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## Effect of low-moderate plyometric exercise in post anterior cruciate ligament reconstruction: A case study

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### Abstract

The anterior cruciate ligament (ACL) is vital for knee joint stability, and its injury is a common concern in active individuals. Despite advances in ACL reconstruction (ACLR), residual instability and performance declines remain significant issues. Diminished proprioception post-ACL rupture further complicates rehabilitation. This case study examines the efficacy of a low-moderate plyometric exercise protocol in ACLR rehabilitation.

A 25-year-old male sustained an ACL injury while playing football, leading to surgery. Post-surgery, he underwent an 8-week plyometric exercise program. The study assessed knee strength, range of motion, and functional outcomes using the International Knee Documentation Committee (IKDC) and Knee Injury and Osteoarthritis Outcome Score (KOOS).

Results showed significant improvements in knee strength, range of motion, and functionality post-intervention without adverse effects. Plyometric training enhanced muscle strength and function, crucial for post-ACL surgery rehabilitation. The study supports the role of plyometric exercises in ACLR recovery, offering a safe and feasible approach to improve outcomes.

This study underscores the importance of incorporating plyometric exercises in ACLR rehabilitation protocols, emphasizing its potential to enhance functional recovery and lower limb power. Further research with larger sample sizes is warranted to validate these findings and optimize ACLR rehabilitation strategies.

**Keywords:** Anterior cruciate ligament, rehabilitation strategies, low-moderate plyometric, knee joint

### Introduction

The anterior cruciate ligament (ACL) plays an important role in the kinematics of the knee joint, limiting the anterior translation of the tibia and stabilizing the knee joint. It also contains mechanoreceptors whose task is to maintain neuromuscular control of the joint. At the same time, it is a structure whose damage is one of the most common and serious locomotor injuries. The consequence of ACL rupture is a disturbance in the biomechanics of the joint, leading to the development of abnormal movement patterns and chronic instability that leads to the loss of function during dynamic tasks and may cause secondary damage to the menisci and cartilage [1]. Tears and sprains in the anterior cruciate ligament (ACL) are common knee injuries in active patients. ACL reconstruction (ACLR), a well-established procedure, restores knee joint stability, improves function, and supports an eventual return to sports. Although the advances in surgical techniques and improved understanding of the ACL anatomy and biomechanics have improved clinical outcomes, residual rotatory instability (related to unsatisfactory clinical outcomes and risks of re-tear) was observed in 25% of the patients [2]. One cause of the increased risk of re-injury and performance declines is attributed to the diminished proprioception after an ACL rupture.

The native intact ACL contains mechanoreceptors that detect changes in the direction of movement, changes in acceleration, speed, tension, and an estimate of the joint position [3].

The goal of primary repair is to reapproximate the torn ends of the ACL resulting in a healed ligament that appears histologically like that of a spontaneously healing ligament. 66,67,70 However, the native ACL has poor healing potential because of its post injury instability, lack of vascularity, and harsh synovial intraarticular environment.

The first stage of ligament healing, inflammation, is dependent on initial clot formation in damaged tissue.

The clot catalyses local inflammation and serves as a scaffold for further healing via recruited extrinsic inflammatory cells. Clot formation is essential for the initiation of the healing cascade and is dependent on local vascularity. Thus, poorly vascularized tissue, such as the mid-portion of the ACL, has a poor innate healing ability. Multiple studies, both basic science and clinical, have suggested that the ACL has some degree of healing potential for acute tears that occur in the proximal ACL<sup>[4]</sup>.

While ACL rehabilitation programs typically include high-intensity resistance training, complete quadriceps strength recovery after ACL reconstruction has been mostly unattainable. A potential cause for the lack of efficacy of current resistance-based exercise used in ACL rehabilitation is that these exercises are typically performed in a “non-functional” manner (i.e., while lying, sitting, or standing in place), which is less than optimal for inducing transfer of benefits to functional activities, such as walking, because of practice specificity<sup>[5]</sup>.

Plyometric exercise is a popular form of training commonly used to improve athletic performance. The stretch-shortening cycle, which involves a stretch of the muscle-tendon unit immediately followed by shortening, is integral to plyometric exercise. The stretch-shortening cycle enhances the ability of the muscle-tendon unit to produce maximal force in the shortest amount of time, prompting the use of plyometric exercise as a bridge between pure strength and sports-related speed. Maximal effort plyometric training, or “shock training”, was first introduced to Russian athletes to aid the development of explosive “speed-strength”.<sup>[6]</sup> Plyometrics consists of the rapid stretching of a muscle (eccentric action) immediately followed by a concentric or shortening action of the same muscle and connective tissue. This training method increases strength and explosiveness and includes a diverse range of bilateral and unilateral jumps, bounds and hops<sup>[7]</sup>.

Objective of the study-To see the effect of low-moderate plyometric exercise protocol in post anterior cruciate ligament reconstruction patient.

### Patient Information and Observation

The patient was alright till 26/01/23. On 26/01/23, around 10:15 pm while playing football on ground in Latur, during running he suddenly turned to right side of his body and felt a quick sudden jerk. He fell on his left side. For next 10 min he was lying on ground as he was not able to get up, his friends gathered around. He got up by himself and he had pain while putting weight on right leg, he saw that there was immediate swelling. The pain is insidious in onset and gradually progressive in nature with an intensity of 8/10 on numeral pain rating scale (NPRS). It is dull aching in nature which gets aggravated by movements. At night around 12:35pm that is on 27/01/23 he went to GMC (Government Medical College) Latur casualty. He took X-ray consultation from medicine resident present over there and X-ray was done. From that time till 28/01/23 3pm he took painkiller (zerodol) and used ice pack. At around 3pm he went to private orthopaedic hospital. In that hospital the doctor performed Anterior drawer test and the findings were positive for ACL injury.

The doctor suggested MRI. So, at 4:30 pm MRI was done and he got back reports at around 6:30 pm. As according to suggestion patient was using long knee brace. After

discussion on 28/01/23-29/01/23 they decided to do surgery in Loni. So, on 2/02/23 he reported OPD at 2:30pm, again anterior drawer test and pivot shift test were done and the findings were positive for the same. Doctors prescribed some medications and surgery was scheduled. On 3/02/23 he went for pre anaesthetic tests and hence after that surgery was planned on 4/02/23. Accordingly, surgery was done on 4/02/23 which started at 9:00 am and lasted till 3:30 pm. After surgery he was kept in post-op room for 1 hour and then he was brought to SPR at around 6pm. On 6/02/2023 patient started Physiotherapy rehabilitation with the proper protocol.

### Examination

The patient was assessed with right knee in a supine position. On general examination, the patient's vital signs were normal: Afebrile fever, PR 86 beats/min, respiratory rate 18 breaths/min, Blood pressure 126/80mmHg, and BMI 26.04 kg/m<sup>2</sup>. The underlying skin appeared to be normal upon examination. The patient maintained 15-degree adduction on the right lower limb. There was not significant difference noticed during a posture evaluation. The local temperature was not increased on examination; grade-2 tenderness was present around the suture. The range of motion of the lumbar spine was normal, and for hip and knee it was slightly alerted as shown in Table 1. Normal reflexes and sensory testing were found during the neurological examination on both sides. Muscle weakness was seen in the right lower limb; in comparison to the left lower leg shown in Table 2. The distal circulation was intact. The gait pattern was unaltered.

**Table 1:** Showing the range of motion of lower limb

HIP	Right		Left	
	Active	Passive	Active	Passive
Flexion	0-100	0-110	0-120	0-120
Extension	0-30	0-30	0-30	0-30
Abduction	0-30	0-35	0-40	0-40
Adduction	30-0	35-0	45-0	45-0

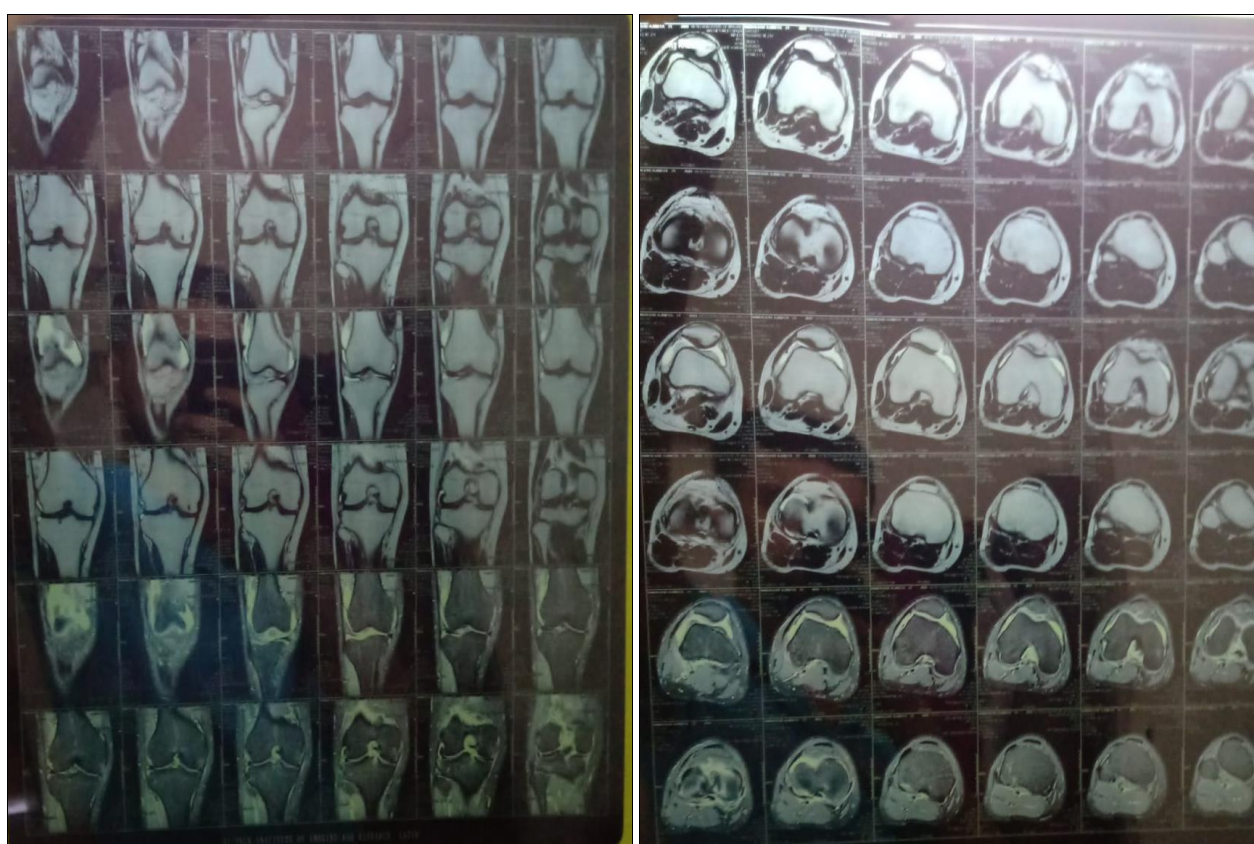
Knee	Right		Left	
	Active	Passive	Active	Passive
Flexion	5-100	5-105	0-120	0-120
Extension	5-0	5-0	30-0	30-0
Ankle				
Plantar Flexion	0°-35	0°-40	0°-35	0°-40
Dorsi Flexion	0°-20°	0°-20°	0°-20°	0°-20°

**Table 2:** Showing the MMT of lower limb

Muscles	Right	Left
Hip Flexors	4	5
Extensors	4	5
Abductors	4	5
Adductors	4	5
Knee Flexors	4	5
Extensors	4	5
Ankle Dorsi flexor	4	5
Plantar flexor	4	5

### Diagnostic Assessment

Red blood cell (RBS), complete blood count (CBC), liver function test (LFT), kidney renal rest (KFT) were carried out. In any of these examinations, no changes were found. The diagnostic tool performed was an X-ray and MRI was done in which the x-ray showed no bony abnormalities and MRI showed complete ACL tear of right side, Marrow edema in lateral condyle of tibia and right knee effusion.



**Outcome Measures**

International Knee Documentation Committee (IKDC).  
Knee Injury and Osteoarthritis Outcome Score (KOOS).

**Therapeutic Intervention**

**Table 3:** Showing type of exercise, Plyometrics drills and dosage

6 <sup>st</sup> Week			
Days	Type of exercise	Plyometrics drills	Dosage
Session 1	Low Intensity	Squat jump Ankle bounce	10 repetitions * 2 sets
Session 2		Jump to box, Split jump	
Session 3		Lateral jump to box, Star jump	
7 <sup>nd</sup> Week			
Days	Type of exercise	Description	Dosage
Session 4	Low Intensity	Lunge jump, Plank jump	12 repetitions* 2 sets
Session 5		Depth jump, Jumping lunges	
Session 6		Knee tuck jump, Skater lunges	
8 <sup>rd</sup> Week			

Days	Type of exercise	Description	Dosage
Session 7	Moderate Intensity	Split squat jump, Lateral hop	8 repetitions* 3 sets
Session 8		Tuck jump, Single leg pick up jump	
Session 9		Lateral box pushups, Standing triple jump	
<b>9<sup>th</sup> Week</b>			
Days	Type of exercise	Description	Dosage
Session 10	Moderate Intensity	Bounding, Seated vertical jump	10 repetitions * 3 sets
Session 11		Box drill with ring, Standing vertical jump	
Session 12		Lateral hurdle jump, Running leg bounds	

## Results

The participant tolerated the 8-week intervention well and completed the FRT protocol without any adverse effects. The participant had no complaints of pain or swelling during or after the intervention.

**Table 4:** Showing range of motion

HIP	Pre-Right		Post-Right	
	Active	Passive	Active	Passive
Flexion	0-100	0-110	0-120	0-120
Extension	0-30	0-30	0-30	0-30
Abduction	0-30	0-35	0-40	0-40
Adduction	30-0	35-0	45-0	45-0

Knee	Pre-Right		Post-Right	
	Active	Passive	Active	Passive
Flexion	5-100	5-105	0-120	0-120
Extension	5	5	0	0

**Table 5:** Showing MMT

Muscles	Pre-Right	Post-Left
Hip Flexors	4	5
Extensors	4	5
Abductors	4	5
Adductors	4	5
Knee Flexors	4	5
Extensors	4	5
Ankle Dorsi flexor	4	5
Plantar flexor	4	5

International Knee Documentation Committee (IKDC). Knee Injury and Osteoarthritis Outcome Score (KOOS)

**Table 6:** Showing IKDC and KOOS

	Pre-Right	Post-Right
IKDC	70	100
KOOS	80	100

## Discussion

The purpose of this case study was to assess whether Low-Moderate Intensity Plyometric exercise protocol could serve as a feasible method to improve knee strength, range of motion and function after ACL reconstruction. For this purpose, we recruited a young ACLR participant and trained him for 4 weeks (3 times per week). After the intervention, the participant showed substantial improvements in knee strength, range of motion and functionality. There were also no adverse events during the training. These results suggest that Low-Moderate Intensity Plyometric exercise protocol is a safe and feasible approach to improve knee strength and function and may serve as a promising adjuvant to traditional rehabilitation.

After ACL surgery, restoration of lower-extremity strength (specifically in the quadriceps) is a top priority, as persistent weakness can lead to altered gait mechanics, degeneration of the knee joint, and eventually lowered quality of life [8, 9].

Previous authors have shown that plyometric training seems to represent the most effective training method as it exerts positive effects on both stability and functional performance in the post-ACL-surgical rehabilitation period [10]. The participant in this study showed substantial improvements in knee extensor and flexor strength in the ACL reconstruction leg. The improvements in knee strength were also paralleled by improvements in limb.

Biomechanically “priming” the muscle is supported by the work of Elftman. The Elftman proposal simply states that the force production of muscle is arranged in a predictable hierarchy. This orderly format is that eccentric muscle contractions create the most force, followed by isometric contractions and then concentric contractions. Concentric muscle contractions therefore, are actually the weakest of the three modes of muscle actions. However, plyometrics create the greatest forces during the concentric power production phase. It is for this reason that the eccentric pre-stretch and the short amortization phases are so critical for the optimum power development in a muscle [11].

## Conclusion

From the results of present study, the low-moderate plyometric showed improvement in lower limb power and functionality. When compared pre and post value there was estimated to be more effect appeared at week 6.

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