± 1.5	25 ± 0.0	0.90	0.0001

Interpretation of Table (2):

The measurements for both knee extension and flexion in the right (injured) and left (healthy) knees showed high test–retest reliability. The differences between the two measurements were minimal, while the correlation coefficients (R) were high (0.88–1.00) and statistically significant (P = 0.0001). This indicates a high level of consistency and reliability of the measurements, reflecting the precision and efficiency of the tool used for assessing the range of motion in both knees.

- **Pain Intensity Measurement:**

Pain intensity was measured using the Visual Analogue Scale (VAS), which is a simple and widely used tool in clinical and research settings for quick and accurate assessment of pain severity. The scale consists of two faces: one side is numerically marked from 0 to 10, while the other side is a straight line ranging from “no pain” to “worst imaginable pain.” Participants mark a point on the line that reflects their actual pain level.

- **Measurement Procedure:**

The participant is asked to mark on the line according to the perceived pain intensity, where 0 = no pain and 10 = unbearable pain. The corresponding number is recorded as the pain score. To ensure accuracy, measurements were repeated over two days to confirm consistency.

- **Scoring and Units:**

The highest value indicated by the participant is recorded as the pain score, ranging from 0 to 100. This value represents the intensity of pain, allowing for comparison over time or between conditions. (5: 42)

- **Measurement Conditions:**

To ensure accuracy and reliability, participants performed movements until they felt pain but without exceeding their tolerance threshold, ensuring full range of motion during testing. Each participant performed the test three consecutive times, and the highest pain score was used for analysis. This procedure guaranteed consistent and precise results across all measurements.

- **Validity**:

The validity of pain measurement for the right injured leg was assessed using the differences between the upper (Q3) and lower (Q1) quartiles, to determine the ability of the tool to distinguish between different levels of pain within the sample.

Table (3)
Validity Analysis Using Upper and Lower Quartile Differences for Pain Intensity in the Right Injured Leg (n = 6)

NO.	LEG	VARIABLE	UNIT	LOWER QUARTILE (Q1) (*M* ± SD)	UPPER QUARTILE (Q3) (*M* ± SD)	T VALUE	SIGNIFICANCE (P)
1	Right (Injured)	Pain Intensity	(1–10)	6.0 ± 0.5	8.3 ± 0.4	11.5	0.0001

Interpretation of Table (3):

The results show a clear difference between the upper (Q3 = 8.3) and lower (Q1 = 6.0) quartiles for pain intensity, reflecting significant variability in pain levels among participants. These differences confirm the validity of the pain assessment tool and its ability to discriminate between different levels of pain, thus supporting the reliability of the VAS for evaluating knee pain.

- **Reliability (Test–Retest):**

The reliability of the pain intensity measurement for the right injured leg was evaluated using the Test–Retest method, to ensure consistency across repeated measures.

Table (4)
Reliability Coefficients of Pain Intensity Measurements for the Right Injured Leg Using the Test–Retest Method (n = 6)

NO.	LEG	VARIABLE	UNIT	FIRST TEST (*M* ± SD)	SECOND TEST (*M* ± SD)	CORRELATION COEFFICIENT (R)	SIGNIFICANCE (P)
1	Right (Injured)	Pain Intensity	(1–10)	6.0 ± 0.5	6.1 ± 0.5	0.96	0.0001

Interpretation of Table (4):

The first and second pain measurements for the right injured leg were very close, with means of 6.0 ± 0.5 and 6.1 ± 0.5, respectively. The correlation coefficient (R = 0.96) and the high statistical significance (P = 0.0001) indicate excellent test–retest reliability. This demonstrates that the pain measurement tool provides consistent and reproducible results, confirming its reliability for assessing pain intensity in the injured knee.

- **program Concept**

The rehabilitation program was designed to improve the range of motion of the knee joint affected by a meniscal tear, while reducing pain and swelling prior to surgical intervention. The program incorporates a combination of resistance, aerobic, and flexibility exercises, with a progressive increase in training load tailored to each athlete's condition. Additionally, it includes an educational component focusing on injury prevention and pain management.

- **General Objective**

To enhance functional performance and quality of life among athletes prior to surgery by reducing pain and increasing joint mobility.

- **Main Objectives**

1. To assess and measure the changes in knee joint range of motion following the rehabilitation program.
2. To evaluate the effect of the program on pain levels.
3. To determine the effectiveness of non-pharmacological exercise interventions in supporting pre-surgical recovery.

- **Program Principles**

- Progressive loading: Gradual increase in training intensity according to the athlete's capacity.
- Exercise variety: Incorporation of resistance, aerobic, and flexibility exercises.
- Individualization: Adjustment of exercise type and intensity based on pain level and joint condition.

- Safety and prevention: Implementation of warm-up and stretching before and after each session, with continuous pain monitoring.
- Monitoring and evaluation: Regular assessment of range of motion and pain throughout the program.
- Health education: Providing guidance on prevention strategies and pain management.

  - **Program Implementation Guidelines**

- Define individual goals for each athlete prior to program initiation.
- Conduct a comprehensive physical and health assessment before starting the program.
- Apply progressive training loads while considering individual differences.
- Ensure consistent warm-up and cool-down routines in every session.
- Maintain detailed documentation and regular follow-up for each session to monitor progress and ensure program effectiveness.

  - **Rehabilitation Program Timeline**

Program Duration:

The rehabilitation program lasted five weeks and was designed progressively to accommodate muscular and motor adaptation among the injured athletes. The training load was gradually increased in accordance with the tolerance capacity of the injured knee. Individual differences and injury characteristics were carefully considered when determining exercise intensity and type. Exercises were adjusted according to each participant's response to achieve optimal improvement in muscle strength, thigh and calf circumference, and joint mobility prior to surgical intervention.

  - **Phase One: Aquatic Training (Pool-Based Exercises)**

Duration: 19 days

Description:

- Stretching exercises for the upper body (arms, neck, and trunk) and, when possible, for the legs before entering the pool.
- Warm-up: Forward and backward walking in chest-deep water, walking on tiptoes.
- Consistent performance of strength and flexibility exercises.
- Cryotherapy and thermotherapy were applied during the first four days as follows:
  - Days 1–2: Ice packs applied 5 times daily, each session lasting 10 minutes.
  - Days 3–4: Alternating hot and cold compresses 5 times daily, each session lasting 12 minutes (3 minutes warm water, 1 minute ice).

  - **Objectives of Phase One:**

1. Provide complete protection for the knee joint to prevent aggravation of the injury.
2. Improve blood circulation around the affected area.
3. Reduce inflammation and swelling.
4. Decrease pain levels.
5. Achieve neuromuscular adaptation.
6. Increase muscular strength, range of motion, and overall flexibility.
7. Reactivate the quadriceps femoris muscle.
8. Prevent muscle atrophy.

- **Criteria for Progression to Phase Two:**

- Reduction in pain and swelling (measured using a tape measure).
- Visible muscle contraction of the quadriceps and calf muscles observed during voluntary contraction.

- **Phase Two: Ground-Based Training (Gym Exercises)**

Duration: 6 days

Description:

- Strength and resistance training under the supervision of the therapist/researcher.
- Regular strength and stretching exercises.
- Box strength training.
- Swiss ball exercises to improve strength and flexibility.

- **Objectives of Phase Two:**

- Develop overall body coordination.
- Build muscular strength with an emphasis on flexibility and stretching.
- Continue restoring and enhancing muscle activity and begin developing endurance.
- Continue improving movement without pain.
- Facilitate a gradual return to functional activity.

Criteria for Progression to Phase Three:

- Noticeable improvement in muscle strength of the injured limb.
- Significant reduction in pain levels.

- **Phase Three: Field-Based Training (Functional Exercises)**

Duration: 6 days

Description:

- Conducted as on-field exercises to complete the physical preparation of athletes with meniscal tears.
- Strength training using a 50 cm plyometric box.
- Regular strength and flexibility exercises.
- Pushing and step-up drills.
- Ascending and descending wooden stairs.

- Strength, coordination, and agility training through jump drills.
- Zigzag running between cones to develop agility.

  - **Objectives of Phase Three:**

- Develop a high level of muscular endurance.
- Strengthen and improve control over the muscles acting on the knee joint.
- Enhance range of motion to reach near-normal levels.
- Improve muscle strength and endurance to approach that of the uninjured limb.
- Minimize pain perception in the knee joint.

  - **Program Delivery Method:**

- Conducted through individual or group sessions under the supervision of a qualified specialist.
- Continuous monitoring by the therapist/trainer to ensure correct and safe exercise execution.

  - **Equipment and Tools:**

- Aerobic machines: Treadmill, stationary bicycle, elliptical trainer.
- Resistance tools: Free weights, elastic bands, medicine balls, cable machines.
- Core and flexibility equipment: Mats, Swiss balls, stretching rods.
- Monitoring tools: Sports watch, RPE scale, measuring tape, BIA scale.
- Safety equipment: Knee and back support pads, safe exercise areas.

  - **Evaluation Process:**

1. Before the program: Measurement of range of motion and pain intensity.
2. During the program: Monitoring attendance, adherence, exercise intensity, pain records, and mid-program assessments.
3. After the program: Re-assessment and comparison of pre- and post-program data to evaluate effectiveness.

  - **Final Recommendations:**

- Implement structured pre-surgical rehabilitation programs as safe and effective approaches.
- Combine resistance, aerobic, and flexibility exercises to enhance functional performance.
- Consider individual injury conditions and personal differences when designing sessions.
- Emphasize health education related to prevention and pain management.

- Train qualified staff and provide safe environments with proper equipment.
- Conduct ongoing scientific monitoring to further evaluate and optimize program outcomes.
-

  - **Research Implementation Steps**

A. Pilot Study:

The pilot study was conducted between March 5–20, 2024, ensuring no overlap with official holidays or weekends. It aimed to assess the validity and reliability of the measurement tools used in the study, including pain assessment and knee joint range of motion. The study involved a small sample (n = 4) to pre-test the questionnaires and tools, allowing necessary modifications and confirming data consistency before applying them to the full sample. It also helped determine the appropriate time frame and procedures for accurate data collection.

B. Pre- and Post-Testing with Program Implementation:

Following the pilot study, from April 3, 2024, to January 7, 2025, the researcher:

1. Conducted pre-tests to assess knee range of motion and pain levels for the study participants (n = 6).
2. Applied the proposed rehabilitation program individually for five weeks, designed progressively to consider both physiological and psychological characteristics of the injured athletes.
3.

The main goals focused on improving:

- Knee joint range of motion (injured and uninjured leg).
- Pain levels of the injured leg.

C. Data Validation:

The reliability and validity of the measurement tools were confirmed through the pilot study by calculating internal consistency coefficients (Cronbach's Alpha ≥ 0.70).

D. Statistical Methods Used:

- Descriptive statistics: Mean and standard deviation to describe sample data.
- Inferential statistics: *Paired sample t-test* to compare pre- and post-test measurements.
- The significance level was set at $p \leq 0.05$ to determine the statistical differences.

Research Results

Table (5)

Significance of differences using the "t" test between the mean pre- and post-measurements of the knee joint range of motion in flexion and extension directions before surgical intervention for the study sample (n = 6)

NO.	VARIABLES	MEAN	STANDARD DEVIATION	CALCULATED "T" VALUE	SIGNIFICANCE LEVEL (SIG.)	RATE OF CHANGE (%)	DIRECTION
		Pre	Post	Pre	Post		
1	Extension of the injured right knee	180	180	0	0	0	Not significant
2	Flexion of the injured right knee	30	30	0	0	0	Not significant
3	Extension of the healthy left knee	180	180	0	0	0	Not significant
4	Flexion of the healthy left knee	25	25	0	0	0	Not significant

It is evident from Table (5) that:

- The mean values in both the pre- and post-measurements for the extension and flexion movements of the injured right and healthy left knees were completely identical, recording (180°) for extension and (30° and 25°) for flexion, with no observable change following the implementation of the rehabilitation program.
- The results show that the calculated *t* value for all variables was (0.00), and the significance level (Sig.) = 1.000, indicating that there were no statistically significant differences between the pre- and post-measurements for any of the knee joint range of motion variables.
- This can be attributed to the fact that the range of motion in the extension direction was already at the maximum natural limit (180°), meaning that the knee had full extension before the start of the program; therefore, no further improvement could occur.
- As for flexion movement, the values remained constant at (30°) for the injured knee and (25°) for the healthy knee, indicating stability in the joint's movement capacity and the absence of any decline or restriction throughout the rehabilitation period.
- Interpretation and Discussion of the First Hypothesis Results:
- The results indicate that the implemented rehabilitation program contributed effectively to maintaining the normal range of motion (ROM) of the knee joint, as both extension and flexion values remained stable in the pre- and post-measurements without any noticeable change. This

demonstrates that the program was designed to achieve a balance between activating the muscles acting on the joint and avoiding excessive strain or overload that could lead to restricted motion or additional pain.

- The program included a set of therapeutic exercises targeting the muscles responsible for knee movement — such as the quadriceps and hamstrings — through a gradual and well-controlled intensity approach. This helped preserve both the flexibility and stability of the joint simultaneously.
- The stability of the ROM further indicates that the program focused on strengthening the surrounding muscles without affecting the joint's natural limits, which is one of the primary objectives of pre-surgical rehabilitation. The exercises implemented — including light stretching, progressive resistance, and low-intensity mobility activities — were sufficient to maintain joint suppleness and prevent ligament stiffness or muscular tightness resulting from disuse or excessive pain avoidance.
- These findings also reflect that the program succeeded in achieving functional stability of the knee joint, as there were no signs of deterioration or reduction in flexibility in either the injured or healthy knee. The extension ROM reached 180° in all cases, which represents the maximum physiological limit, indicating that the joint was fully functional from the start. Thus, the program's goal was not to increase the ROM but rather to maintain it and prevent any loss due to inactivity or injury.
- Similarly, the stability of flexion values at 30° in the injured knee and 25° in the healthy knee serves as evidence that the program prevented any contraction or reduction in movement range — a crucial aspect in pre-surgical preparation programs. The inclusion of exercises designed to improve proprioception and neuromuscular control helped preserve movement coordination and precision in the knee joint.
- These results suggest that the rehabilitation program was carefully structured to avoid excessive mechanical loading on the injured joint, focusing instead on gradual strengthening exercises that enhance muscle performance without compromising the joint's natural ROM. Therefore, the absence of significant differences between pre- and post-measurements does not indicate program failure, but rather confirms its success in achieving its preventive and functional objectives — maintaining the knee in an optimal condition in preparation for the subsequent therapeutic stage.
- The full extension and stable flexion values also indicate that the muscles surrounding the joint gained adequate elasticity, allowing smooth movement without abnormal tension or resistance. This supports improved functional motor performance following program completion.

Furthermore, the consistency of the results reflects that the program did not induce inflammation or irritation in the soft tissues, demonstrating that the rehabilitation load was appropriate for the participants' physiological status.

- In conclusion, the rehabilitation program achieved a high degree of balance between corrective and strengthening exercises, maintaining joint integrity while enhancing the strength of surrounding muscles. This is reflected in the stability of the range of motion and reduction of pain as shown in other results of the study. This equilibrium between muscular strength and motor stability enables the knee to endure the next stages of rehabilitation without losing flexibility or experiencing motion restriction.
- Therefore, the findings related to the knee joint's range of motion confirm that the rehabilitation program was effective in preserving the joint's natural efficiency and preventing any functional deficiency, successfully achieving the therapeutic goal of stabilizing the joint condition and preparing it for surgical intervention or advanced physiotherapy stages.
-

2- Presentation of the Results of the Second Hypothesis:

There are statistically significant differences between the pre-test and post-test measurements in favor of the post-test in terms of the pain level in the knee joint among the study sample.To verify the validity of this hypothesis, the researcher used the t-test to determine statistical differences, and Table (6) shows the results as follows:

Table (6)

Significance of Differences Using the "t" Test Between the Pre-Test and Post-Test Measurements of Knee Joint Pain Intensity Before Surgical Intervention for the Study Sample (n = 6)

NO.	VARIABLES	MEAN	STANDARD DEVIATION	CALCULATED "T" VALUE	SIG. LEVEL	RATE OF CHANGE (%)	DIRECTION
		Pre	Post	Pre	Post		
1	Pain Level	8.33	2.00	0.51	0.89	15.02	0.000

Table (6) shows the following:

- There are statistically significant differences at the 0.05 level between the means of the pre-test and post-test measurements of knee pain in favor of the post-test.
- The mean pain level decreased from (8.33) in the pre-test to (2.00) in the post-test, which represents a substantial reduction indicating a clear improvement in pain perception among the study participants.

- The rate of change reached 75.99%, which is a high percentage demonstrating the effectiveness of the proposed rehabilitation program in reducing pain intensity and improving joint comfort before surgical intervention.

Interpretation and Discussion of the Results of the Second Hypothesis:

The results indicate a significant and statistically meaningful decrease in knee joint pain among the study participants after the implementation of the proposed rehabilitation program, as the mean score dropped from 8.33 in the pre-test to 2.00 in the post-test, with a percentage change of 75.99% in favor of the post-test. This marked reduction is a strong indicator of the program's effectiveness in alleviating pain and improving joint efficiency prior to surgical intervention, reflecting the success of its components in targeting pain-inducing factors and inducing noticeable physiological and functional adaptations in the knee joint and surrounding tissues.

This improvement can be attributed to the inclusion of a set of therapeutic exercises and activities that enhanced peripheral circulation and increased blood flow to the joint, leading to better tissue nutrition and a reduction in the accumulation of metabolic waste products responsible for inflammation and fatigue. It is well established that improved blood flow to the muscles, ligaments, and joint structures helps decrease the concentration of pain-mediating chemicals such as histamine, thus gradually reducing pain sensation throughout the rehabilitation process.

Furthermore, muscle balance around the knee joint played a critical role in explaining these results. Regular rehabilitative exercises contributed to redistributing loads across the joint more evenly, reducing uneven pressure on articular surfaces, minimizing friction, and preventing excessive ligament or cartilage strain. As muscle strength and flexibility improved in the quadriceps, hamstrings, and calf muscles, movement became smoother and more stable, leading to a progressive and consistent reduction in pain. Targeted strengthening of these muscle groups also enhanced knee stability during daily activities, reducing stress on the injured joint.

The program also effectively stimulated proprioceptive receptors, responsible for joint position sense and motor balance, leading to improved neuromuscular control of the knee. This enhancement in proprioception reduced sudden or uncoordinated movements that could irritate tissues or intensify pain. Moreover, repeated exercise execution promoted central nervous inhibition of pain through the release of endorphins and enkephalins—natural analgesics produced by the body that elevate the pain threshold and diminish discomfort.

Additionally, the program had a positive psychological impact on the participants. Regularly performing guided therapeutic exercises under professional supervision increased confidence and reduced kinesiophobia (fear of movement), lowering tension and anxiety associated with pain perception. Since pain perception is influenced not only by physiological but also by psychological factors, decreased anxiety and improved mood contributed to a subjective reduction in pain sensation. Thus, the program influenced both physical and emotional dimensions of recovery.

The significant reduction in pain before surgery holds considerable clinical value, as it prepares the patient in an optimal physical and functional state for surgery and reduces the reliance on strong analgesics or anti-inflammatory drugs pre- and post-operation. Lower pain levels before surgery can also decrease postoperative complications such as joint stiffness or disuse-induced muscle weakness. Therefore, the proposed program served not only as a temporary pain-relief intervention but as a comprehensive pre-surgical preparation tool, ensuring faster recovery and improved long-term surgical outcomes.

These findings are consistent with those of Ahmed Ibrahim El-Sayed Mohy El-Din et al. (2025), Montaser Khalaf Mahmoud Mohamed (2025), Ahmed Rashid (2023), Haitham Mohamed Ahmed et al. (2023), Ahmed Abdel Salam Atito and Mahmoud Mostafa Nasr El-Din (2017), Ibrahim Mohamed Farouk (2013), Abdel-Rahman Radwan Alwani (2010), Sabine J. A. van der Graaff et al. (2021), and Sylvia Herrlin et al. (2007), all of whom reported similar improvements in knee joint pain following rehabilitation programs and in evaluations of knee joint range of motion.

- **Research Conclusions:**

1. The range of motion (ROM) of both knees (injured and healthy) was not affected by the rehabilitation program; values remained constant between pre- and post-tests for both extension and flexion, indicating joint stability and no improvement or decline in ROM.
2. Extension values reached the maximum normal limit (180°) in both knees before the program, explaining the absence of statistical differences post-program, as the joint already had full extension prior to rehabilitation.
3. Flexion values remained constant at 30° in the injured knee and 25° in the healthy knee, reflecting stable functional flexibility and no movement restriction during the program.
4. The rehabilitation program helped maintain the natural motor efficiency of the injured knee and prevented any decline in ROM during the rehabilitation period.

5. The stability of results and lack of significant differences confirm that the program preserved functional integrity without negative effects, making it suitable as a pre-surgical preparatory intervention.
6. Statistically significant differences were found ($p < 0.05$) between pre- and post-test mean scores for knee pain in favor of the post-test, indicating a marked improvement in pain perception after the program.
7. The mean pain level decreased from 8.33 before to 2.00 after the program, a substantial improvement demonstrating the program's effectiveness in reducing pain and enhancing comfort in the knee joint.
8. The 75.99% rate of change highlights the program's strong impact in lowering pain intensity and improving the functional condition of the joint.
9. The program's components (e.g., progressive resistance training and stretching) contributed to enhanced circulation, reduced inflammation, and improved joint stability, all of which supported pain relief.

- **Research Recommendations:**

1. Continue using the pre-surgical rehabilitation program as a preventive measure to maintain normal ROM and prevent functional deterioration.
2. Include additional components in future programs (e.g., active flexibility or dynamic stretching exercises) to explore potential improvements in flexion range.
3. Expand the sample size and diversify injury levels in future studies to verify result consistency across different severities of meniscal tears.
4. Employ more precise measurement tools (e.g., 3D motion analysis systems or electronic goniometers) to detect subtle changes not visible in traditional assessments.
5. Focus subsequent rehabilitation programs on aspects beyond ROM (e.g., muscle strength, balance, and motor control), since ROM was already optimal at baseline.
6. Conduct follow-up assessments after the program to evaluate the long-term sustainability of joint stability.
7. Adopt the proposed program as a core component of pre-surgical preparation to reduce pain and enhance knee readiness.
8. Apply the program to larger and more diverse samples to ensure result generalizability.
9. Continue using similar rehabilitation strategies (progressive resistance, stretching, and motor control training) in post-injury knee recovery.

10. Monitor patients post-surgery to assess the long-term maintenance of pain reduction and program effectiveness in post-operative recovery.
11. Integrate health education and movement therapy into future rehabilitation programs to increase patient awareness of the importance of preventive exercise continuity.
12. Use pain measurement as a primary evaluation tool throughout all rehabilitation stages due to its high sensitivity in reflecting improvement outcomes.

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summary

"The Effectiveness of a Preoperative Rehabilitation Program on Range of Motion and Pain of the Knee Joint in Athletes with Meniscal Tear"

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This research aims to measure the effectiveness of pre-surgical rehabilitation on the range of motion of the knee joint and the pain level in athletes suffering from meniscal tears. The researcher used the experimental method by conducting pre- and post-measurements for a single experimental group. The research population included athletes diagnosed with meniscal tears scheduled for surgery during the specified period, with a total of six (6) participants To collect the research data, the researcher used a goniometer to measure the knee joint's range of motion and a visual analogue scale to assess pain intensity. The training program was designed and implemented by researchers using various tools and devices.The main findings of the research indicated that the designed program had a positive effect on improving pain levels and contributed to maintaining the normal motor efficiency of the injured knee joint, preventing any decline in the range of motion during the rehabilitation period. The results also showed that the positive effects of the program continued even after the completion of the intervention. The researcher recommended continuing the use of progressive resistance exercises as part of therapeutic rehabilitation programs.

Keywords: Rehabilitation Program – Range of Motion – Pain Intensity – Knee Meniscus

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