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Case Report

Physical Therapy Interventions for a Patient with Poor Muscle Strength, Knee Function, and Psychological Readiness After Anterior Cruciate Ligament Reconstruction with Meniscus Repair: A Case Report

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ABSTRACT

Background: This case report aims to evaluate phase III of physical therapy management, focusing on the late rehabilitation phase tailored to a patient's specific goals and athletic demands. The objective was to improve muscle strength, knee function, and psychological readiness following anterior cruciate ligament reconstruction (ACLR).
Case Presentation: A patient underwent ACLR with a hamstring tendon graft and lateral meniscus repair on November 7, 2022. Thirteen weeks post-surgery, the patient exhibited poor muscle strength (<10 mmHg compared to the uninjured leg), reduced knee function (Lysholm score <80), and low psychological readiness (ACL Return to Sport Index [ACL-RSI] score <70). From February 6 to February 15, 2023, the patient participated in five sessions of standard physical therapy interventions. Baseline and follow-up assessments were conducted, measuring leg circumferences, muscle strengths, and knee functions. Improvements were noted in leg circumferences: increases of 0.2 cm, 1 cm, and 0.5 cm at 20 cm, 10 cm, and 5 cm above the center of the patella (COP), respectively, and a 1 cm increase below COP. Muscle strength improvements were recorded for the quadriceps (+12 mmHg), hamstrings (+15 mmHg), and calf muscles (+25 mmHg). The Lysholm score increased by 27 points, and the ACL-RSI score improved by 32 points.
Conclusion: This case study demonstrates that phase III physical therapy interventions effectively enhance leg circumferences, muscle strength, knee function, and psychological readiness in post-ACLR patients. The protocols used in this case provide a valuable reference for treating similar cases.
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Introduction

Sports injuries frequently occur during exercise or sports activities, but they are not limited to athletes alone. External risk factors for sports injuries include tackling or collisions, impacts, inadequate playing surfaces, substandard equipment, and the absence of protective gear. Internal risk factors include poor posture, improper body mechanics, muscle weakness, and pre-existing physical conditions [1].

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Basketball is a dynamic and popular sport classified as a level I sport, known for its high incidence of sports-related injuries, including muscle strains, ligament sprains, and bone fractures. Among these, the lower extremities are most vulnerable, accounting for 62.4% of all basketball-related injuries, compared to 15.4% involving the upper extremities. Knee injuries, particularly joint sprains that lead to partial or complete ligament tears, are common, with an incidence rate of approximately 16% [2].

The knee is a critical hinge joint responsible for flexion and extension, making it essential for sports activities. It relies on multiple muscles and ligaments to maintain joint stabilization. The knee joint works in coordination with the hip and ankle joints to facilitate high-impact bipedal movements, such as running and jumping. These movements require optimal joint stability to prevent injuries caused by excessive forces acting on the knee structures, including muscles, ligaments, the meniscus, cartilage, and bone [3].

The anterior cruciate ligament (ACL) is a vital stabilizing structure within the knee joint, preventing excessive tibial translation relative to the femur during sports activities. The ACL comprises two distinct bundles: the anteromedial (AM) and posterolateral (PL). The AM bundle primarily resists anterior tibial translation, while the PL bundle plays a more significant role in resisting rotational movements. The ACL's length ranges from 22 mm to 41 mm, with a width of 7 mm to 12 mm. Structurally, the ACL consists predominantly of type I collagen fibers and is located crosswise on the anterior aspect of the posterior cruciate ligament (PCL), attaching specifically to the lateral femoral condyle and the intercondylar eminence of the tibia [4].

ACL injuries typically occur through contact or non-contact mechanisms. Contact injuries result from direct impacts to the outer knee or lower leg, such as being hit, kicked, pushed, tripped, or bumped. Non-contact injuries, which are more common, are caused by sudden changes in direction, abrupt stops, excessive knee bending or straightening, and improper knee alignment during landing movements [5].

When an ACL tear occurs, the injured knee often produces a distinct "pop" sound, becomes unstable, and exhibits symptoms of inflammation, including pain, redness, swelling, and limited range of motion [6]. ACL injuries are frequently accompanied by damage to surrounding tissues, with meniscus injuries being the most common [7]. Furthermore, an athlete's activity level and sports performance often decline following an ACL injury.

ACL reconstruction (ACLR) is the standard surgical approach for addressing ACL injuries. This procedure involves replacing the damaged ligament with grafts sourced from various body parts, such as the hamstring tendon, Achilles tendon, patellar tendon, or an allograft. The primary goal of ACLR is to restore knee joint stability and address accompanying tissue damage, such as performing meniscus repair or meniscectomy in cases of concomitant meniscus injury.

Physical therapy interventions play a pivotal role in post-ACLR recovery, helping patients regain their ability to return to sports. These interventions, typically 6 to 12 months, aim to achieve a normal range of motion, reduce pain and swelling, restore muscle strength, enhance dynamic stability, and prevent recurrent knee injuries [8].

When assessing the adult population during the recovery phase, an athlete's psychological readiness to return to sports has been found to strongly correlate with actual return-to-sport rates and performance [9]. Delayed return to sports has been linked to various challenges, including reduced coping abilities, difficulties performing under pressure, and diminished knee function and muscle strength [10-12]. Moreover, decreased psychological preparedness and heightened fear of movement during the return-to-sport phase have been associated with an increased risk of sustaining a second ACL injury [13].

Despite the critical role of psychological readiness in recovery outcomes, few studies have documented physical therapy management strategies specifically addressing psychological readiness after ACL reconstruction (ACLR). Phase III of physical therapy intervention is designed to optimize muscle strength and endurance, enhance muscle power, improve agility, and restore sport-specific functions. Given the limited literature detailing specific interventions and evaluations for addressing these factors, this report focuses on Phase III physical therapy management to address poor muscle strength, knee function, and psychological readiness following ACLR with meniscus repair.

Case Description

A 25-year-old male patient injured his right knee while playing basketball, experiencing severe pain. Initially, the patient was assessed by a physical therapist and suspected to have an ACL injury but opted not to undergo surgery due to fear. A month later, in October 2022, the patient experienced unbearable pain and knee instability while squatting during a mountain climbing activity. The following day, he consulted an orthopedic specialist for further evaluation, including physical and MRI assessments, which confirmed a diagnosis of an ACL rupture and a lateral meniscus injury (Figure 1).

Subsequently, on November 7, 2022, the patient underwent ACL reconstruction (ACLR) and lateral meniscus repair using a hamstring tendon graft at the Jakarta Army Hospital, Indonesia. Three weeks post-ACLR, the patient began a physical therapy intervention program, attending sessions thrice weekly.

By the 13th week post-ACLR, from February 6 to 15, 2023, the patient continued Phase III rehabilitation under the supervision of physical therapists (NAW, IPPD, PDA, TFW). At this stage, the patient reported unequal muscle strength between his right and left legs and could not perform physical activities such as jogging and mountain climbing.

The patient provided informed consent to publish this case and accompanying figures for scholarly purposes, with assurances of confidentiality regarding personal information.

Assessments

On February 6, 2023, the patient underwent a comprehensive evaluation to ensure readiness for

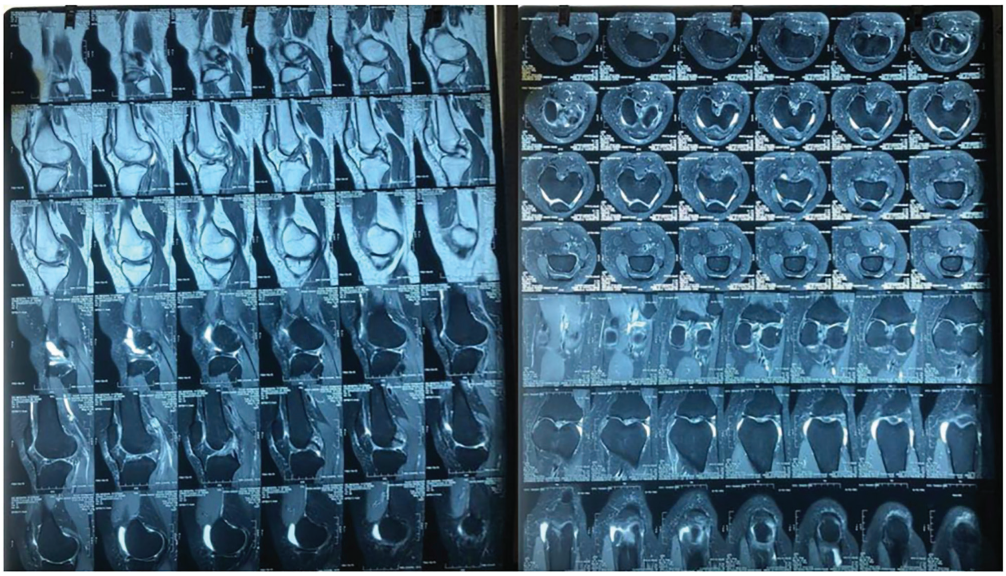

Figure 1: MRI result of ACL and lateral meniscus tears.

continued physical therapy and to rule out any contraindications. Vital signs were assessed and found to be within normal limits, with a heart rate of 75 beats per minute, respiration rate of 20 breaths per minute, oxygen saturation of 98%, blood pressure of 120/80 mmHg, and body temperature of 36.7°C. Subsequently, the knee's essential movement functions and range of motion (ROM) were assessed through active, passive, and isometric tests to evaluate joint mobility, end-feel, and any potential muscle or tendon injuries [14].

The assessment of active range of motion (AROM) revealed flexion of 135° and extension of 3° in the right knee, compared to flexion of 140° and extension of 3° in the left knee. The passive range of motion (PROM) was measured by the physical therapist, who extended and flexed the knee to assess joint end-feel and laxity, with results showing no joint contractures or abnormalities. The PROM findings were flexion of 140° and extension of 3° in both knees. Finally, the patient performed resisted flexion and extension movements against the physical therapist's counterforce. No pain or signs of muscle or tendon injury were observed in the quadriceps or hamstring muscles during these tests [14].

These results confirmed that the patient had adequate baseline knee ROM and no significant joint or soft tissue injuries, making them suitable for progressing to Phase III physical therapy interventions.

In addition, the specific anterior drawer test, Lachman test, and McMurray test were performed to evaluate the integrity of the ACL and meniscus, with all tests yielding negative results. Leg segment circumference measurements were conducted to compare the muscle size between the involved side (left) and the uninvolved side (right). These measurements were taken at four points: 20 cm above the center of the patella (COP), 10 cm above COP, 5 cm above COP, and 10 cm below COP. Measurements were recorded at the baseline, first, second, and third follow-up, revealing changes ranging from 0.2 cm to 1.0 cm (Table 1).

The quadriceps, hamstring, and calf muscle strengths were measured using a sphygmomanometer with isometric contraction. Before each assessment, the sphygmomanometer cuff was inflated to 20 mmHg, and the participant's foot was placed on the cuff. The strength of the hamstrings, quadriceps, and calf muscles was assessed at 90 degrees of knee flexion and the straight knee position. Each leg and movement were tested with three maximal contractions [15]. The functional assessment of the knee was conducted using Lysholm's knee score and the ACL Return to Sport after Injury (ACL-RSI) score.

Table 1: Baseline and follow-up measurements of leg circumferences, muscle strengths, and knee functions after physical therapy program on phase III post-anterior cruciate ligament reconstruction patient.

Measurements	Baseline (dif*)	First follow-up (dif*)	Second follow-up (dif*)	Third follow-up (dif*)
Leg circumference, cm				
20cm above COP	64.5 (-1.5)	64.6 (-1.4)	64.7 (-1.3)	64.7 (-1.3)
10cm above COP	51.0 (-3.0)	51.4 (-2.8)	51.7 (-2.5)	52.0 (-2.2)
5cm above COP	45.0 (-1.2)	45.2 (-1.1)	45.4 (-0.9)	45.5 (-0.8)
10cm below COP	37.7 (-1.2)	37.9 (-1.0)	38.5 (-0.4)	38.7 (-0.2)
Muscle strength, mmHg				
Quadriceps	75.0 (-15.0)	85.0 (-5.0)	86.0 (-4.0)	87.0 (-3.0)
Hamstrings	50.0 (-20.0)	60.0 (-10.0)	65.0 (-5.0)	65.0 (-5.0)
Calf muscles	70.0 (-30.0)	80.0 (-20.0)	85.0 (-15.0)	95.0 (-10.0)
Knee functions, 1-100				
Lysholm's score	73.0	83.0	100.0	100.0
ACL-RSI	56.0	56.0	88.0	88.0

ACL-RSI, anterior cruciate ligament-return to sports index; cm, centimetre; COP, the center of the patella; dif, difference; mmHg, millimetres of mercury. *Comparing with the contralateral leg.

Table 2: Intervention

No.	Intervention	Implementation Method	Dosage	Evidence-Based
1	Static Bike	Purpose: To increase knee ROM and warm-up Method: The patient is instructed to ride a stationary bicycle	resistance: 3 time:10 minutes	Bousquet et al., 2018 [21].
2	Double and Single Calf Raise	The patient's position is standing on the edge of the deck, and then the patient is instructed to make a tiptoe movement of both feet, then one foot.	3x10	Buckthorpe, 2021 [19].
3	Step up–down box (forward)	The patient is asked to climb a 40 cm high box by holding two dumbbells weighing 4 kg. Then the patient goes up and down the box with feet straight, knees parallel to the front, eyes straight ahead, and the body does not bend	3x12 with a load of 4 kg	Asghar, Fateme, 2016 [22].
4	Step up–down box (diagonal)	The patient is asked to climb a 40 cm high box by holding two dumbbells weighing 4 kg. Then, the patient goes up and down the box diagonally with the feet straight, knees parallel to the front, eyes straight ahead, and the body does not bend.	3x15 with a load of 4 kg	Asghar, Fateme, 2016 [22].
5	Pulley (flexion-add-extension)	The patient is instructed to attach the pulley rope to the ankle, and then the patient is asked to pull the rope linked to a load of 14 kg. When pulling the patient's weight upright, the legs are straight, not bent, and one hand rests on a pole. The patient pulls on the rope in flexion, adduction, and extension.	3x12 with a load of 14 kg	Bonilla et al., 2022 [23].
6	Static squat	The patient is instructed to do squats in place using a resistance band attached to both upper limbs.	Work: 10, cycle 10, rest: 6, set 3	Buckthorpe, 2021 [19].
7	Forward and lateral dynamic squats	The patient is instructed to squat while moving forward using a resistance band attached to both upper limbs. Then, instruct the patient to do squat movements while moving sideways.	3 Set	Buckthorpe, 2021 [19].
8	Single Romanian Deadlift	The patient is instructed to stand up and hold a 4 kg weight in each hand and then lift one leg with the knee bent, and then the patient is asked to swing the bent leg backward until the knee is straight. At the same time, the patient also lifts the weight that has been given	3x12 with a load of 4 kg	Schellenberg et al. 2013 [8].
9	Double leg press + Double calf press	Instruct the patient to sit on the leg press with a load of 52 kg, then push the leg press.	43 kg 3x15	Lepley et al, 2015 [24].
10	Single leg press	Instruct the patient to sit on the leg press with a weight of 27 kg, then push the leg press with 1 foot.	27 kg, 3x15	Lepley et al, 2015 [24].
11	Double leg curl	Instruct the patient in a prone position on the leg curl tool with a load of 14 kg, then pull the leg curl tool by flexing the knee.	14 kg 3x15	Buckthorpe et al., 2020 [25].
12	Single leg curl	The patient uses straps on the sore leg on the left thigh and is instructed by the patient to be in a prone position on the leg curl tool with a load of 5 kg, then pull the leg curl tool by flexing the injured Knee	7 Kg 3x12 Hold: 10 s	Llurda-Almuzara et al., 2021 [26].
13	Single Leg Stance on trampoline + catch and throw the ball	Instruct the patient to stand on one foot on the trampoline. After balance, invite the patient to play catch and throw the ball.	10x	Lee, Lim, 2020 [27].
14	Backwards walking	Instruct the patient to walk backwards on the treadmill.	t: 20 minutes, speed: 1.3 km/hour, incline: 1	Shen et al., 2021 [28].
15	Cold Compression	The patient is given an ice pack using two cold packs on the knee joint and tied with a strap.	10 minutes	Hart et al., 2014 [29].

Measurements were taken at the baseline, first follow-up, second follow-up, and third follow-up, yielding score ranges from 73 to 100 for Lysholm's score and 56 to 88 for the ACL-RSI score. A higher score indicated better knee function and greater readiness for return to sport [16].

Interventions

The physical therapy management for this case aimed to improve the strength of the quadriceps, hamstrings, and calf muscles and increase the circumference of the leg muscles and knee functions. The intervention was carried out from February 6, 2023, to February 15, 2023, following the applicable protocol at the hospital (Table 2). The physical therapist implemented both closed kinetic chain exercises, such as step-up and step-down box exercises, forward dynamic squats, lateral dynamic squats, and backward walking (Figure 2), as well as open kinetic chain exercises, including knee extension, knee curl, and plantarflexion and dorsiflexion with an elastic band. Following the prescribed regimen, the patient was also encouraged to perform exercises at home. Additionally, the physical therapist educated the patient on the importance of warming up and cooling down, which included bicycle training and stretching before and after exercise. The patient was advised to avoid activities like jogging, running, jumping, and playing football or basketball and to stop exercising if feeling tired or experiencing pain during home exercises.

Evaluations

The follow-up evaluations, conducted three times during the five intervention sessions, assessed leg circumferences, muscle strength, knee functions, and psychological readiness (Table 1). The leg segmental circumference measurements revealed increases in the 20 cm above the center of the patella (COP) by 0.2 cm, 10 cm above COP by 1 cm, 5 cm above COP by 0.5 cm, and 10 cm below COP by 1 cm. Furthermore, the difference between the left and right leg circumferences decreased, with an increase in the circumference of the injured side. Muscle strength measurements showed an improvement in quadriceps strength by 12 mmHg, hamstring strength by 15 mmHg, and calf muscle strength by 25 mmHg. Additionally, as measured by Lysholm's score, knee function increased by 27 points out of 100, and the ACL-RSI score also improved by 32 points out of 100, indicating progress in knee function and psychological readiness.

Figure 2: Physical therapy interventions and range of motion (ROM) evaluation for anterior cruciate ligament reconstruction

Discussion

The goals of phase III physical therapy intervention focused on achieving minimal or no swelling in the knee, full range of motion (ROM), muscle strength of the injured knee reaching 85% of the uninjured knee, and restoring the patient's functional ability and quality of life. The results from the five intervention sessions showed an increase in the circumference of the injured leg, which aligns with previous studies highlighting the effectiveness of strengthening exercises in addressing muscle weakness. These exercises support a biological process that helps fuse damaged muscle fibers, forming new muscle protein strands or myofibrils [17]. Repairing these myofibrils enhances muscle cell quantity and thickness, ultimately contributing to muscle hypertrophy. Additionally, strengthening exercises provide benefits beyond muscle rehabilitation, including increased physical fitness and the prevention of weight gain after ACLR, which could reduce the risk of cardiovascular issues such as high blood pressure and diabetes [17].

Furthermore, increased muscle strength in the quadriceps by 12 mmHg, hamstrings by 15 mmHg, and calf muscles by 25 mmHg was clinically significant in improving knee function and preventing reinjury after ACLR [18]. The closed kinetic chain exercises, including isometric, concentric, and eccentric muscle contractions (such as static and dynamic squats, calf raises, and single- and double-leg presses), likely activated the neuromuscular system of the hip, knee, and ankle joints. These exercises facilitated muscle co-contractions and joint stability during functional movements. Closed kinetic chain exercises can be combined with dual-task exercises to enhance the patient's concentration and sports performance. The improvements in muscle strength asymmetries between the injured and uninjured legs suggest that these exercises may reduce the risk of knee reinjury as the patient progresses toward returning to sport [19].

There was a notable increase in the functional knee scores using the Lysholm and ACL-RSI measures, with 27% and 32% improvements, respectively. The intervention program effectively targeted the neuromuscular system, optimizing muscle strength, endurance, and power, which enhanced the knee joint's mechanical function during sports activities such as squatting, jumping, and pivoting. Additionally, the improvement in the neuromuscular system (including intermuscular coordination, motor unit recruitment, and firing frequency) and the morphology of the muscle-tendon unit (such as muscle volume and tendon properties) after ACLR likely contributed to increased patient confidence in the operated knee for performing sport-specific tasks [20]. Comprehensive interventions and progress tracking that include patient perceptions are crucial for boosting motivation and fostering optimism about the long-term goals during phase III of physical therapy interventions after ACLR.

This study had several limitations that must be considered. First, the study's design was a case report, meaning the results of this intervention program might not apply to different patients. Second, the evaluations were only conducted during the five intervention sessions due to limited research time. As a result, the study could not assess the long-term effects on muscle strength, endurance, and reinjury rates, which are essential indicators of ACLR rehabilitation success.

Conclusion

In conclusion, this study demonstrated that phase III of physical therapy interventions after ACLR increased leg segment circumference, muscle strength, and knee function. Hopefully, this case can serve as a reference for interventions in ACLR patients, particularly those in phase III with concomitant lateral meniscus injury. Further studies with a larger sample size and long-term evaluations are necessary to assess the efficacy of this intervention.

Authors' Contribution

I.P.G.S.A. conducted the research, was responsible for the research design, and compiled the results. I.G.N.W.A., P.A.S.S., F.P., I.K., I.P.P.D., P.D.A., and T.F.W. contributed to drafting the manuscript and assisting with data collection for this study.

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