Physiotherapy and Neuromuscular Electrical Stimulation Enhance Functional Recovery After Meniscus Repair in a Basketball Player

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ABSTRACT
Basketball involves complex and intense movements such as jumping, pivoting, and cutting. These activities impose significant mechanical loads on the knee joint, increasing the risk of meniscus tears. Meniscus repair is highly recommended to prevent early osteoarthritis, but the postoperative period often leads to clinical impairments that require structured physiotherapy. This study aimed to determine the effectiveness of comprehensive physiotherapy management in a basketball player after right meniscus repair surgery on knee function recovery. This study utilized a descriptive qualitative method with a case report design and a single-subject pre-test and post-test approach. The subject was a 14-year-old male basketball player diagnosed with sub-acute postoperative right meniscus repair (9th week). The 4-week intervention program included Neuromuscular Electrical Stimulation (NMES), strengthening exercises, balance training, and core stability exercises. Clinical parameters were measured using the Visual Analog Scale (VAS), goniometer, Manual Muscle Testing (MMT), anthropometry (midline), and the Barthel Index. After 4 weeks of therapy, the results showed a reduction in motion pain intensity (from score 3 to 2) and tenderness (from score 4 to 2), an increase in the right knee flexion range of motion (ROM) from 110° to 120°, and a decrease in thigh (quadriceps) muscle atrophy. Muscle strength remained stable at an MMT score of 4, and the patient's daily functional activity level remained optimally independent (Barthel Index score of 100). In conclusion, a structured exercise-based rehabilitation program combined with NMES is effective in reducing pain, increasing ROM, improving muscle atrophy, and maintaining the patient's initial functional ability toward a safe return to sport.
Keywords: meniscus repair; basketball; physiotherapy; structured rehabilitation; neuromuscular electrical stimulation

INTRODUCTION
Basketball is one of the most popular and rapidly developing sports in Indonesia, widely practiced among school-aged children, university students, and the general public. The game requires mastery of fundamental techniques such as dribbling, passing, shooting, and lay-up, which must be integrated with the ability to perform dynamic movements including running, jumping, landing, pivoting, and rapid directional changes (cutting). The high intensity and complexity of these movements impose substantial mechanical loads on the knee joint, thereby increasing the risk of injury, particularly meniscal injuries [1].

The meniscus is a semilunar fibrocartilaginous structure located between the femoral condyles and the tibial plateau [2]. It plays a crucial role in maintaining the biomechanical function of the knee joint, acting as a shock absorber, distributing joint pressure, enhancing joint stability, facilitating lubrication through synovial fluid distribution, and contributing to proprioceptive feedback [3]. Damage to the meniscal structure disrupts these functions and may lead to pain, swelling, restricted range of motion (ROM), muscle weakness, knee instability, and reduced functional capacity, all of which negatively affect daily activities and athletic performance [4].

One of the most frequently encountered meniscal injuries is the meniscus tear, a disruption of the meniscal tissue caused by trauma or degenerative processes. This injury commonly occurs in young, physically active individuals and athletes who engage in sports involving rotational knee movements, rapid directional changes, and repetitive jumping, such as basketball, soccer, and volleyball. Meniscus tears may present with symptoms including pain, swelling, locking sensations, limited mobility, and impaired knee function. If not managed appropriately, these symptoms may progress to cartilage degeneration and increase the risk of early-onset osteoarthritis. The prevalence of meniscal tears is estimated at 12–14%, with an incidence of approximately 61 cases per 100,000 people annually. Acute traumatic meniscus tears are more common among active young individuals and those participating in sports. The estimated number of cases per year reaches 850,000, and orthopedic surgical procedures to repair meniscal tears account for approximately 10–20% of these cases [5].

Meniscus repair is recommended over meniscectomy because it preserves the meniscal tissue, thereby reducing the risk of cartilage degeneration and future osteoarthritis. Meniscus repair has demonstrated favorable clinical outcomes, particularly in young patients with high activity levels. However, the postoperative period is often accompanied by pain, inflammation, limited joint mobility, quadriceps muscle atrophy, proprioceptive deficits, and impaired neuromuscular control, all of which may hinder optimal knee function recovery [6].

Physiotherapy rehabilitation plays a pivotal role in optimizing postoperative recovery following meniscus repair. According to Cong et al. (2024), postoperative rehabilitation should be tailored to the type and location of the tear, repair stability, surgeon instructions, ROM progression, and weight-bearing status. Tears with preserved hoop integrity allow for faster progression, whereas radial or root tears require more conservative rehabilitation. Typically, early ROM is restricted to 0–90°, with full ROM expected around the sixth week, while weight-bearing is adjusted based on repair stability and patient condition [7]. A structured and progressive rehabilitation program aims to reduce pain and inflammation, improve ROM, enhance muscle strength, restore neuromuscular control and proprioception, and ultimately return the patient to functional activities and sports safely [8]. Common physiotherapy interventions include neuromuscular electrical stimulation (NMES), strengthening exercises, balance training, proprioceptive exercises, and functional training tailored to the tissue healing phase [9].

A growing body of evidence indicates that structured, exercise-based rehabilitation programs yield positive outcomes in knee function improvement and return-to-sport (RTS) success among patients following meniscus repair. Migliorini et al. (2023) reported that exercise programs emphasizing muscle strengthening, proprioception, agility, and sport-specific training play a critical role in preventing reinjury after meniscus repair [10]. Furthermore, researchers have documented a 96% success rate of meniscal repair in patients undergoing concurrent anterior cruciate ligament (ACL) reconstruction at two-year follow-up. These findings highlight the importance of considering tear pattern, location, size, tissue quality, repair technique, and any concomitant procedures (e.g., ligament reconstruction, realignment osteotomy, cartilage restoration) when designing an optimal rehabilitation protocol [9].

In basketball athletes, the rehabilitation process presents additional challenges due to the sport's demands, which require the ability to run, jump, land, pivot, and perform rapid directional changes with optimal knee stability. Therefore, rehabilitation success is not solely determined by tissue healing but also by the athlete's ability to safely resume training and competition without increasing the risk of reinjury. Consequently, evidence-based, progressive, and well-structured physiotherapy management becomes essential for restoring knee joint function, improving quality of life, and supporting optimal athletic performance recovery. Based on these considerations, a comprehensive evaluation of physiotherapy management in post-meniscus repair cases among basketball athletes is necessary to illustrate the application of physiotherapy interventions and assess rehabilitation outcomes related to knee function recovery and readiness to return to sport.

METHODS

This study employed a descriptive research method with a case report design using a single-subject pre-test and post-test approach. The research subject was a 14-year-old male basketball athlete diagnosed with postoperative right meniscus repair (meniscus repair dextra). The study was conducted at IBEST Physio Solo Baru Clinic, where the patient underwent a structured physiotherapy rehabilitation program.

The injury history began in August 2025 when the patient sustained a knee injury while playing basketball, resulting in a meniscus tear. Prior to surgery, the patient had completed 12 physiotherapy sessions; however, clinical improvement remained suboptimal, leading to the decision to perform a meniscus repair procedure on February 24, 2026, at RSO Soeharso Surakarta. The postoperative physiotherapy rehabilitation program commenced on March 10, 2026.

At the time of data collection, the patient was in the postoperative phase of 9 weeks and 2 days. Based on the anamnesis and physiotherapy examination, the patient reported pain occurring only during high-load activities such as stair climbing and squatting. Clinical assessment revealed quadriceps and hamstring muscle atrophy in the right lower extremity. Although the patient was able to ambulate without assistive devices, gait pattern abnormalities were still present. Further examination indicated restricted right knee flexion range of motion (ROM), reduced lower-extremity muscle strength, and impaired functional abilities including running, jumping, squatting, and inability to return to basketball activities at pre-injury performance levels.

Manual Muscle Testing (MMT) demonstrated decreased muscle strength in the quadriceps, hamstring, and gastrocnemius muscle groups on the right side. Anthropometric measurements showed reduced quadriceps muscle mass in the right lower limb compared to the left, indicating postoperative muscle atrophy. Pain intensity was evaluated using the Visual Analog Scale (VAS), revealing that the patient no longer experienced pain during light activities, although pain persisted during tasks that imposed greater mechanical load on the knee, such as stair climbing and squatting. These limitations contributed to reduced functional capacity, particularly in activities requiring knee flexion and weight-bearing, including stair negotiation, squatting, running, and jumping. Furthermore, the functional deficits affected the patient's sports participation and social interaction, as he had not yet regained the ability to train or play basketball at his previous level.

Physiotherapy interventions were administered progressively according to the postoperative rehabilitation phase following meniscus repair. The rehabilitation program consisted of Neuromuscular Electrical Stimulation (NMES), strengthening exercises (straight leg raise, hip abduction and adduction, calf raises, isotonic squats, isometric squats, squat in-out, walking squat side, and walking squat forward), balance training, and core stability exercises such as plank and side plank. Exercise dosage was progressively adjusted based on the principles of Frequency, Intensity, Time, and Type (FITT), ensuring safe and optimal progression aligned with tissue healing.

Table 1. Physiotherapy Interventions

Intervention	Purpose	Dosage (FITT principles)
Neuromuscular Electrical Stimulation (NMES)	- Enhance muscle strength - Prevent or reduce muscle atrophy - Facilitate optimal muscle contraction - Improve neuromuscular control of the knee	Frequency: 3×/week Intensity: progressed according to patient tolerance Time: 15 minutes Type: electrical stimulation
Straight Leg Raise	- Increase quadriceps strength - Improve knee stability	Frequency: 3–4×/week Intensity: 3-kg load Time: 10 repetitions × 3 sets Type: strengthening exercise
Hip Abduction and Adduction	- Strengthen hip abductors and adductors - Improve knee stability	Frequency: 3–4×/week Intensity: 3-kg load Time: 10 repetitions × 3 sets Type: strengthening exercise
Calf Raises	- Strengthen gastrocnemius–soleus complex - Support stability during standing and walking	Frequency: 3–4×/week Intensity: 10 repetitions × 2 sets Time: 5 minutes Type: strengthening exercise
Isotonic Squat	- Strengthen quadriceps, gluteus, and hamstring muscles - Improve knee function	Frequency: 3×/week Intensity: 4-kg load Time: 10 repetitions × 2 sets Type: strengthening exercise
Isometric Squat	- Improve static knee stability - Activate muscles without excessive joint movement	Frequency: 3×/week Intensity: 10 repetitions × 2 sets Time: 10-second hold Type: isometric exercise
Squat In-Out	- Train valgus/varus knee control - Activate gluteus medius	Frequency: 3×/week Intensity: red resistance band Time: 10 repetitions × 2 sets Type: functional exercise
Walking Squat Side	- Improve lateral stability - Train dynamic movement control	Frequency: 3×/week Intensity: red + purple band + 4-kg load Time: 2 laps Type: dynamic training
Walking Squat Forward	- Train forward movement control - Improve functional strength	Frequency: 3×/week Intensity: red + purple band + 4-kg load Time: 2 laps Type: functional exercise
Balance Training	- Improve knee proprioception - Enhance postural stability	Frequency: 3–5×/week Intensity: moderate Time: 1 minute × 2 repetitions Type: balance training
Plank	- Improve core stability - Support lower-extremity control	Frequency: 3–4×/week Intensity: moderate Time: 1 minute Type: core stability exercise
Side Plank	- Strengthen lateral core musculature - Improve pelvic stability	Frequency: 3–4×/week Intensity: moderate Time: 30 seconds Type: core stability exercise

Evaluation was conducted at the end of week 1 (T0), week 2 (T1), week 3 (T2), and week 4 (T3). Pain intensity was assessed using the Visual Analog Scale (VAS), knee ROM was measured using a goniometer, muscle strength was evaluated using Manual Muscle Testing (MMT), anthropometric measurements were used to assess changes in lower-extremity muscle mass, and functional ability was evaluated using the Barthel Index. The collected data were analyzed descriptively by comparing examination results across evaluation periods to determine changes in the patient's condition following the physiotherapy rehabilitation program.

RESULTS

The findings of this study were obtained through a case-report methodology and a four-week therapeutic intervention period, conducted from April 27 to May 23, 2026. The patient, a 14-year-old male basketball athlete who had undergone right meniscus repair surgery, completed a structured physiotherapy rehabilitation program over the course of four weeks. The rehabilitation protocol consisted of exercise-based therapy, including neuromuscular electrical stimulation (NMES), progressive strengthening exercises, balance training, proprioceptive exercises, and functional movement training. The overall outcomes demonstrated measurable improvements in several clinical domains, including pain reduction, increased right knee range of motion (ROM), enhanced anthropometric parameters, and improved functional ability. The detailed results obtained throughout the four-week intervention period are presented below.

Based on Table 2, pain intensity progressively decreased over the four-week rehabilitation period. Resting pain was absent throughout all evaluation points, indicating stable postoperative comfort during non-loaded activities. Movement-induced pain decreased from a score of 3 to 2, while palpation pain decreased from 4 to 2 by the final evaluation (T3). These findings demonstrate that the physiotherapy program effectively reduced postoperative pain gradually and consistently following meniscus repair surgery.

As shown in Table 3, the right knee range of motion (ROM) for flexion gradually increased from 110° at T0 to 120° at T3, while extension consistently remained at full range throughout the evaluation period. This progressive improvement indicates enhanced joint mobility and flexibility following the structured physiotherapy rehabilitation program.

According to Table 4, muscle strength in the knee flexors, extensors, endorotators, and exorotators remained consistently at MMT grade 4 throughout the evaluation period. This stability indicates that the patient's muscle strength was successfully maintained during rehabilitation, preventing postoperative decline and supporting functional recovery.

Table 5 illustrates a reduction in the circumference difference of the right lower limb across most measurement points, particularly in the thigh region (quadriceps area). These changes indicate improved muscle mass and reduced postoperative atrophy following the four-week rehabilitation program. The progressive normalization of anthropometric values reflects effective strengthening and neuromuscular reactivation.

As shown in Table 6, the Barthel Index score remained consistently at 100 throughout all evaluation periods. This indicates that the patient maintained full independence in daily activities from the beginning of the assessment and continued to do so throughout the rehabilitation program. The stable functional score suggests that despite postoperative impairments, the patient's basic functional independence was preserved and remained optimal.

Table 2. Pain assessment using the Visual Analog Scale (VAS)

Pain type	T0	T1	T2	T3
Resting pain	0	0	0	0
Movement-induced pain	3	3	3	2
Palpation pain	4	4	3	2

Table 3. Range of Motion (ROM) assessment using goniometric measurement

Active movement	Measurement
T0	S. 0° – 0° – 110°
T1	S. 0° – 0° – 110°
T2	S. 0° – 0° – 115°
T3	S. 0° – 0° – 120°

Table 4. Muscle strength assessment using Manual Muscle Testing (MMT)

Muscle group	T0	T1	T2	T3
Knee flexors	4	4	4	4
Knee extensors	4	4	4	4
Endorotators	4	4	4	4
Exorotators	4	4	4	4

Table 5. Anthropometric assessment using midline measurements

Location	T0	T1	T2	T3
20 cm above	–0.5	–0.3	0	0
15 cm above	–1	–0.5	–0.2	–0.1
10 cm above	–2	–1	–0.5	–0.3
5 cm above	–1.5	–1	–0.5	–0.3
Tibia	+1	+0.5	+0.5	+0.5
5 cm below	–0.5	–0.3	–0.3	–0.1
10 cm below	–1	–0.5	0	0
15 cm below	–0.5	–0.3	0	0
20 cm below	0	0	0	0

Table 6. Functional ability assessment using the Barthel Index

Activity	T0	T1	T2	T3
Total Score	100	100	100	100

DISCUSSION

The present study demonstrates that the implementation of a structured physiotherapy rehabilitation program over a four-week period in a patient who underwent right-sided meniscus repair resulted in measurable improvements across several clinical domains. Specifically, the intervention contributed to reductions in pain intensity, enhancements in knee joint range of motion (ROM), and decreases in muscle atrophy. Throughout the evaluation period, muscle strength assessed using Manual Muscle Testing (MMT) and functional independence measured through the Barthel Index remained stable without observable decline. These findings indicate that the rehabilitation program not only facilitated improvements in selected impairments but also preserved the patient's pre-existing functional abilities during the postoperative recovery phase. Such outcomes align with established principles of post-meniscus repair rehabilitation, which emphasize gradual progression, restoration of ROM, strengthening, and continuous monitoring of clinical responses [11].

Pain assessment using the Visual Analog Scale (VAS) revealed a reduction in movement-induced pain from a score of 3 to 2 and a decrease in palpation pain from 4 to 2, while resting pain remained absent throughout the study period. This reduction in pain may be attributed to the combined effects of neuromuscular electrical stimulation (NMES) and therapeutic exercise, both of which are known to enhance local circulation, reduce inflammation, improve neuromuscular activation, and increase knee joint stability [12]. The alleviation of pain likely enabled the patient to participate more effectively in therapeutic exercises, thereby supporting subsequent phases of rehabilitation. These findings are consistent with the work of Calanna et al. (2022), who reported that staged, exercise-based rehabilitation following meniscus repair effectively reduces pain and improves knee function during recovery [6]. Similarly, Arner et al. (2022) emphasized that progressive rehabilitation combined with strengthening exercises plays a crucial role in reducing pain and accelerating postoperative recovery [13].

The assessment of knee joint ROM demonstrated an improvement in flexion from 110° at baseline to 120° after four weeks of therapy, while knee extension remained within normal limits. This enhancement in ROM may be associated with reduced pain, increased soft-tissue flexibility, and the systematic application of strengthening and functional exercises tailored to the tissue healing phase. Exercises such as straight leg raises, isometric and isotonic squats, walking squats, and balance training are known to improve knee mobility without imposing excessive stress on healing tissues [14]. These findings corroborate the observations of Calanna et al. (2022), who noted that increasing ROM is a primary objective in post-meniscus repair rehabilitation due to its direct relationship with functional recovery and readiness to resume daily activities [6]. Furthermore, Monson et al. (2025) highlighted that postoperative rehabilitation should prioritize early protected joint mobilization with gradual ROM progression based on tissue healing phases and patient response, ensuring that increases in ROM do not provoke pain or effusion [4]. Recent consensus recommendations also emphasize that rehabilitation progression must be individualized according to tear characteristics, repair technique, and patient-specific responses [15].

Muscle strength evaluation using MMT showed consistent scores of 4 across all muscle groups throughout the study period. Although no increase in MMT scores was observed, the stability of muscle strength indicates that the physiotherapy program successfully maintained muscular function during postoperative recovery and prevented potential declines associated with reduced activity. This maintenance of strength may be attributed to the combined application of NMES and progressive strengthening exercises, which help sustain neuromuscular activation during tissue healing. According to Calanna et al. (2022), strengthening exercises administered in accordance with rehabilitation phases aim to preserve muscle activation and prevent atrophy before maximal strength gains can be achieved [6]. Migliorini et al. (2023) further noted that progressive strengthening enhances neuromuscular control and supports readiness for return to sport, even though substantial strength gains typically require longer rehabilitation durations [10].

Anthropometric measurements revealed reductions in limb circumference differences at most measurement points, particularly in the thigh region, indicating decreased muscle atrophy following the four-week rehabilitation program. These improvements are likely due to increased muscle activation facilitated by NMES and gradual strengthening exercises, which enhance motor unit recruitment and help maintain lower-extremity muscle mass [16]. This finding aligns with Calanna et al. (2022), who reported that early strengthening exercises following tendon surgery reduce muscle mass loss and accelerate functional recovery in the lower extremities [6]. Jakobsen et al. (2022) also demonstrated that blood-flow restriction combined with low-load resistance training can preserve muscle mass in postoperative knee patients, offering an alternative strategy during early rehabilitation phases [17]. Restoration of muscle mass and function is essential, as meniscal injuries can influence biomechanical and biological properties of the knee joint and affect tissue healing processes [18].

Overall, the findings of this study indicate that the combination of NMES, strengthening exercises, balance training, and core stability exercises administered progressively produced positive outcomes in the postoperative recovery of a basketball athlete following meniscus repair. The rehabilitation program contributed to reductions in pain, improvements in ROM, and decreases in muscle atrophy, while muscle strength and functional independence were preserved. These results support the role of structured, exercise-based physiotherapy as an essential component of knee function recovery following meniscus repair. However, early clinical improvements should not be interpreted as readiness for return to sport. Recent evidence emphasizes that return-to-sport decisions must be criterion-based and incorporate functional and performance testing rather than relying solely on postoperative time or symptom resolution [19].

Limitations of the study

This study has several limitations that should be considered when interpreting the findings. First, the single-subject case report design involves only one patient, limiting the generalizability of the results to the broader population of athletes recovering from meniscus repair [20]. Second, the intervention and monitoring period lasted only four weeks, which is insufficient to capture medium- and long-term outcomes such as meniscal healing success, reinjury rates, and return-to-competition readiness. Third, the absence of a comparison group prevents definitive conclusions regarding the causal effectiveness of NMES combined with exercise. Fourth, MMT and the Barthel Index have limited sensitivity in detecting subtle changes in strength and function, particularly in patients who are already independent at baseline. Additionally, the study did not incorporate performance-based assessments relevant to return to sport, such as hop tests, limb symmetry index, agility testing, or directional-change evaluations [21]. Therefore, the findings should be interpreted as an individualized clinical response to the rehabilitation program rather than causal evidence of intervention efficacy.

Clinical implications

The findings of this study provide important clinical implications. A structured rehabilitation program integrating NMES, strengthening, balance training, and core stability exercises may be utilized as part of physiotherapy management during the postoperative recovery phase following meniscus repair, with progression tailored to patient response. Improvements in pain, ROM, and anthropometric measures within four weeks suggest that regular monitoring can assist physiotherapists in determining appropriate exercise progression. However, given that the patient is a basketball athlete whose sport requires running, jumping, landing, pivoting, and cutting, return-to-sport decisions should not rely solely on pain reduction or ROM improvement. Subsequent evaluations must include objective strength testing, limb symmetry assessment, hop tests, dynamic movement control, agility training, and sport-specific exercises. This approach aligns with consensus recommendations stating that return to sport after meniscus repair should be both time-based and criterion-based, incorporating performance metrics and individualized patient factors [11].

CONCLUSION

The four-week structured rehabilitation program combining Neuromuscular Electrical Stimulation (NMES), strengthening exercises, balance training, and core stability work demonstrated positive clinical outcomes in a basketball athlete following right-sided meniscus repair. The intervention effectively reduced movement- and pressure-induced pain, improved knee range of motion (ROM), and decreased quadriceps muscle atrophy. In addition, the program successfully maintained muscle strength and preserved functional independence, providing an essential foundation for a safe progression toward the return-to-sport phase.

The recommendations derived from this study emphasize that the athlete should maintain consistent adherence to a gradual and progressive exercise program while avoiding premature engagement in high-intensity activities to reduce the risk of re-injury; physiotherapists are encouraged to advance the rehabilitation process by integrating progressive agility training, dynamic stability exercises for landing, pivoting, and cutting, as well as sport-specific basketball drills to adequately prepare the athlete for higher functional demands; and future researchers are advised to

conduct studies with longer follow-up durations until athletes fully return to play, accompanied by larger sample sizes to enhance clinical evidence and improve generalizability.

Ethical consideration, competing interest and source of funding

-This study adhered to fundamental ethical principles in physiotherapy research, including autonomy, beneficence, non-maleficence, and patient data confidentiality. Ethical approval was obtained through informed consent from the patient and formal authorization from the relevant institution prior to data collection.
-No conflicts of interest are associated with this publication
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