Majalah Ilmiah Fisioterapi Indonesia
Indonesian Scientific Journal of Physiotherapy

Case Reports / Case Studies
ISSN (Print): 2303-1921
ISSN (Online): 2722-0443
Volume 14, Number 03, Pages 1006-1012 (2026)
DOI: https://doi.org/10.24843/mifi.000002063

Delayed Rehabilitation After ACL Reconstruction: Phase III–IV Physiotherapy Case Report

Zaenal Muttaqqin[1], Wijianto[2], Halim Mardianto[3]

[1,2]Professional Program in Physiotherapy, Universitas Muhammadiyah Surakarta, Surakarta, Indonesia
[3]Department of Physiotherapy, KRMT Wongsonegoro Hospital, Semarang, Central Java, Indonesia

Corresponding author:
Name: Wijianto
E-mail: wij165@ums.ac.id
Phone: +62 856-0029-8587

Received 29 May 2026; Revised 28 September 2026; Accepted 30 May 2026; Published 28 September 2026.

Abstract

Background: Delayed rehabilitation after anterior cruciate ligament reconstruction (ACLR) may result in persistent pain, muscle weakness, impaired balance, and functional limitations despite successful surgical healing. Evidence regarding advanced physiotherapy management in patients who initiate rehabilitation several months after surgery remains limited.

Objective: To describe the clinical outcomes of Phase III and transitional Phase IV physiotherapy rehabilitation in a patient with delayed recovery following ACLR.

Methods: This case report involved a 17-year-old male who underwent right ACLR using a hamstring tendon autograft and did not receive structured physiotherapy for approximately seven months after surgery. A four-week criterion-based rehabilitation program (eight sessions) consisting of strengthening, proprioceptive, neuromuscular, balance, and agility exercises was implemented. Outcomes included Numeric Rating Scale (NRS), knee range of motion (ROM), muscle strength, thigh muscle girth, and Y Balance Test performance.

Results: Movement pain decreased from 7/10 to 2/10, while resting and tenderness pain resolved completely. Knee flexion ROM improved from 140° to 145°. Hamstring strength increased from 110 mmHg to 130 mmHg (+18.2%). Thigh girth increased by 2 cm at all measurement sites. Y Balance Test composite score improved from 76% to 89% (+17.1%), indicating enhanced dynamic balance and neuromuscular control.

Conclusion: Criterion-based Phase III and transitional Phase IV rehabilitation was associated with improvements in pain, hamstring strength, muscle girth, dynamic balance, and functional performance in a patient who initiated rehabilitation seven months after ACLR.

Keywords
Anterior Cruciate Ligament Reconstruction; Rehabilitation; Postural Balance; Muscle Strength; Physical Therapy Modalities

Introduction

Anterior cruciate ligament (ACL) injury is one of the most common knee injuries among physically active individuals and athletes, particularly during activities involving pivoting, cutting, landing, and rapid deceleration. The ACL serves an essential biomechanical function by limiting anterior tibial translation, contributing to rotational stability, and providing proprioceptive input required for coordinated lower-extremity movement. ACL rupture may result in joint instability, impaired neuromuscular control, decreased functional performance, reduced sports participation, and an increased risk of secondary knee injury. Consequently, ACL reconstruction (ACLR) is frequently recommended for young and active individuals to restore mechanical stability and facilitate return to physical activity and sports participation.[1,2]

Although ACLR effectively restores structural knee stability, surgical reconstruction alone does not guarantee complete functional recovery. Contemporary evidence indicates that many patients continue to experience deficits in muscle strength, dynamic balance, movement symmetry, proprioception, and neuromuscular control long after surgery.[1,3,4] Persistent functional impairments may compromise athletic performance, delay return-to-sport progression, and increase the risk of reinjury despite satisfactory surgical outcomes. Therefore, postoperative physiotherapy rehabilitation is considered a fundamental component of ACLR management and is increasingly recognized as equally important as the surgical procedure itself.[1,3]

Over the past decade, ACL rehabilitation has evolved from a predominantly time-based approach toward a criterion-based rehabilitation model. Current clinical practice guidelines emphasize that rehabilitation progression should be guided by objective clinical and functional criteria rather than postoperative duration alone.[1,4,5] Variables such as pain levels, range of motion (ROM), muscle strength symmetry, movement quality, dynamic balance, neuromuscular control, and psychological readiness are now considered critical indicators for progression through rehabilitation phases and return-to-sport decision-making.[4,6] This individualized approach aims to optimize recovery while reducing the risk of recurrent ACL injury, which remains a substantial clinical concern among physically active populations.[3,4]

Phase III and transitional Phase IV rehabilitation represent critical stages of ACL recovery because they focus on restoring advanced functional capacity through progressive strengthening, proprioceptive training, neuromuscular re-education, dynamic balance exercises, landing control, and agility progression. During these phases, rehabilitation aims to address residual deficits that frequently persist after surgery, including altered movement mechanics, impaired postural control, lower-extremity asymmetry, and decreased sensorimotor function.[1,4,7] Several studies have demonstrated that neuromuscular and proprioceptive interventions can significantly improve dynamic stability, movement efficiency, and functional performance while contributing to safer return-to-sport progression.[7–9]

Despite substantial advances in ACL rehabilitation, delayed initiation of postoperative physiotherapy remains a clinically relevant challenge. In routine clinical practice, some patients fail to receive structured rehabilitation immediately after surgery because of limited access to rehabilitation services, insufficient postoperative education, financial constraints, or a lack of awareness regarding

the importance of physiotherapy. As a result, patients may present several months after surgery with persistent impairments, including pain, muscle weakness, reduced ROM, impaired balance, neuromuscular deficits, and functional limitations despite adequate surgical healing.[2,4] Delayed rehabilitation may also negatively affect long-term prognosis by prolonging recovery, increasing compensatory movement patterns, and delaying achievement of functional milestones required for higher-level activities and sports participation.[10]

Recent literature has highlighted the importance of identifying residual functional deficits rather than relying solely on chronological postoperative timelines.[1,3,4] Studies have reported that clinically meaningful deficits in dynamic balance, strength symmetry, neuromuscular control, and movement quality may persist beyond six months after ACLR, particularly in individuals who do not undergo comprehensive rehabilitation.[7,9,11] These findings suggest that postoperative duration alone is an inadequate indicator of functional readiness and reinforce the rationale for criterion-based rehabilitation approaches in patients with delayed recovery progression.

Although numerous studies have investigated ACL rehabilitation outcomes, most published reports focus on early postoperative management or standard rehabilitation pathways initiated shortly after surgery. Evidence describing patients who begin structured physiotherapy more than six months after ACLR remains limited, particularly during advanced rehabilitation phases involving Phase III and transitional Phase IV progression.[1,3] Furthermore, few case reports have comprehensively documented clinical reasoning, rehabilitation progression, and functional outcomes in patients who are chronologically advanced postoperatively but continue to demonstrate substantial functional deficits. This gap in the literature creates uncertainty regarding appropriate rehabilitation strategies and progression criteria for delayed rehabilitation cases encountered in everyday physiotherapy practice.

The clinical relevance of this issue is considerable because delayed rehabilitation is frequently encountered in musculoskeletal and sports physiotherapy settings, particularly in developing healthcare systems where access to postoperative rehabilitation may be inconsistent. Understanding whether meaningful functional recovery can still be achieved despite prolonged delays in rehabilitation initiation may assist clinicians in developing individualized treatment plans, setting realistic expectations, and making evidence-informed decisions regarding progression toward higher-level functional activities and return-to-sport readiness.

Therefore, this case report aimed to describe the physiotherapy management and clinical outcomes of a patient who initiated structured rehabilitation approximately seven months after ACL reconstruction and subsequently underwent Phase III and transitional Phase IV criterion-based rehabilitation. It was hypothesized that a rehabilitation program emphasizing strengthening, neuromuscular re-education, proprioceptive training, balance exercises, and agility progression would be associated with improvements in pain, ROM, muscle strength, dynamic balance, and functional performance despite delayed rehabilitation initiation. By documenting this uncommon clinical presentation, the present report seeks to contribute additional evidence regarding the management of delayed postoperative recovery following ACL reconstruction and to support the implementation of individualized criterion-based rehabilitation in contemporary physiotherapy practice.

Methods

This study was conducted as a single-patient case report following the CARE (CAse REport) guideline to describe the physiotherapy management and clinical outcomes of a patient with delayed recovery following anterior cruciate ligament reconstruction (ACLR). The report focused on the implementation of criterion-based Phase III and transitional Phase IV rehabilitation in a patient who initiated structured physiotherapy approximately seven months after surgery.

The participant was a 17-year-old male recreational football player who sustained a non-contact right knee injury during a football match involving a sudden change of direction. Following clinical examination and magnetic resonance imaging (MRI), the patient was diagnosed with a complete ACL rupture and subsequently underwent ACL reconstruction using a hamstring tendon autograft on January 27, 2025. Before injury, he participated in recreational football three to four times per week and reported no previous history of knee injury, lower-extremity surgery, neurological disorders, or other medical conditions that could influence rehabilitation outcomes.

Following surgery, the patient did not receive structured physiotherapy rehabilitation for approximately seven months because he was unaware of the importance of postoperative rehabilitation after ACL reconstruction. Although daily activities gradually improved, he continued to experience movement-related knee pain, hamstring weakness, impaired balance, reduced confidence during unilateral loading activities, and difficulty performing higher-level functional tasks. Consequently, he presented to the Medical Rehabilitation Department of KRMT Wongsonegoro Hospital, Semarang, Indonesia, for physiotherapy assessment and management.

A comprehensive baseline assessment was performed before intervention to identify residual impairments and determine the appropriate rehabilitation phase. The baseline findings are presented in Table 1.

Table 1. Baseline Clinical Assessment Findings

Outcome Measure	Instrument	Right/Involved Side	Left/Uninvolved Side
Resting pain	Numeric Rating Scale (NRS)	2/10	0/10
Tenderness pain	Numeric Rating Scale (NRS)	4/10	0/10
Movement pain	Numeric Rating Scale (NRS)	7/10	0/10
Knee flexion ROM	Universal goniometer	140°	150°
Quadriceps strength	Modified sphygmomanometer test	120 mmHg	140 mmHg
Hamstring strength	Modified sphygmomanometer test	110 mmHg	130 mmHg
Muscle girth (5 cm above patella)	Measuring tape	41 cm	43.5 cm
Muscle girth (10 cm above patella)	Measuring tape	50 cm	55 cm
Muscle girth (15 cm above patella)	Measuring tape	55 cm	60.5 cm
Y Balance Test composite score	Y Balance Test	76%	Not assessed

The baseline findings demonstrated persistent movement-related pain, hamstring weakness, thigh muscle atrophy, and impaired dynamic balance despite the patient being approximately eight months postoperative. Based on these findings, the patient was classified within Phase III rehabilitation according to functional criteria rather than postoperative chronology.

To comply with CARE recommendations, the clinical course of the patient is summarized below and can subsequently be converted into a visual timeline.

The clinical timeline of the patient's ACL injury and rehabilitation is presented in Figure 1. The sequence begins with a football-related ACL injury, followed by clinical examination and MRI confirmation of complete ACL rupture and subsequent ACL reconstruction using a hamstring tendon autograft on January 27, 2025. Approximately seven months without structured physiotherapy rehabilitation was followed by persistent pain, muscle weakness, balance deficits, and functional limitations. The

patient subsequently underwent an initial physiotherapy evaluation in September 2025 and was classified as being in Phase III rehabilitation based on functional criteria. A four-week physiotherapy intervention consisting of eight sessions was then implemented, with reassessment at week 2, progression toward transitional Phase IV rehabilitation, and final evaluation at week 4.

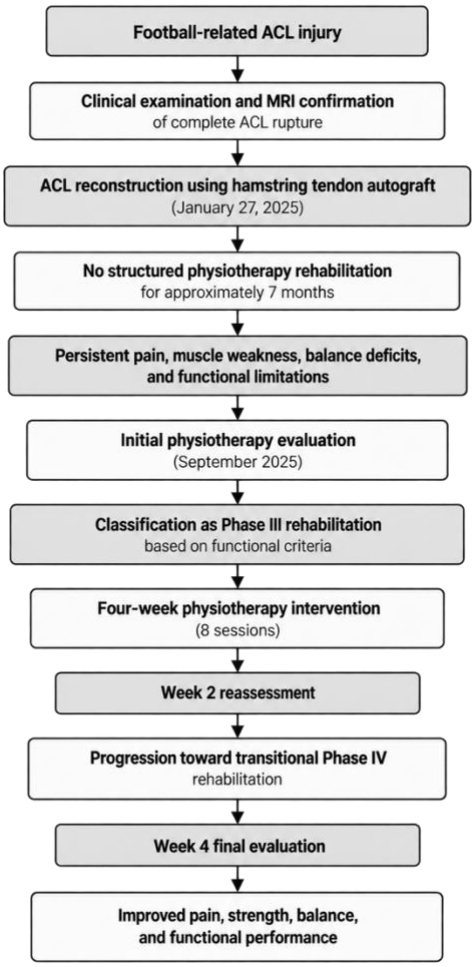

Figure 1. Clinical Timeline of ACL Injury and Physiotherapy Rehabilitation

Pain intensity was assessed using the Numeric Rating Scale (NRS), which has demonstrated excellent reliability and responsiveness in musculoskeletal populations.[12] Knee range of motion (ROM) was measured using a universal goniometer, a valid and reliable instrument for knee joint assessment.[13] Muscle strength was evaluated using a modified sphygmomanometer test, which has shown good validity and reliability as an alternative to handheld dynamometry for lower-extremity muscle testing.[14] During assessment, the cuff was pre-inflated to 20 mmHg and positioned consistently according to the tested muscle group. Three maximal isometric contractions were performed, and the highest value was recorded. Thigh muscle girth was measured using a non-elastic measuring tape at standardized locations 5 cm, 10 cm, and 15 cm proximal to the superior border of the patella. Dynamic balance and neuromuscular control were assessed using the Y Balance Test, which has demonstrated excellent reliability for evaluating unilateral dynamic postural control.[15] Composite scores were calculated by normalizing reach distances to limb length according to established procedures.[15]

The rehabilitation program was conducted over four weeks with a total of eight supervised physiotherapy sessions delivered by the same physiotherapist to ensure treatment consistency. The intervention emphasized strengthening, proprioceptive training, neuromuscular re-education, balance exercises, landing control, and agility progression. The intervention protocol is presented in Table 2.

Table 2. Physiotherapy Rehabilitation Program

Category	Exercise	Dosage
Range of motion	Wall climb squat	3 sets × 5 repetitions
Strengthening	Lunges (6 kg)	3 sets × 5 repetitions
Strengthening	Squats (6 kg)	3 sets × 5 repetitions
Strengthening	Smith machine squat	5 sets × 10 repetitions at 85% 1RM
Strengthening	Hamstring curl	5 sets × 10 repetitions at 85% 1RM
Strengthening	Quadriceps curl	5 sets × 10 repetitions at 85% 1RM
Strengthening	Leg press	3 sets × 10 repetitions at 85% 1RM
Balance and proprioception	BOSU lunges	3 sets × 5 repetitions
Balance and proprioception	BOSU squats	3 sets × 5 repetitions
Balance and proprioception	Passing drills on BOSU	1 set × 10 repetitions
Balance and proprioception	Star Excursion Balance Training	3 sets × 10 repetitions
Balance and proprioception	Landing drills on BOSU	3 sets × 10 repetitions
Agility	Cone jogging drills	3 sets × 5 repetitions
Agility	Cone skipping and ladder drills	3 sets × 5 repetitions

Exercise progression was individualized according to pain response, movement quality, dynamic balance performance, and exercise tolerance. Progression from Phase III toward transitional Phase IV rehabilitation required movement pain ≤3/10, near-symmetrical knee ROM, adequate single-leg balance performance, controlled landing mechanics, and successful completion of agility tasks without symptom exacerbation.[4,16,17]

In addition to supervised sessions, the patient completed a home exercise program consisting of active ROM exercises, stretching, bodyweight squats, step-up exercises, and single-leg balance training three times per week. Adherence was monitored through exercise logs and therapist interviews. Attendance during supervised sessions reached 100%, while adherence to the home exercise program was estimated at approximately 90%.

Outcome measures including NRS, ROM, muscle strength, muscle girth, and Y Balance Test performance were assessed at baseline, week 2, and week 4. Throughout the intervention period, the patient was monitored for adverse events, including increased pain, swelling, episodes of instability, or exercise-related injuries.

Because this report involved a single patient, data were analyzed descriptively. Results were presented as absolute values, percentage changes, and clinical interpretations of progression over time. The analysis focused on changes in pain intensity, knee mobility, muscle performance, dynamic balance, neuromuscular control, and functional capacity throughout the rehabilitation period.

Written informed consent was obtained from the patient and his legal guardian for participation and publication of anonymized clinical information. The patient specifically consented to the publication of clinical findings, rehabilitation procedures, and outcome data. Ethical approval was not required because this manuscript reports a single clinical case managed as part of routine physiotherapy practice without experimental procedures or research-related interventions. All procedures were performed in accordance with the ethical principles of the Declaration of Helsinki.

Results

The patient completed the four-week rehabilitation program consisting of eight supervised physiotherapy sessions without interruption. Attendance during supervised treatment sessions was 100%, while adherence to the prescribed home exercise program was approximately 90% based on exercise logs and therapist verification. No adverse events, episodes of knee instability, excessive pain exacerbation, or exercise-related injuries were reported throughout the intervention period.

To evaluate rehabilitation progression, clinical outcomes were assessed at baseline, week 2, and week 4. Overall, progressive improvements were observed in pain intensity, knee mobility, hamstring strength, muscle girth, dynamic balance, and functional performance throughout the intervention period.

The primary clinical outcomes are summarized in Table 3.

Table 3. Clinical Outcome Progression During Rehabilitation

Outcome	Baseline	Week 2	Week 4	Percentage Change
Resting pain (NRS)	2/10	1/10	0/10	−100%
Tenderness pain (NRS)	4/10	2/10	0/10	−100%
Movement pain (NRS)	7/10	4/10	2/10	−71.4%
Knee flexion ROM	140°	143°	145°	+3.6%
Hamstring strength	110 mmHg	120 mmHg	130 mmHg	+18.2%
Quadriceps strength	120 mmHg	120 mmHg	120 mmHg	0%
Y Balance composite score	76%	83%	89%	+17.1%

As shown in Table 3, clinically meaningful improvements were observed across most outcome measures. Movement-related pain decreased from 7/10 at baseline to 2/10 at week 4, while resting pain and tenderness pain resolved completely. Improvements were already evident at week 2 and continued until the final evaluation. Hamstring strength increased progressively from 110 mmHg to 130 mmHg, whereas quadriceps strength remained unchanged throughout the intervention period. Dynamic balance also improved substantially, as reflected by the increase in Y Balance Test composite score from 76% to 89%.

Changes in thigh muscle girth throughout rehabilitation are presented in Table 4.

Table 4. Anthropometric Muscle Girth Progression

Measurement Site	Baseline	Week 2	Week 4	Change
5 cm above patella	41 cm	42 cm	43 cm	+2 cm
10 cm above patella	50 cm	51 cm	52 cm	+2 cm
15 cm above patella	55 cm	56 cm	57 cm	+2 cm

As presented in Table 4, gradual increases in thigh circumference were observed at all measurement locations. Improvements occurred consistently throughout the intervention period and suggested recovery of lower-extremity muscle mass following progressive strengthening exercises and increased functional loading. Although asymmetry between limbs remained, the overall trend indicated positive muscular adaptation.

Because restoration of dynamic balance and neuromuscular control represented major rehabilitation goals, detailed Y Balance Test outcomes are presented separately in Table 5.

Table 5. Y Balance Test Outcomes

Direction	Baseline	Week 4	Percentage Change
Anterior	56 cm	64 cm	+14.3%
Posterolateral	85 cm	95 cm	+11.8%
Posteromedial	70 cm	89 cm	+27.1%
Composite Score	76%	89%	+17.1%

Improvements were observed in all reach directions. The largest increase occurred in the posteromedial direction (+27.1%), followed by the anterior direction (+14.3%). These findings indicated enhanced unilateral stability, improved neuromuscular control, and better coordination during multidirectional movement tasks. The increase in composite score suggested meaningful improvement in dynamic balance performance and functional lower-extremity control.

In addition to quantitative outcomes, functional progression was observed throughout the rehabilitation process. At baseline, the patient demonstrated compensatory loading patterns, reduced confidence during unilateral stance, impaired balance during BOSU-based activities, and difficulty performing dynamic movements. By week 2, improvements in movement symmetry, postural

control, and loading tolerance became evident. During the final week of intervention, the patient successfully completed BOSU stabilization exercises, landing drills, multidirectional balance training, cone jogging, and ladder exercises without symptom exacerbation.

The rehabilitation goals established at baseline included reducing movement pain to ≤3/10, improving knee flexion ROM, increasing hamstring strength, restoring dynamic balance, and progressing safely toward transitional Phase IV rehabilitation activities. All predefined rehabilitation goals were achieved by the final evaluation. The patient met the functional criteria for progression to higher-level rehabilitation activities based on improvements in pain levels, movement quality, balance performance, and functional loading tolerance.

Return-to-sport readiness was evaluated clinically using symptom response, movement quality, balance performance, and functional task execution. Although substantial improvements were observed, unrestricted return to competitive sport was not recommended at the end of the intervention period because residual asymmetry in strength and muscle girth remained. Therefore, the patient was considered suitable for continued advanced rehabilitation but had not yet achieved full return-to-sport readiness.

Patient Perspective

The patient reported greater confidence when loading the operated limb during daily and exercise-related activities. He perceived a substantial reduction in knee pain and improved stability during walking, stair negotiation, squatting, and sport-related movements. The patient also expressed satisfaction with the rehabilitation program because he had previously believed that the prolonged delay in initiating physiotherapy would permanently limit his recovery. Following intervention, he reported increased confidence regarding future participation in recreational physical activity and sport.

Discussion

This case report described the clinical outcomes of a criterion-based Phase III and transitional Phase IV physiotherapy rehabilitation program in a patient who initiated structured rehabilitation approximately seven months after anterior cruciate ligament reconstruction (ACLR). Despite being eight months postoperative at the time of physiotherapy assessment, the patient continued to demonstrate clinically meaningful impairments, including movement-related pain, hamstring weakness, reduced thigh muscle girth, impaired dynamic balance, and decreased functional loading tolerance. Following four weeks of rehabilitation, improvements were observed across multiple outcome domains, including pain intensity, knee flexion range of motion (ROM), hamstring strength, muscle girth, dynamic balance, and functional performance. These findings support the importance of functional assessment and criterion-based progression when managing patients with delayed postoperative recovery.[1,3,4]

One of the most notable findings in this case was the substantial improvement in dynamic balance performance, as demonstrated by the increase in Y Balance Test composite score from 76% to 89%. Dynamic balance is frequently impaired following ACL injury because disruption of ligament mechanoreceptors may alter proprioceptive feedback, neuromuscular coordination, and postural control.[7,9] Although ACL reconstruction restores mechanical stability, deficits in sensorimotor function often persist long after surgery and may contribute to altered movement patterns and reduced functional performance.[7] The improvement observed in the present case likely reflects the combined effects of proprioceptive training, BOSU-based stabilization exercises, Star Excursion Balance Training, and progressive functional loading. Previous studies have similarly reported that neuromuscular and balance-oriented rehabilitation can improve dynamic stability, movement symmetry, and lower-extremity control following ACL reconstruction.[7,9,18]

The improvement in Y Balance Test performance is clinically relevant because dynamic balance has been associated with functional readiness and injury-risk reduction during advanced rehabilitation stages.[19] Persistent asymmetry in balance performance may contribute to compensatory movement strategies and increase biomechanical stress on the reconstructed knee during sport-related activities.[20] Although the patient demonstrated substantial improvement, the final score should not be interpreted as evidence of complete recovery. Instead, it suggests meaningful restoration of neuromuscular function while reinforcing the need for continued rehabilitation before unrestricted sports participation. This interpretation aligns with contemporary return-to-sport frameworks, which recommend integrating balance, strength, movement quality, and functional testing when evaluating readiness for higher-level activity.[1,3,4]

Pain reduction represented another clinically important outcome. Movement-related pain decreased from 7/10 to 2/10, while resting pain and tenderness pain resolved completely. Persistent pain after ACL reconstruction has been associated with altered movement patterns, muscular inhibition, reduced loading confidence, and incomplete neuromuscular recovery.[2,4] In the present case, pain reduction was accompanied by improved functional loading tolerance and greater confidence during unilateral activities. These findings suggest that progressive strengthening and neuromuscular rehabilitation may have improved load distribution and movement efficiency around the knee joint, thereby reducing mechanical stress during daily and sport-related tasks.

Although knee flexion ROM improved only modestly from 140° to 145°, the clinical significance of this change should be interpreted within the context of the patient's postoperative status. Because the patient was already eight months postoperative, substantial gains in passive mobility would not typically be expected.[4] More importantly, the increase in ROM was accompanied by improved movement quality during squatting, landing, and agility-related activities. Therefore, the observed improvement likely reflects enhanced functional utilization of available ROM rather than a purely mechanical increase in joint mobility.

The increase in hamstring strength observed during rehabilitation may have played a central role in the patient's functional improvement. Hamstring muscles contribute to dynamic stabilization of the knee by resisting anterior tibial translation and supporting neuromuscular control during movement.[2] Residual hamstring weakness is frequently reported following ACL reconstruction using hamstring tendon autografts because graft harvesting may compromise muscular performance during the recovery period.[4] The strengthening interventions implemented in this case, including hamstring curls, lunges, squats, and leg press exercises, likely facilitated neuromuscular adaptation and improved force-generating capacity. Enhanced hamstring function may also have contributed to the observed improvements in balance performance, landing control, and unilateral loading tolerance.

Interestingly, quadriceps strength remained unchanged throughout the intervention period. Several factors may explain this finding. First, baseline quadriceps strength was relatively well preserved compared with hamstring performance, limiting the potential for substantial measurable improvement. Second, the four-week intervention period may have been insufficient to induce detectable changes in quadriceps strength. Third, the modified sphygmomanometer test may have limited sensitivity for identifying subtle strength gains in patients with relatively high baseline values. Importantly, the absence of measurable quadriceps improvement should not be interpreted as a lack of functional recovery because improvements were observed in multiple other clinically relevant outcomes. Similar discrepancies between isolated strength measures and broader functional performance outcomes have been reported in previous ACL rehabilitation studies.[9,21,22]

A particularly important aspect of this case is the persistence of functional deficits despite the patient being approximately eight months postoperative. This finding highlights a critical limitation of relying solely on chronological postoperative milestones when evaluating rehabilitation progression. Contemporary evidence consistently demonstrates that biological healing does not necessarily correspond with restoration of strength symmetry, dynamic balance, neuromuscular control, or movement quality.[1,3,5] In the present case, the absence of structured rehabilitation for approximately seven months likely contributed to persistent impairments despite successful surgical reconstruction. Consequently, the patient remained functionally within Phase III rehabilitation even though he had progressed far beyond the corresponding postoperative timeline.

The delayed initiation of rehabilitation may also have implications for long-term prognosis. Failure to address deficits in strength, proprioception, and movement control may contribute to prolonged functional limitations, altered biomechanics, reduced physical activity participation, and potentially increased risk of secondary injury.[10] Although meaningful improvements were achieved during the intervention period, residual asymmetry remained at the final evaluation, particularly in muscle girth and strength outcomes. These findings suggest that delayed rehabilitation may prolong the recovery process and require additional rehabilitation exposure before optimal functional restoration can be achieved.

Several alternative explanations should also be considered when interpreting the results. Because this report describes a single patient without a comparison condition, it is not possible to establish a direct causal relationship between the intervention and observed outcomes. Natural recovery processes, increased activity levels, repeated exposure to testing procedures, and psychological adaptation may have contributed to some degree of improvement. However, the patient had experienced persistent deficits for several months before initiating physiotherapy, suggesting that spontaneous recovery alone is unlikely to explain the consistent improvements observed across multiple outcome measures during the intervention period. Nevertheless, the descriptive nature of the study design precludes definitive conclusions regarding treatment effectiveness.

From a clinical perspective, this case emphasizes the importance of patient education regarding postoperative rehabilitation following ACL reconstruction.[23] The primary reason for delayed rehabilitation in this patient was a lack of awareness regarding the necessity of structured physiotherapy after surgery. This finding highlights the need for improved communication between surgeons, physiotherapists, and patients to ensure timely rehabilitation referral and adherence.[23] Additionally, the case reinforces the value of objective assessment of pain, strength, balance, and functional performance when determining rehabilitation progression, particularly in patients presenting with delayed recovery.

Several limitations should be acknowledged. First, this report involved only a single patient, limiting the generalizability of the findings. Second, long-term follow-up was not performed, preventing evaluation of sustained outcomes and eventual return-to-sport status. Third, biomechanical analysis, motion analysis, and electromyographic assessment were not included. Fourth, standardized patient-reported outcome measures were not collected; therefore, subjective perceptions of knee function and quality of life could not be quantified alongside objective clinical improvements. Finally, psychological factors known to influence ACL rehabilitation outcomes, such as fear of reinjury and return-to-sport confidence, were not assessed.[24] Future studies should incorporate validated patient-reported and psychological outcome measures, longer follow-up periods, and larger samples to better understand rehabilitation outcomes in patients with delayed postoperative recovery.

Overall, this case demonstrates that criterion-based Phase III and transitional Phase IV rehabilitation may be associated with meaningful improvements in pain, hamstring strength, dynamic balance, muscle girth, and functional performance in patients who initiate rehabilitation several months after ACL reconstruction. However, the findings should be interpreted as descriptive observations from a single case and should not be generalized without further investigation.

Conclusion

This case report demonstrated that a criterion-based Phase III and transitional Phase IV physiotherapy rehabilitation program was associated with improvements in pain intensity, hamstring strength, thigh muscle girth, dynamic balance, and functional performance in a patient who initiated structured rehabilitation approximately seven months after anterior cruciate ligament reconstruction. Despite being eight months postoperative, the patient continued to exhibit clinically meaningful functional deficits, indicating that postoperative duration alone may not accurately reflect recovery status or rehabilitation readiness.

The findings highlight the importance of individualized rehabilitation progression based on objective clinical and functional criteria rather than chronological postoperative milestones. Comprehensive assessment of pain, muscle performance, dynamic balance, and movement quality may assist physiotherapists in identifying persistent deficits and guiding appropriate rehabilitation strategies in patients presenting with delayed recovery following ACL reconstruction.

From a clinical perspective, this case underscores the importance of early patient education regarding the necessity of postoperative physiotherapy after ACL reconstruction. Delayed rehabilitation may contribute to prolonged functional impairments; however, meaningful functional improvements may still be achieved through structured rehabilitation emphasizing strengthening, neuromuscular re-education, proprioceptive training, balance exercises, and progressive functional activities.

Because this report describes a single clinical case, the findings should be interpreted with caution and cannot be generalized to all individuals undergoing ACL reconstruction. Future studies involving larger samples, longer follow-up periods, and multidimensional outcome assessments are recommended to further evaluate rehabilitation outcomes and optimize management strategies for patients experiencing delayed postoperative rehabilitation.

Author Contributions

Zaenal Muttaqqin: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Visualization, Writing – Original Draft Preparation.
Wijianto: Conceptualization, Methodology, Validation, Supervision, Writing, Review and Editing, Project Administration.
Halim Mardianto: Investigation, Resources, Supervision, Writing, Review and Editing.
All authors have read and approved the final version of the manuscript.

Acknowledgments

The authors would like to express their sincere gratitude to the Medical Rehabilitation Department of KRMT Wongsonegoro Hospital, Semarang, Indonesia, for facilitating the rehabilitation process and clinical assessment described in this case report. The authors also thank the patient and his legal guardian for their cooperation and willingness to participate and provide consent for publication.

Conflict of Interest Statement

The authors declare no conflict of interest.

Funding Sources

This research received no external funding.

Ethics Statement

Written informed consent for participation and publication was obtained from the patient and his legal guardian. Ethical approval was not required because this manuscript reports a single clinical case managed as part of routine physiotherapy practice without experimental procedures or research-related interventions. All procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki.

References

1. Glattke KE, Tummala SV, Chhabra A. Anterior cruciate ligament reconstruction recovery and rehabilitation: a systematic review. J Bone Joint Surg Am. 2022;104(8):739-754.
2. Elabd OM, Elabd AM. Functional outcomes of a criterion-based rehabilitation protocol for anterior cruciate ligament reconstruction in amateur athletes: a randomised clinical trial. J Bodyw Mov Ther. 2023;35:7-13.
3. Jenkins SM, Guzman A, Gardner BB, Bryant SA, del Sol SR, McGahan P, et al. Rehabilitation after anterior cruciate ligament injury: review of current literature and recommendations. Curr Rev Musculoskelet Med. 2022;15(3):170-179.
4. Kotsifaki R, Korakakis V, King E, Barbosa O, Maree D, Pantouveris M, et al. Aspetar clinical practice guideline on rehabilitation after anterior cruciate ligament reconstruction. Br J Sports Med. 2023;57(9):500-514.
5. Dingenen B, Gokeler A. Optimization of the return-to-sport paradigm after anterior cruciate ligament reconstruction: a critical step back to move forward. Sports Med. 2017;47(7):1487-1500.
6. Turk R, Shah S, Chilton M, Thomas TL, Anene C, Mousad A, et al. Return to sport after anterior cruciate ligament reconstruction requires evaluation of >2 functional tests, psychological readiness, quadriceps/hamstring strength, and time after surgery of 8 months. Arthroscopy. 2023;39(3):790-801.e6.
7. Webster KE, Hewett TE. What is the evidence for and validity of return-to-sport testing after anterior cruciate ligament reconstruction surgery? A systematic review and meta-analysis. Sports Med. 2019;49(6):917-929.
8. Gokeler A, Dingenen B, Hewett TE. Rehabilitation and return to sport testing after anterior cruciate ligament reconstruction: where are we in 2022? Arthrosc Sports Med Rehabil. 2022;4(1):e77-e82.
9. Irfan A, Kerr S, Hopper G, Wilson W, Wilson L, Mackay G. A criterion based rehabilitation protocol for ACL repair with internal brace augmentation. Int J Sports Phys Ther. 2021;16(3):870-878.
10. Alqahtani TA, Kardm SM, Alnakhli HH, Alyazedi FM, Kandakurti PK, Reddy RS. Impact of early vs. delayed physical therapy on functional recovery, proprioception, and return to sport after anterior cruciate ligament (ACL) reconstruction: a cross-sectional study. J Orthop Surg Res. 2025;20:644.
11. Kotsifaki A, Whiteley R, Van Rossom S, Korakakis V, Bahr R, Sideris V, et al. Single leg hop for distance symmetry masks lower limb biomechanics: time to discuss hop distance as decision criterion for return to sport after ACL reconstruction? Br J Sports Med. 2022;56(5):249-256.
12. Modarresi S, Lukacs MJ, Ghodrati M, Salim S, MacDermid JC, Walton DM. A systematic review and synthesis of psychometric properties of the Numeric Pain Rating Scale and the Visual Analog Scale for use in people with neck pain. Clin J Pain. 2021;38(2):132-148.
13. Acar S, Aljumaa H, Şevik K, Karatosun V, Ünver B. The intrarater and interrater reliability and validity of universal goniometer, digital inclinometer, and smartphone application measuring range of motion in patients with total knee arthroplasty. Indian J Orthop. 2024;58(6):732-739.
14. Brito SAF, Santana MM, Benfica PA, Aguiar LT, Gomes GC, Faria CDCM. The modified sphygmomanometer test for assessment of muscle strength of community-dwelling older adults in clinical practice: reliability and validity. Disabil Rehabil. 2022;44(1):131-138.
15. Plisky P, Schwartkopf-Phifer K, Huebner B, Garner MB, Bullock G. Systematic review and meta-analysis of the Y-Balance Test Lower Quarter: reliability, discriminant validity, and predictive validity. Int J Sports Phys Ther. 2021;16(5):1190-1209.
16. Dawkins J, Teel J, Kitziger R, Khair M. Anterior cruciate ligament injury prevention and rehabilitation. HSS J. 2023;19(3):365-372.
17. Sayer TA, van Melick N, Riera J, Jackson J, Bryant A, Bogie R, et al. Is it time to develop specific return to running criteria for ACL rehabilitation? An international survey of physiotherapists criteria for return to running following ACL injury. Phys Ther Sport. 2024;67:19-24.
18. Logerstedt D, Lynch A, Axe MJ, Snyder-Mackler L. Pre-operative quadriceps strength predicts IKDC2000 scores 6 months after anterior cruciate ligament reconstruction. Knee. 2013;20(3):208-212.
19. Kim JG, Lee DW, Bae KC, Choi BC, Yang SJ, Cho SI, et al. Correlation of Y Balance with clinical scores and functional tests after anterior cruciate ligament reconstruction in young and middle-aged patients. Clin Orthop Surg. 2023;15(1):50-58.
20. Song Y, Li L, Jensen MA, Dai B. Jump-landing kinetic asymmetries persisted despite symmetric squat kinetics in collegiate athletes following anterior cruciate ligament reconstruction. Sports Biomech. 2025;24(4):999-1012.
21. Greenberg EM, Greenberg ET, Albaugh J, Storey E, Ganley TJ. Anterior cruciate ligament reconstruction rehabilitation clinical practice patterns: a survey of the PRiSM Society. Orthop J Sports Med. 2019;7(4):2325967119839041.
22. Kim JS, Hwang UJ, Chung KS, Yi CH, Choi WJ, Kwon OY. Influence of strength and balance ability on functional performance in the involved and uninvolved sides after anterior cruciate ligament reconstruction. J Back Musculoskelet Rehabil. 2024;37(2):407-417.
23. Walker A, Hing W, Lorimer A, Rathbone E. Rehabilitation characteristics and patient barriers to and facilitators of ACL reconstruction rehabilitation: a cross-sectional survey. Phys Ther Sport. 2021;48:169-176.
24. Xiao M, van Niekerk M, Trivedi NN, Hwang CE, Sherman SL, Safran MR, et al. Patients who return to sport after primary anterior cruciate ligament reconstruction have significantly higher psychological readiness: a systematic review and meta-analysis of 3744 patients. Am J Sports Med. 2023;51(10):2774-2783.