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The Effectiveness of the Hold–Relax Technique of PNF Exercises in the Rehabilitation of Athletes with Adductor Muscle Strain

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Abstract. The importance of this study lies in its attempt to provide applied scientific evidence regarding the effectiveness of the Hold–Relax technique, as part of Proprioceptive Neuromuscular Facilitation (PNF) exercises, in accelerating recovery and restoring the functional performance of the adductor muscles in athletes suffering from muscle strain. The study aimed to design rehabilitation exercises based on the Hold–Relax technique of PNF for athletes with adductor muscle strain, as well as to identify the effect of these exercises on the rehabilitation outcomes of the injured athletes, The researcher employed the experimental method using a one-group pretest–posttest design. The research sample consisted of six athletes from different sports disciplines, selected based on a medically diagnosed adductor muscle strain injury. The field procedures included conducting experimental trials and a series of tests, such as muscular strength assessment using the EK3–200 force sensor device (measuring adductor muscle strength in a relaxed position and during muscular contraction), range of motion assessment of the hip joint in abduction, and pain level measurement, Based on the obtained results, the researcher concluded that a rehabilitation program built upon the application of the Hold–Relax technique within the framework of PNF exercises was effective in improving movement mechanics and accelerating functional recovery in athletes with adductor muscle strain. The rehabilitation program lasted eight weeks and consisted of four sequential and integrated rehabilitation phases. The program was initiated two to three weeks after the onset of medical treatment and continued for six weeks, with three rehabilitation sessions per week, The study recommends incorporating the Hold–Relax technique of PNF exercises within rehabilitation programs designed for athletes suffering from adductor muscle strain injuries, due to its positive impact on muscular strength, range of motion, pain reduction, and functional recovery.

Keywords. Hold–Relax, PNF, adductor muscles

1. Introduction:

Adductor muscle strain is among the most common injuries encountered by athletes participating in sports that require sudden changes of direction and high levels of acceleration and deceleration, such as football, hockey, gymnastics, and combat sports. These injuries are characterized by pronounced functional consequences, including localized pain, restricted range of motion at the hip joint, and a reduced ability to generate force, which collectively lead to a decline in athletic performance and interruption of competitive participation for periods that may be prolonged depending on injury severity. Despite advances in diagnostic and therapeutic strategies, selecting the optimal therapeutic intervention that ensures rapid and safe recovery remains a significant challenge for specialists in physical therapy and rehabilitation.

Within this context, Proprioceptive Neuromuscular Facilitation (PNF) exercises have emerged as a contemporary therapeutic approach aimed at enhancing neuromuscular interaction and restoring the functional properties of injured muscles. The Hold–Relax technique is considered one of the most widely used PNF methods in functional rehabilitation of musculoskeletal injuries. It is based on the principle of autogenic inhibition, achieved through an isometric contraction followed by a carefully controlled passive stretch, with the objective of increasing flexibility, reducing muscle tension, and improving muscular function.

PNF refers to *Proprioceptive Neuromuscular Facilitation*, which is defined as a method designed to stimulate or facilitate neuromuscular mechanisms through activation of sensory receptors. These receptors are sensory structures located in muscles, tendons, and joints, responsible for transmitting information or signals related to physical status, as well as the position of the musculoskeletal system and joints. Moreover, proprioceptors provide essential information for coordinated basic movements and postural control.

PNF stretching techniques are derived from physical therapy practices used with injured patients. Stretching based on the PNF approach—also referred to as sensory receptor activation or neuromuscular coordination—represents a relatively modern and advanced method for developing and improving flexibility. These exercises involve the integration of both stretching and contraction of the muscle groups engaged in the movement. Their use became increasingly widespread during the 1980s and typically includes successive isometric contractions followed by muscle relaxation (International Association of Athletics Federations, 2010).

PNF is considered one of the most prominent therapeutic concepts in physical therapy. It was first developed in the 1940s by Dr. Kabat and Margaret Knott, who continued to expand and refine the techniques and procedures of this therapeutic approach. Subsequently, Dorothy Voss joined the team in 1953, and Margaret Knott and Dorothy Voss authored the first textbook on PNF, which was published in 1956 (Susan S. Adler, 2008).

Initially, PNF exercises were utilized in rehabilitation and physical therapy. In 1940, Dr. Kabat applied this approach in the treatment of paralysis resulting from poliomyelitis and multiple sclerosis. In 1948, Kabat, in collaboration with Henry Kaiser, established a hospital in California, where PNF (proprioceptive sensory facilitation) exercises were introduced into physical therapy practice. Over time, these exercises continued to evolve, leading to the emergence of multiple methods and the publication of numerous reports. By 1984, PNF techniques were used for the first time within both physical and occupational rehabilitation contexts, demonstrating high effectiveness and substantial therapeutic impact. One of their key advantages lies in their targeted focus on specific muscle groups. As flexibility (range of motion) improves, muscular strength correspondingly follows a natural progression. Since every skill or movement results from cycles of contraction and relaxation, this repeated muscular activity depends on several neural factors, including sensory receptors. Reliance on reflexive sensory receptors is particularly important in flexibility and stretching training, in addition to the high levels of joint stability they promote, as they enhance neuromuscular coordination within the targeted muscle groups (Hussam Al-Din et al., 1997).

From an applied perspective, numerous contemporary studies indicate that the timely and appropriate selection of therapeutic procedures—both in terms of type and duration—plays a pivotal role in accelerating recovery and preventing secondary complications at the level of the muscle unit, particularly when dealing with acute and subacute muscle injuries. The Hold–Relax technique is expected to contribute to improving the mechanical properties of the adductor muscles and enhancing their capacity to tolerate functional loading, thereby facilitating a return to pre-injury performance levels within a shorter timeframe compared with traditional rehabilitation methods.

Accordingly, investigating the effectiveness of the Hold–Relax technique within the framework of functional physical therapy gains importance from two primary perspectives. The first is the clinical dimension, which relates to improving recovery speed, movement quality, and restoration of athletic performance. The second is the applied dimension, which provides practical evidence to assist physical therapists in selecting the most appropriate rehabilitation protocols for athletes with adductor muscle strains. This renders research in this area of considerable scientific and practical value and supports the development of more precise therapeutic standards that are responsive to the demands of high-performance sport.

The significance of the present study lies in its aim to provide applied scientific evidence regarding the effectiveness of the Hold–Relax technique within Proprioceptive Neuromuscular Facilitation (PNF) exercises in accelerating recovery and enhancing the functional performance of the adductor muscles in athletes with muscle strain injuries. This importance is further underscored by the high prevalence of such injuries, their evident impact on motor performance, and the lack of clearly defined, methodologically grounded rehabilitation protocols in this field. Moreover, the study contributes to supporting specialists in physical therapy and sports rehabilitation in selecting evidence-based therapeutic mechanisms, thereby reducing time away from sports participation, limiting injury recurrence, and improving movement efficiency associated with competitive performance.

Research Problem

Despite the substantial advancements in physical therapy and sports rehabilitation methods, adductor muscle injuries continue to represent a significant challenge for athletes, owing to their direct impact on physical performance and the duration of absence from competitive participation. One of the most critical challenges faced by specialists lies in selecting the most appropriate therapeutic intervention that can accelerate recovery while ensuring the safe restoration of muscular function. The Hold–Relax technique, as part of Proprioceptive Neuromuscular Facilitation (PNF) exercises, is considered a promising approach for improving the flexibility of injured muscles and restoring functional performance. However, its effectiveness in accelerating recovery of the adductor muscles in injured athletes has not been sufficiently investigated. This gap highlights the need for scientific research to determine its actual impact and the extent of its contribution to improving movement quality and athletic performance.

Aims of the Study

The present study aims to:

1. Develop rehabilitation exercises based on the Hold–Relax technique within Proprioceptive Neuromuscular Facilitation (PNF) for athletes with adductor muscle strain in the study sample.
2. Identify the effects of rehabilitation exercises using the Hold–Relax technique within PNF on the recovery of athletes with adductor muscle strain in the study sample.

2. Research Methodology and Field Procedures

2.1. Research Design:

The researcher adopted the experimental method using a single experimental group with pre- and post-testing, as this design was deemed appropriate to the nature of the study and its objectives.

2.2. Research Sample:

The research sample consisted of six (6) athletes from different sports disciplines who were selected based on their medically diagnosed adductor muscle strain. Participants were recruited from patients attending the Rehabilitation Center for Physical Therapy at Baqubah Teaching Hospital, in addition to several private clinics specialized in musculoskeletal injuries, joint disorders, and fractures.

All injuries underwent an approved medical diagnosis, which included a clinical examination conducted by a specialist physician. The diagnosis was confirmed through radiological examinations, and the injured participants received appropriate pharmacological treatment according to their individual health conditions.

To enhance the internal validity of the study and ensure objectivity of the results, a statistical homogeneity test was conducted for the research sample with respect to relevant demographic and physical variables, namely age, height, body mass, and injury duration. This procedure aimed to minimize the influence of extraneous variables, as presented in Table (1).

Table (1). Descriptive characteristics of the research sample (age, height, body mass, and injury duration)

No.	Variable	Unit of Measurement	Mean	Median	Standard Deviation	Skewness
1	Age	Years	22.6667	22.5000	0.81650	0.857
2	Height	cm	178.8333	179.0000	2.78687	0.172
3	Body Mass	kg	79.0000	79.5000	1.26491	−0.889
4	Injury Duration	Days	23.5000	23.5000	1.87083	0.000

2.3. Equipment and Instruments Used in the Study:

The following devices and tools were used for data collection and implementation of the experimental procedures: two (2) Sony cameras for recording the testing and experimental sessions; two (2) Dell personal computers; a body mass (weight) measuring device; two (2) stopwatches; compact discs (CDs); data recording forms; a goniometer for measuring range of motion; a measuring tape; and a digital medical scale.

EK3–200 Force Sensor Device : The EK3–200 force sensor is a U.S.-manufactured device produced by 10 Mark. It is a calibrated instrument with a measurement error rate of 0.001 and is used to assess muscular strength in Newtons. The device stores measurement data internally, which can subsequently be transferred to a computer for analysis. It allows for the assessment of individual muscles or muscle groups and is capable of measuring muscular force during both relaxation and contraction states.

2.4. Measurements and Tests Used in the Study

2.4.1. Muscular Strength Test Using the EK3–200 Device:(Hussein, 2018: p. 39)

First: Measurement of Adductor Muscle Strength in the Relaxed State

Test Name: Measurement of Adductor Muscle Strength in the Relaxed State

Purpose of the Test: To assess the strength of the adductor muscles of the thigh.

Instruments Used: Force sensor device, recording form, pen.

Test Description: The injured participant lies in a supine position on the plinth, and the force sensor device is placed over the adductor muscle of the thigh while the muscle is in a relaxed state.
Recording: The value displayed on the device is recorded.
Second: Measurement of Adductor Muscle Strength in the Contracted State
Test Name: Measurement of Adductor Muscle Strength in the Contracted State
Purpose of the Test: To assess the strength of the adductor muscles of the thigh during muscle contraction.
Instruments Used: Force sensor device, plinth.
Performance Description: The injured participant lies on the plinth and is instructed to voluntarily contract the adductor muscles of the thigh.
Recording: The value displayed on the device is recorded.
2.4.2. Range of Motion Test: Hip Joint Abductio :(Hussein, 2018: p. 43)
Test Name: Hip Joint Abduction Range of Motion Test
Purpose of the Test: To measure the range of motion of the hip joint during abduction in order to estimate the flexibility of the adductor muscles of the thigh and to assess the effect of injury on joint movement capacity.
Instruments Used: Universal goniometer, exercise mat, pen and data recording form, and a qualified examiner/therapist.
Performance Description: From a supine position, the examiner abducts the injured leg outward to the maximum possible extent within the limits of pain, using a gradual movement until the participant reaches the pain threshold or the end of the available range of motion. The non-injured leg remains fixed, while abduction is performed on the injured limb. The examiner moves the lower limb outward into abduction.
Anatomical Landmarks for Goniometer Alignment:
Fulcrum (Axis of Rotation): Positioned over the greater trochanter of the femur, or according to the adopted protocol.
Stationary Arm: Aligned with the imaginary line of the pelvis toward the spine.
Moving Arm: Aligned with the midline of the femur toward the patella.
Recording:
The final angle of the available range of motion is recorded in degrees (°) on the measurement form.
Pain Intensity Assessment
Test Name: Pain Intensity Measurement :(Hussein, 2018: p. 38)
Purpose of the Test: To assess the level of pain experienced by the injured participants.
Instruments Used: Pain assessment form, pen, plinth.
Performance Description: Pain intensity is assessed by a specialist physician across several positions and movement conditions.
Recording: Pain scores are recorded for all positions listed on the pain assessment form. The injured participant is assigned one point if pain is present at rest, two points when pain is elicited by pressure on the injured area, and pain is subsequently assessed at different movement angles: three points at 30°, four points at 60°, five points at 90°, and six points at the specified angle, as determined by the examining physician.

2.6. Pilot Study

The pilot study was conducted on Monday, 29/9/2025, at the Physiology Laboratory, College of Physical Education and Sports Sciences. The pilot study aimed to achieve the following objectives:

1. To evaluate the suitability of the tests in relation to the difficulty level and physical capabilities of the research sample.
2. To verify the adequacy of the testing venue in terms of space, equipment, and its appropriateness for implementing the required procedures.
3. To assess the participants' understanding of the nature of the tests used and the procedures for their execution.
4. To evaluate the efficiency of the assisting team in terms of number and ability to perform the assigned tasks accurately and effectively.
5. To estimate the time required to administer each test and the total duration needed to complete all tests.
6. To prepare the assisting team by familiarizing them with the work procedures and clearly distributing tasks in an organized manner to ensure smooth implementation.

2.7. Pre-Tests

The pre-tests were conducted at different times for each member of the research sample and were repeated on more than one occasion, due to the difficulty of assembling all injured participants at the same time. The first pre-test for one of the participants was carried out on Wednesday, 1/10/2025, following the completion of all research requirements.

2.8. Rehabilitation Program

A rehabilitation program was designed based on the application of the Hold–Relax technique within the framework of Proprioceptive Neuromuscular Facilitation (PNF) exercises, with the aim of improving movement quality and accelerating functional recovery in athletes with adductor muscle strain. The program extended over a period of eight (8) weeks and comprised four sequential and integrated rehabilitation phases. These phases were structured according to the scientific progression of functional recovery, beginning with pain control and culminating in a safe return to athletic performance. The program was initiated after (2–3) weeks from the onset of medical treatment and was implemented for a duration of six (6) weeks, with three rehabilitation sessions per week.

Due to variations in the timing of injuries among the participants, the rehabilitation program was initiated for the first injured athlete on Saturday, 4/10/2025, and concluded with the last injured athlete on Monday, 5/1/2026. Each participant completed a total of 18 rehabilitation sessions, with each session lasting approximately 35–40 minutes.

First: Acute Phase

Duration: 3–7 days

Therapeutic Objectives:

- Pain control and reduction of inflammation
- Prevention of increased intramuscular bleeding
- Maintenance of pain-free range of motion

Therapeutic Interventions:

- Application of the POLICE protocol (Protection, Optimal Loading, Ice, Compression, Elevation)
- Performance of gentle isometric contractions of the adductor muscles within a pain-free range

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- Active, pain-free range of motion exercises for the hip joint (Hip ROM), with emphasis on flexion and extension
- Core muscle activation exercises to maintain pelvic stability

Progression Criteria:
- Reduction of pain intensity to ≤ 3/10
- Ability to ambulate without a noticeable limp

Second: Subacute Phase

Duration: Weeks 2–3 of rehabilitation

Therapeutic Objectives:
- Increase range of motion
- Improve muscle flexibility
- Enhance initial functional capacity

Main Therapeutic Intervention:

Application of the Hold–Relax technique to the adductor muscles according to the following steps:

1. Positioning the lower limb in partial abduction within a pain-free range
2. Isometric contraction of the adductor muscles against manual resistance for 6–10 seconds
3. Relaxation for 3–4 seconds
4. Passive stretching for 20–30 seconds
5. Repetition of the sequence 3–5 times per session, with three sessions per week

In the Hold–Relax (contract–relax) technique, the individual is instructed to gently stretch the target muscles. When the muscle is stretched to the point of acceptable discomfort, the participant performs a sustained isometric contraction for 5–15 seconds against the partner's resistance, followed by a relaxation phase. The partner then slowly increases the stretch. The isometric contraction induces an autogenic inhibitory response in the working muscles, thereby reducing resistance in the opposing muscles during the final phase of stretching and allowing for greater assisted muscle elongation (International Association of Athletics Federations, 2010).

This technique is typically applied following a passive stretch and an isometric contraction of the target muscle for 7–15 seconds, after a brief relaxation period of 2–3 seconds. The muscle is then immediately subjected to a passive stretch to the maximum achievable range of motion—greater than the initial range—and maintained for 10–15 seconds, followed by a relaxation period of 20 seconds before repeating the exercise (Al-Tamimi, 2015).

Complementary Interventions:
- Initial strengthening exercises for the hip and pelvic muscles (abductors, flexors, extensors)
- Basic proprioceptive balance training using air cushions and BOSU devices
- Continued core muscle activation to enhance movement stability

Progression Criteria:
- Restoration of near-full, pain-free range of motion
- Ability to perform movements against light resistance

Third: Strengthening Phase

Duration: Weeks 3–6

Therapeutic Objectives:
- Restoration of muscular strength
- Improvement of neuromuscular endurance
- Development of pelvic dynamic stability

Therapeutic Interventions:

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- Dynamic strengthening of the adductor muscles using elastic resistance bands (isotonic strengthening)
- Functional lower-limb exercises (squat, step-down, lunge) with emphasis on correcting movement mechanics
- Application of pelvic PNF patterns using D1/D2 flexion–extension patterns
- Continued use of the Hold–Relax technique to enhance dynamic flexibility

Fourth: Return-to-Sport Phase
Duration: Weeks 6–10
Therapeutic Objectives:

- Restoration of sport-specific motor abilities
- Improvement of motor control during acceleration and change-of-direction tasks
- Ensuring a safe return to competition without recurrence of injury

Return-to-Competition Criteria:

- Full, pain-free range of motion
- Muscular strength reaching ≥ 90–100% of the uninjured limb

2.9. Post-Tests

Post-tests were conducted on different dates, with the final post-testing session carried out on Wednesday, 7/1/2026, following completion of the rehabilitation program. The post-tests were administered using the same procedures as the pre-tests, and care was taken to ensure that testing conditions (time and location) were consistent with those of the pre-testing phase.

2.10. Statistical Methods

The Statistical Package for the Social Sciences (SPSS) was used to process and analyze the study data.

3. Presentation, Analysis, and Discussion of Results

3.1. Presentation and Analysis of Pre- and Post-Test Results for the Research Variables

Table (2) presents the mean values, standard deviations, and standard errors of the research variables in the pre- and post-tests.

Table (2). Means, standard deviations, and standard errors of the research variables

Variable	Unit	Test	Mean	Standard Deviation	Standard Error
Adductor muscle strength in the relaxed state	Degree	Pre-test	23.1550	2.28860	0.93432
		Post-test	30.6567	1.54367	0.63020
Adductor muscle strength in the contracted state	Degree	Pre-test	32.7917	1.67457	0.68364
		Post-test	39.5183	1.51912	0.62018
Hip joint range of motion during abduction	Degree	Pre-test	46.6667	2.80476	1.14504
		Post-test	67.6667	8.16497	3.33333
Pain score	Degree	Pre-test	2.0000	0.63246	0.25820
		Post-test	5.5000	0.54772	0.22361

Table (2) illustrates the mean values and standard deviations for the pre- and post-tests of the study variables, demonstrating clear differences in favor of the post-test measurements.

Table (3) shows the mean differences, standard deviations of differences, standard error, calculated *t* values, significance levels, and statistical significance for the research variables.

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Table (3). Paired-sample *t*-test results for the research variables

Variable	Mean Difference (Pre–Post)	SD of Differences	Standard Error	*t* value	Sig.	Significance
Adductor muscle strength (relaxed state)	−7.5016	2.72706	1.11332	6.738	0.001	Significant
Adductor muscle strength (contracted state)	−6.7266	1.92191	0.78462	8.573	0.000	Significant
Hip joint ROM during abduction	−21.000	9.81835	4.00832	5.239	0.003	Significant
Pain score	−3.5000	0.83666	0.34157	10.247	0.000	Significant

- *Significant at Sig ≤ 0.05 with 5 degrees of freedom.*

Discussion of Results

The results presented in Table (3) indicate a statistically significant improvement in adductor muscle strength in the relaxed state following the implementation of the rehabilitation program, as evidenced by the higher post-test mean values compared with the pre-test. This improvement can be attributed to the physiological effects of the Hold–Relax technique, which involves an isometric contraction followed by complete relaxation. This sequence induces autogenic inhibition and reduces excessive activity of muscle spindles, thereby allowing more effective stretching of the injured muscle and contributing to the restoration of its force-producing capacity. Furthermore, the regular repetition of these exercises facilitates the reorganization of muscle fibers and enhances their functional efficiency after injury.

Similarly, the results for adductor muscle strength in the contracted state revealed statistically significant differences in favor of the post-test, reflecting an improvement in the functional capacity of the injured muscles. This finding can be explained by the fact that PNF exercises do not merely enhance flexibility; they also improve neuromuscular coordination and increase the number of motor units recruited during performance, in addition to enhancing the efficiency of neural transmission between the central nervous system and the working muscles. Such improvements constitute an important indicator of the effectiveness of the rehabilitation program in restoring the adductor muscles to their normal functional state.

With respect to hip joint range of motion during abduction, the findings demonstrated a significant improvement in the post-test compared with the pre-test, indicating the effectiveness of the Hold–Relax technique in increasing joint range of motion. This enhancement can be attributed to the ability of PNF exercises to reduce muscle tension and increase the elasticity of the soft tissues surrounding the joint, in addition to improving the responsiveness of sensory receptors responsible for movement regulation. Restoring normal joint range of motion is a fundamental requirement in rehabilitation programs, as it plays a critical role in reducing the likelihood of injury recurrence and improving overall motor performance.

The results also revealed a statistically significant reduction in pain scores following completion of the rehabilitation program, indicating an overall functional improvement in the participants' health status. The reduction in pain may be attributed to improved blood circulation in the injured area, decreased muscle spasm, and the positive effects of PNF exercises on neural nourishment of the injured muscles. Moreover, these exercises contribute to reducing mechanical stress on muscle fibers and surrounding tissues, thereby accelerating the healing process and alleviating pain perception.

PNF exercises are considered a fundamental component of rehabilitation programs due to their therapeutic value. In this regard, Victoria et al. (2013) reported that PNF techniques constitute a valuable element in all rehabilitation programs (Victoria, G. D., et al., 2013).

Selecting PNF-based stretching techniques represents an appropriate approach for sports injury rehabilitation and increasing range of motion. Sabri (2018) indicated that muscle stretching exercises contribute effectively to accelerating recovery from injury within rehabilitation programs when the therapist applies the appropriate type of stretching during the rehabilitation process (Sabri, 2018).

Furthermore, several scientific studies have confirmed the effectiveness of PNF exercises in developing joint range of motion. Funk et al. (2003), Lucas and Koslow (1984), and Wallin et al. (1985) demonstrated that PNF stretching techniques significantly increase joint range of motion (Funk et al., 2003).

The use of PNF exercises has also been shown to enhance muscular strength. In this context, Ismail Hamid (2019) reported that these exercises function as a form of rehabilitation and are highly effective in targeting specific muscle groups. In addition to improving flexibility (range of motion), they contribute to the development of muscular strength (Saleh, 2019). Scifers (2013) further noted that PNF techniques aid in improving strength, endurance, joint stability, movement control, neuromuscular control, and coordination (Scifers, 2013).

The increase in muscular strength resulting from PNF exercises can be attributed to neural adaptations within the muscle, including improved muscle activation, reduced inhibition of antagonist muscles due to enhanced coordination, and the recruitment of a greater number of motor units. In this regard, Aref Abdel-Jabbar (2009) indicated that strength training influences the central nervous system by reducing inhibitory mechanisms and increasing the capacity to recruit muscle fibers (Abdel-Jabbar, 2009).

Isometric muscle contraction has also been shown to contribute to strength development through muscle tension without changes in muscle length, relying on internally generated tension. This type of contraction is considered safe and effective in developing strength at the specific joint angle at which the contraction is performed. Progressive improvements in range of motion allow isometric contractions to be performed at multiple joint angles, thereby enhancing overall strength development. Al-Hazzaa (2009) explained that the force produced during isometric contraction is attributed to shortening of the contractile component (CC) and elongation of the series elastic component (SEC), resulting in force generation without joint movement (Al-Hazzaa, 2009).

Song et al. (2020) reported a reduction in pain intensity following 12 weeks of PNF exercises, along with an increase in knee joint range of motion, in individuals with knee osteoarthritis (Song, Qipeng, et al., 2020). Similarly, Kim and Hye (2017) found a reduction in pain following six weeks of PNF exercises targeting trunk muscles in individuals with low back pain, in addition to improvements in respiratory function (Kim & Hye, 2017).

In general, therapeutic exercises address the underlying causes of pain rather than merely alleviating pain symptoms, as is the case with most analgesic medications.

Overall, the findings of the present study confirm that the use of the Hold–Relax technique within PNF-based rehabilitation programs is an effective approach for rehabilitating adductor muscle strains in athletes. This approach demonstrated positive effects on improving muscular strength, increasing range of motion, and reducing pain intensity. These results are consistent

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with the scientific and physiological principles of sports rehabilitation and underscore the importance of adopting this technique in contemporary rehabilitation practice.

4. Conclusion

Conclusions

1. The rehabilitation program based on the Hold–Relax technique within Proprioceptive Neuromuscular Facilitation (PNF) exercises demonstrated clear effectiveness in rehabilitating athletes with adductor muscle strain.
2. The application of the Hold–Relax technique contributed to improving adductor muscle strength in both the relaxed and contracted states, indicating its positive role in restoring the functional efficiency of the injured muscles.
3. The rehabilitation program resulted in a statistically significant increase in hip joint range of motion during abduction, reflecting improved flexibility of the adductor muscles and the surrounding soft tissues.
4. PNF exercises using the Hold–Relax technique effectively reduced pain intensity in the injured athletes, indicating an overall improvement in functional status and an acceleration of the healing process.
5. The findings confirm that integrating Hold–Relax exercises into rehabilitation programs contributes to achieving better muscular balance and reducing the negative effects associated with adductor muscle strain injuries.
6. The significant differences observed between the pre- and post-tests reflect the effectiveness of the applied approach compared with the participants' baseline condition, highlighting its importance as a modern method in sports rehabilitation.
7.

Recommendations

1. The researcher recommends adopting the Hold–Relax technique within PNF exercises as part of rehabilitation programs designed for adductor muscle strain injuries in athletes.
2. It is essential to apply a progressive approach in the intensity and volume of PNF exercises according to the stage of rehabilitation and the type of injury, in order to achieve optimal outcomes and prevent re-injury.
3. Emphasis should be placed on integrating PNF exercises with functional strength and flexibility training to achieve comprehensive rehabilitation and ensure a safe return of athletes to their pre-injury performance level.
4. The results of the present study may be utilized in designing individualized rehabilitation programs that account for individual differences among injured athletes, such as age, training level, and injury severity.
5. Future studies are recommended to compare the Hold–Relax technique with other rehabilitation approaches to determine the most effective method for rehabilitating adductor muscle injuries.
6. Further research is encouraged to expand the use of PNF exercises to investigate their effects on other types of muscular and joint injuries across various sports disciplines.
7. Greater attention should be given to the education and training of professionals working in physical therapy and sports rehabilitation on the scientific and practical foundations of PNF exercises to ensure their correct and safe application.

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Appendix (1): Pain Assessment Form – Adductor Muscle Injury Test
Athlete's Name: …………………
Age: ………
Sport: ………………
Date: …… / …… / ……
Examiner's Name: …………………………
Scoring is recorded as follows:

Position / Angle	Score
Pain at rest	1
Pain on palpation	2
Pain at 30°	3
Pain at 60°	4
Pain at 90°	5
Pain at 120°	6

Examination Results

Assessment Item	Pain Present	No Pain	Score
Pain at rest	☐	☐	1
Pain on palpation	☐	☐	2
Pain during movement at 30°	☐	☐	3
Pain during movement at 60°	☐	☐	4
Pain during movement at 90°	☐	☐	5
Pain during movement at 120°	☐	☐	6
Total Score			

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Appendix (2): Sample Rehabilitation Session

Day: Monday
Week: First
Session: First
Session Duration: 35–40 minutes
Objective: Improve range of motion and muscular strength of the adductor muscles.

Section	Exercises	Performance Method	Repetitions / Time	Rest
Warm-up	Light walking or stationary cycling	Continuous, without fatigue	5 minutes	—
	Warm-up movements for the hip and knee joints	Active movements in all directions	5–7 minutes	Intermittent
Main	PNF (Hold–Relax) for the adductor muscles	Hip abduction to the maximum pain-free range → isometric contraction for 6–8 s → relaxation for 3–5 s → increase range	4–6 reps × 2–3 sets	10–15 s
	Squeezing a rubber ball between the knees	Isometric contraction of the adductor muscles	8–10 reps × 2 sets	60 s
	Hip adduction using a resistance band	Slow, controlled adduction movement	8–12 reps × 2–3 sets	60 s
	Active hip abduction and adduction	Active performance within pain limits	6–8 minutes	Intermittent
Cool-down	Static stretching of the adductor muscles	Hold stretch position without pain	20–30 s × 2–3 times	—
	Relaxation and deep breathing exercises	Slow, regular breathing	3–5 minutes	—