

Patient-Centric Customised Isokinetic Training Improves the Muscular Performance and Physical Function of an Individual with Bone-Patella Tendon-Bone Autograft Anterior Cruciate Ligament Reconstruction: A Case Report

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Abstract

Background: Anterior Cruciate Ligament Reconstruction using Bone-Patella Tendon-Bone autograft is a commonly performed surgical procedure to restore knee stability. Postoperative rehabilitation plays a vital role in optimizing muscle performance and restoring functional mobility. However, the application of individualised isokinetic training combined with task-specific biofeedback remains limited in clinical practice.

Case Presentation: This case report presents a 23-year-old male who underwent Anterior Cruciate Ligament Reconstruction using Bone-Patella Tendon-Bone autograft following a sports-related injury. A six-week rehabilitation program was implemented, emphasizing patient-specific progressive isokinetic training and task-specific biofeedback exercises using an isokinetic dynamometer.

Methods: The rehabilitation protocol was tailored to the individual's strength profile and functional goals, incorporating real-time visual and auditory feedback to improve neuromuscular control. Outcome measures related to muscular performance and physical function were assessed both before and after the intervention. Objective assessment of muscle performance was done through isokinetic testing, while physical function and knee-related quality of life were evaluated using the Knee Injury and Osteoarthritis Outcome Score.

Results: Following the intervention, the subject showed consistent and significant improvements in isokinetic strength parameters and functional performance. Increases in muscle torque, endurance, and improvements in the Knee Injury and Osteoarthritis Outcome scores indicated positive clinical outcomes. The individualised protocol was well-tolerated, with no adverse effects reported.

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Conclusion: The novel patient-centric customised isokinetic training, combined with task-specific biofeedback exercises, significantly improved both muscle performance and physical function in this post-Anterior Cruciate Ligament Reconstruction individual. This case report demonstrates that muscular performance and physical functions can be effectively enhanced through a structured and individualised isokinetic rehabilitation program, suggesting promising applications for broader clinical use.

Keywords: Isokinetic training, Anterior cruciate ligament reconstruction, ACL Rehabilitation

Introduction

A variety of exercise training regimes have been proven to prevent associated complications following anterior cruciate ligament reconstruction (ACLR) surgery. Employing isokinetic exercise training is one of the stand-alone methods used in reconditioning patients following ACLR to have sufficient power and endurance to return to their routine daily life¹ and various clinical trials have also shown that musculotendinous soft tissues could adapt to progressive Isokinetic exercises without obligatory muscle damage whilst obtaining benefits in increasing muscle mass and strength under repeated bout effects.^{2,3}

However, this case report aims to describe the effects of employing a novel patient-centric progressive isokinetic training along with task-

specific biofeedback exercise protocol in improving muscle performance and physical function in an individual following bone-patella tendon-bone autograft ACLR surgery which has not been studied elsewhere.

Case History

The subject is a 23-year-old male with a degree in agriculture and a body mass index of 20.5 kg/m². He injured his right knee during a college football game and later experienced recurrent instability and pain after a slip in the bathroom. Ten months post-injury, he was diagnosed with a complete Anterior cruciate ligament tear and underwent reconstruction surgery. Following surgery, he participated in a regular progressive rehabilitation program. Three months later, after obtaining written consent, he began isokinetic testing and training (Figure 1).

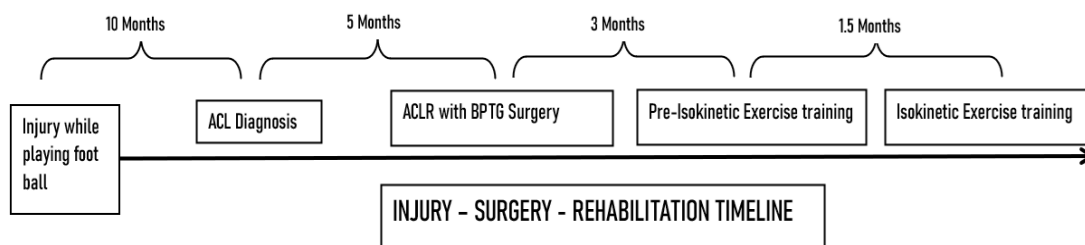


Figure 1: Timeline of injury, surgery, and rehabilitation

Procedures and Outcome Measures

A routine pre-therapy evaluation was conducted to assess knee stability post-surgery before isokinetic training. This included the Lachmann test, Pivot shift test, and unilateral semi-squats, with pain intensity measured using a Visual Analogue Scale before and after each session. The muscle performance and physical function were evaluated pre and post-intervention (before and after the Isokinetic exercise training program of six weeks).

Dynamometry testing was performed in concentric isokinetic mode at 15 °/s using a TUR Isoforce Dynamometer (TUR Therapietechnik GmbH., Rostock, Germany). The subject was seated on the dynamometer and stabilized with belts around the trunk, and thighs. The dynamometer set-up was as follows: height = 0°, rotation = 40°, tilt = 0°, chair rotation = 60°, back seat tilt: 100°, Chair height = 3-5 and Chair horizontal = 110° (TUR Isoforce - Positioning Guide, 2014). All the device

calibration and operational procedures followed the equipment manual. The subject was encouraged to exert maximum effort, aided by verbal support and visual feedback. Specifically designed Anterior-sheer knee Adapter was used to control undue stress developed by anterior translation forces over the repaired ACL graft and the patellar tendon while performing Isokinetic exercise training. The built-in Isoforce Smart-Pro software of the device performed isokinetic data processing.

The outcome measures evaluated concerning the subject's muscular performance and physical function were briefly listed in the outcome summary (Table 1). The isokinetic evaluation objectively measured knee performance, while the Knee Injury and Osteoarthritis Outcome Score (KOOS) assessed physical function, with scores calculated using the Free Online KOOS Calculator from the Ortho Toolkit website.

Table 1. Overview of outcome measures

Table 1

| OUTCOME MEASURES | | |
|-------------------------|-----------------------------|--|
| 1. | Muscular Performance | <p>Isokinetic testing variables</p> <ul style="list-style-type: none"> • Peak Torque (Peak TQ) - the highest muscular Peak Torque produced by the muscle in Nm. • Maximum Mean Torque - the average of the maximum torques produced by the muscle in Nm. • Mean of peak Torques - average of the peak torques produced by muscle in Nm. • Time to peak Torque - a measure of time from the start of a muscular contraction to the point of the highest torque development in seconds of work for every repetition performed in the bout. • Time to peak to Relaxation - a measure of time from the point of the highest torque development to the end of a muscular contraction in seconds. • Mean Power - the amount of total work divided by the time to complete that total work. • Fatigue Index - ratio of the difference between the work carried out in the first three repetitions compared to work in the last three repetitions which was measured in percentage. |
| 2. | Physical Performance | <p>The Knee Injury and Osteoarthritis Outcome Score (KOOS)</p> <ul style="list-style-type: none"> • Overall Score • Pain • Symptoms • ADL Function • Sport and Recreation Function • Quality of Life |

Intervention

After setting up the dynamometer, the subject engaged in daily continuous passive motion training as a warm-up using the isokinetic device. Following this, the isokinetic protocol included three sets of ten repetitions, starting at 90°/s. A gradual reduction

in velocity was implemented over time to increase exercise complexity, along with different modes of isokinetic exercise training applied in a randomized order. Each session included a 15-second rest between sets and was conducted five times per week over a six-week training period (Figure 2).



Figure 2. The subject undergoing Isokinetic training using an Isokinetic dynamometer.

Following each isokinetic session, proprioceptive visual biofeedback training was provided using three built-in programs with varying muscular torque, challenge levels, duration, and exercise modes. A detailed description of the post-surgical ACLR rehabilitation protocol and a training video are available as supplementary material for this study.

Results

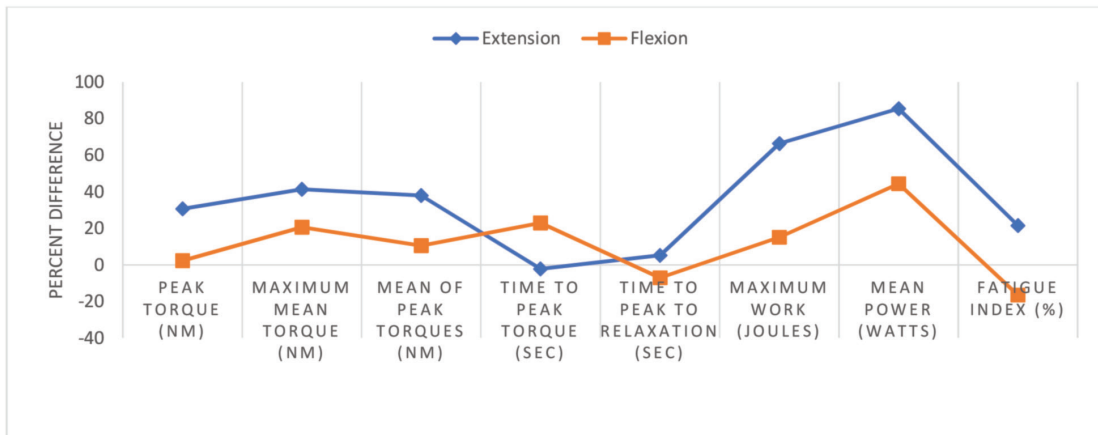
The study suggests that isokinetic training presents a significant positive difference in the components of muscular performance, such as torque, work, power, and fatigue; details of the same are shown in Table 2. It shows the various pre and post-isokinetic tests for knee extension and flexion at the velocity of 15 deg/s for the reconstructed (ACLR) limb at the start and 6 weeks post-isokinetic training.

Table 2
Isokinetic Muscular Performance

| Parameters (Unit) | Extension | | | Flexion | | |
|---|-----------|-----------|-----------------|----------|-----------|-----------------|
| | Pre-test | Post-test | Percent changes | Pre-test | Post-test | Percent changes |
| Peak Torque (Nm) | 155.1 | 202.7 | 30.68 | 120.5 | 123.3 | 2.32 |
| Maximum Mean Torque (Nm) | 75.6 | 106.9 | 41.40 | 54.6 | 65.9 | 20.69 |
| Mean of Peak Torques (Nm) | 126.7 | 174.9 | 38.04 | 105.6 | 116.8 | 10.60 |
| Time to peak Torque (sec) | 1.148 | 1.123 | -2.17 | 0.543 | 0.668 | 23.02 |
| Time to peak to Relaxation (sec) | 4.693 | 4.935 | 5.15 | 4.830 | 4.488 | -7.08 |
| Maximum Work (joules) | 84.3 | 140.3 | 66.42 | 66.0 | 76.0 | 15.15 |
| Mean Power (Watts) | 11.0 | 20.4 | 85.45 | 9.0 | 13 | 44.44 |
| Fatigue index (%) | -8.2 | 13.3 | 21.5 | 26.5 | 10 | -16.5 |

The results indicate a significant difference for most of the isokinetic parameters analysed in this

study (Graph 1).



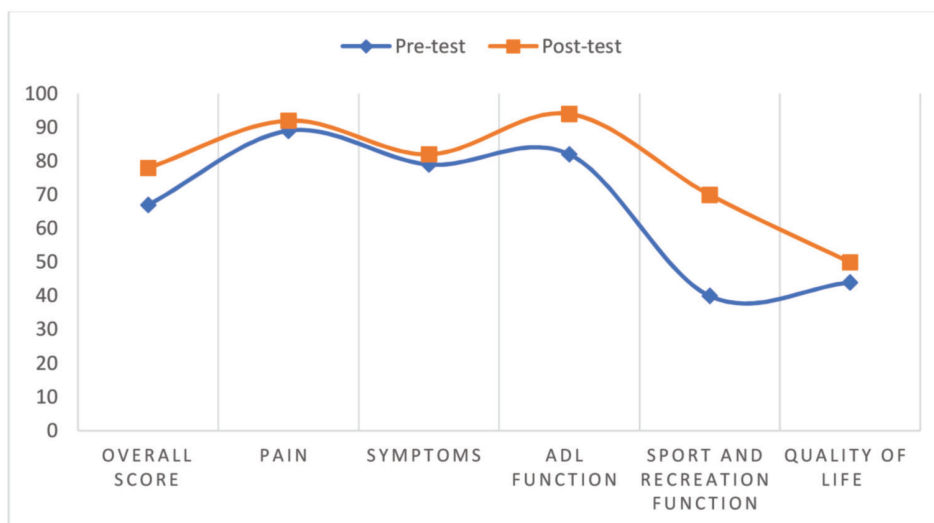
Graph 1: Isokinetic Muscular Performance (Pre & Post test Percent change)

The differences in the total KOOS score and its various subscale scores were detailed (Table 3).

Table 3
Physical performance KOOS Scores

| | Pre-test | Post-test |
|--------------------------------------|----------|-----------|
| Overall Score | 67 | 78 |
| Pain | 89 | 92 |
| Symptoms | 79 | 82 |
| ADL Function | 82 | 94 |
| Sport and Recreation Function | 40 | 70 |
| Quality of Life | 44 | 50 |

The significant increments in the overall scores and sub-scale were identified (Graph 2).



Graph 2: Pre and Post-KOOS Scores

Discussion

This case report examines the effects of patient-specific tailored progressive isokinetic training combined with task-specific biofeedback exercises on muscle performance and physical function in an individual after bone-patella tendon-bone autograft ACL reconstruction surgery.

The study results show consistent improvements in muscle performance and physical function, with significant positive changes in knee extensor and flexor isokinetic parameters at 15 °/s before and after therapy. This speed was chosen because lower pre-set velocities can produce more torque concentrically, leading to greater motor unit recruitment for more realistic muscular performance with regard to evaluation based on the principle of Isokinetics⁴. Although low-speed training can increase anterior tibial translation, the anti-shear adapter minimizes strain on the surgical ACL graft⁵.

As this study focuses on improving power and speed rather than endurance, the training employed slow velocity isokinetic exercises (30 to 90 °/s), which resulted in increased fatigue index values. This likely indicates a predominance of fast-twitch muscle fiber recruitment, as noted by Carr et al.⁶

The physical functional status improved significantly, with most KOOS sub-scales showing notable post-test scores, except for quality of life. The limited improvement in this area can be attributed to the fact that Individuals who have had anterior cruciate ligament reconstruction often experience long-term impairments and slow progression in the quality of life.⁷

There are some limitations of this case report. Firstly, the isokinetic training in this study focuses only on low-speed power training (less than 90°/s of velocity) and not on high-speed endurance training. Also, to add the individual was trained in high sitting position focusing predominantly on the extensor group. Prone lying will be useful for exclusive knee flexor training.

Overall, this case report presents a novel patient-centric approach to progressive isokinetic

training and biofeedback exercises, highlighting their potential to improve muscle performance and physical function after ACL surgery.

Patient Perspective

“Isokinetic exercise training really helped me recover from my surgery after ACL injury. They made my knee muscles stronger in a safe and controlled way. I felt more confident as I saw my progress and could tell my knee was becoming more stable. This training also helped me worry less about getting injured again.”

Conclusion

The results of this case report demonstrate that six weeks of patient-centric progressive isokinetic training combined with a task-specific biofeedback exercise program enhances muscle performance and physical function in an individual after bone-patella tendon-bone autograft ACLR surgery.

Key Messages

- The novel patient-centric customised Isokinetic training, along with task-specific biofeedback exercise protocol, improves both muscle performance and physical function in an individual following bone-patella tendon-bone autograft Anterior cruciate ligament reconstruction surgery.
- The muscular performance and physical functions were significantly enhanced following Iso-kinetic training in individual following Anterior cruciate ligament reconstruction surgery.

Ethical Permission and Informed Consent

Ethical permission was obtained from the Institutional Ethics Committee of JIPMER, Puducherry, India (Approval No: JIP/IEC/964(161)/2024, dated 16th May 2024). Written informed consent was obtained from the subject for participation in the study and the publication of associated data, images, videos, and the patient's perspective included in this report.

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SUPPLEMENTARY MATERIAL 1:

POST ACLR ISOKINETIC REHABILITATION TRAINING PROTOCOL

| PHASE – I | PRE – ISOKINETIC EXERCISE TRAINING PHASE |
|---------------|--|
| 0-3 Weeks | Isometric Quads Ankle pumps Partial weight-bearing walking with long leg brace with crutches Knee Closed chain exercises |
| 3-6 Weeks | Isometric Quads Ankle pumps Full weight-bearing walking with knee brace with crutches Knee open-chain exercises |
| 6-8 Weeks | Knee muscle strengthening exercises Knee ROM exercises Static cycling Full weight-bearing exercises without braces and crutches |
| 8-14 Weeks | Progressive muscle strengthening exercises Static cycling (Forward/Reverse) Treadmill walking Proprioception training using wobble board Jogging on the spot |
| PHASE – II | ISOKINETIC EXERCISE TRAINING PHASE |
| 14 – 16 Weeks | Progressive CON/CON Isokinetic training (90°/s Ext & 90°/s Flex → 60°/s Ext /90°/s Flex) * Routine pre-isokinetic exercise training workups** |
| 16-18 Weeks | Progressive CON/CON Isokinetic training (60°/s Ext & 90°/s Flex → 30°/s Ext & 40°/s Flex) * Biofeedback Proprioceptive Isokinetic training (Isotonic mode) Routine pre-isokinetic exercise training workups** |
| 18-20 Weeks | Alternate day CON/CON Isokinetic training (30°/s Ext /40°/s Flex → 20°/s Ext & 35°/s Flex) *and ECC/ECC Isokinetic training (90°/s Ext & 90°/s Flex → 70°/s Ext & 65°/s Flex) * Biofeedback Proprioceptive Isokinetic training (Isometric mode at multiple angles > 40-degree extension) Routine pre-isokinetic exercise training workups** |

- CON/CON – Concentric/Concentric type of Isokinetic training
- ECC/ECC – Eccentric/Eccentric type of Isokinetic training
- * 3 sets x 10 reps, 5 days a week
- **Pre-isokinetic exercise training phase (8-14 weeks)
- → Gradually progressed over 2 weeks

SUPPLEMENTARY MATERIAL – 2:

Isokinetic training Video- <https://www.youtube.com/shorts/v8bTPJkPaY>