Longitudinal Monitoring of Biomechanical and Performance Metrics Before and After ACL Reconstruction: A Return-to-Play Case Study

Tamar D. Kritzer[1], Kaylee White[1], Meaghan Maynard[2], Dylan Kobsar[1]
[1]Department of Kinesiology McMaster University Department of Kinesiology, Hamilton, Canada
[2]Athletics and Recreation, McMaster University, Hamilton, Canada
Email: kritzert@mcmaster.ca

Summary

Anterior cruciate ligament injuries are common and impactful in sports. This case study examines the rehabilitation of a female varsity basketball player who sustained a contact-related ACL tear and underwent reconstruction. Findings suggest that while pre-injury performance and confidence may be regained, detailed analyses reveal athletes return in altered movement states. Enhancing return-to-play protocols with baseline data and biomechanical assessments may improve rehabilitation monitoring and re-injury prevention.

Introduction

Anterior cruciate ligament (ACL) tears are among the most severe and common knee injuries in sports, leading to over 400,000 reconstructions annually in the U.S. and approximately 17,000 in Canada, with an estimated $3 billion annual cost in the U.S. [2,4]. Despite surgical intervention, only 50–65% of athletes return to competitive play, often with reduced performance and a higher risk of re-injury to the same or contralateral knee [1,3]. Current return-to-play protocols primarily focus on strength and power benchmarks, neglecting detailed biomechanical assessments and psychological factors that influence recovery [1,3]. Incorporating biomechanical strategies and pre-injury data may provide a more objective and comprehensive recovery framework, reducing bias of contralateral limb and subjective assessment limitations [3].

This study examines changes in biomechanical, performance, and psychological metrics compared to pre-injury data during an ACL reconstruction return-to-play protocol.

Methods

This case study details the rehabilitation of a female varsity basketball player who sustained a contact-related left ACL tear (date of injury, DOI) and underwent ACL reconstruction 15 weeks post-injury. Baseline countermovement jump (CMJ) and on-court inertial sensor data were collected 20 weeks pre-injury and resumed 32 weeks post-injury, continuing until the first in-season game at 36 weeks post full clinician clearance. CMJ testing was conducted using a dual force plate system (Dawkins Dynamics, Westbrook, ME, USA) following a 5-minute standardized warm-up. Weekly CMJs were averaged, analyzing jump height, modified reactive strength index (mRSI), and peak force asymmetries across braking, propulsive, and landing phases. On-court acceleration impact data were collected during team practices using two inertial sensors (IMeasureU Inc., IMU Step, Denver, CO, USA) attached above the lateral malleoli, assessing peak impact asymmetries. Psychosocial and asymmetrical return-to-play performance were evaluated using clinician-reported ACL-RSI scale and IKDC Subjective Knee Evaluation during the RTP stage. Given the longitudinal, single-case design, a minimal detectable change band was used to detect shifts in mean values compared to pre-injury data over time.

Results and Discussion

Findings indicate that clinician clearance for return-to-play closely aligns with the restoration of baseline performance metrics. However, despite achieving pre-injury jump height and reporting confidence in knee function early in rehabilitation, movement asymmetries and altered strategies may persist beyond clearance. Additionally, some data suggest eventual overcompensation, particularly in peak braking and propulsive force asymmetries, highlighting the need for continued monitoring post-clearance.

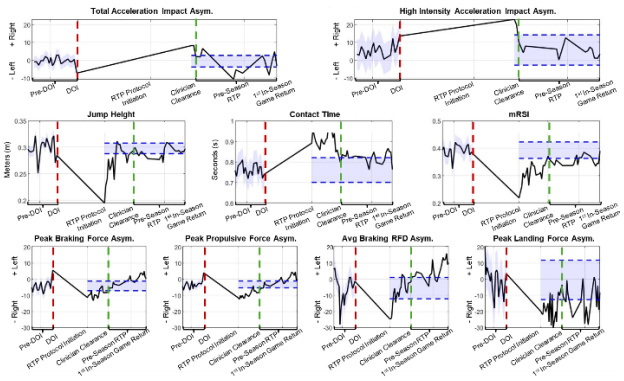

Figure 1: Pre-injury through return-to-play CMJ and wearable sensor data. Injury date: vertical red line, clinical clearance: vertical green line, and minimal detectable change bands are shown in blue.

Conclusions

Return-to-play protocols can be enhanced by incorporating baseline-to-post-injury comparisons, particularly through biomechanical assessments. Individualized clinical care benefits from tracking athlete-specific movement strategies throughout rehabilitation. Future research should focus on a holistic RTP approach post-ACL reconstruction, integrating performance, biomechanical, and psychological factors to mitigate the risk of re-injury and long-term impairment.

Acknowledgments

The researchers are grateful for the subject of the study for participating.

References

[1] Davies et al. (2020). *Sports Medicine*, **50**: 485-495.
[2] Devana et al. (2022). *Rev. in Musculoskel. Medicine*, 1-9.
[3] Jordan et al. (2024). *J. Strength & Conditioning*, **46**: 406-414.
[4] Larose et al. (2022). *J. Surgery*,**65(2)**: E269.