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The Role of Single-Leg Vertical Jump in Return-to-Sport Evaluation After ACL Reconstruction — A Critical Review Based on Optical Motion Capture

Muze Du

W.P. Carey business school, Arizona State University, Tempe, Arizona, the United States, 85281
Muzedu200405@gmail.com

Abstract:

Anterior cruciate ligament (ACL) injuries and reconstruction surgeries are very common in sports medicine. Scientific evaluation and documentation of return-to-sport (RTS) readiness are key steps to reduce the risk of re-injury. This paper builds on research published in the British Journal of Sports Medicine (2022), explaining the use of optical motion capture in evaluating functional performance after ACL reconstruction. The study found that while horizontal hop tests often appear symmetrical, the single-leg vertical jump (SLJ) more effectively reveals deficits in knee joint function. This review summarizes the contributions of the research, critically analyzes its limitations, and proposes directions for future improvement. In addition, ACL injuries are common in sports requiring single-leg deceleration, cutting, and landing movements, such as basketball, soccer, handball, and skiing, with most being non-contact injuries. As competition levels rise, ACL injuries and reconstructions are increasingly frequent, highlighting the necessity of establishing sensitive and reproducible RTS evaluation indicators.

Keywords: ACL Reconstruction; Optical Motion Capture; Return-to-Sport Evaluation; Single-Leg Vertical Jump; Critical Review

1. Introduction

ACL injuries frequently occur in high-impact sports such as basketball and rugby, often during non-contact single-leg deceleration or pivoting movements such as landing, cutting, or rotation. Determining whether an athlete is truly ready to return to sport after surgery is central to sports medicine and rehabilitation science. Traditional assessment methods often rely on single-leg horizontal hop tests; howev-

er, some scholars argue that these may misjudge recovery. A 2022 article published in the British Journal of Sports Medicine suggests that single-leg horizontal hops can more thoroughly reveal functional asymmetries. This finding provides a new reference for rehabilitation and training, but its scientific and limitations warrant further discussion.

This article, through a literature review and case analysis, examines the task-specific sensitivity of different single-leg hop tasks (SLH, SLJ, and SLDJ) to residual knee functional deficits in athletes undergoing return-to-play (RTS) after ACL reconstruction. This article aims to provide theoretical contributions to the relevant field.

2. Literature Review

ACL injuries often occur in sports involving rapid direction changes and vertical or horizontal impact absorption, such as basketball, soccer, and alpine skiing. The injury mechanism is usually non-contact valgus and anterior tibial translation [1]. Whether an athlete can safely return to sport after reconstruction has long been a major research and clinical concern. Systematic reviews show that only about 55–65% of athletes return to their pre-injury competitive level, with significant individual variation [2,3]. Notably, adolescents and young competitive athletes face a 20–30% risk of secondary ACL injuries after RTS [4]. Thus, the focus has shifted from simple single-leg horizontal hop (SLH) distance tests to more revealing and multidimensional evaluation tasks.

In functional assessments, symmetry may be masked depending on the task. Kotsifaki et al. found that SLH symmetry can be influenced by compensatory strategies, potentially over-estimating recovery [5]. By contrast, the SLJ and single-leg drop jump (SLDJ) better expose deficits in knee extension and hip–knee coordination [6]. Return-to-sport criteria based on objective thresholds—such as quadriceps torque ≥ 90% of the uninjured side or composite hop LSI ≥ 90%—have been linked to lower re-injury risk [7], supporting 'criteria-based RTS' over 'time-based RTS.' Psychological readiness also plays a key role; the ACL-RSI scale is useful for predicting RTS and re-injury risk [8].

Overall, consensus now favors multi-task, multidimensional assessments using standard thresholds and sensitive jumping tasks (e.g., SLJ/SLDJ), supplemented by strength, symmetry, and psychological metrics. The BJSM study reviewed in this paper further supports this transition by demonstrating that although SLH may appear symmetrical, SLJ/SLDJ reveal residual deficits in stiffness and knee function [5,6].

3. Case Study

3.1 Study Design

In a study, the researchers recruited 26 athletes who had undergone anterior cruciate ligament (ACL) reconstruction approximately nine months after surgery and had been medically cleared for return to sport (RTS), along with 22 healthy male controls serving as a comparison group. To comprehensively assess lower-limb biomechanics, the study employed a three-dimensional motion analysis system consisting of 14 Vicon optical motion capture cameras (sampling rate: 250 Hz) synchronized with embedded force plates to record kinematic and kinetic data during three functional performance tasks: the Single-Leg Hop for Distance (SLH), the Single-Leg Vertical Jump (SLJ), and the Single-Leg Drop Jump (SLDJ). These tasks were designed to challenge dynamic stability, explosive power, and landing control. The primary outcome measures included the Limb Symmetry Index (LSI), jump height, and landing impact force, which were used to quantify inter-limb asymmetries and evaluate functional recovery following ACL reconstruction.

3.2 Results and Findings

The results of the study demonstrated significant differences among the three single-leg jump tasks in evaluating functional symmetry in athletes following ACL reconstruction. Specifically, during the Single-Leg Hop for Distance (SLH), the ACL-reconstructed group exhibited a high level of symmetry (approximately 97%), showing minimal difference compared to the healthy control group. However, symmetry decreased markedly to around 83% during the Single-Leg Vertical Jump (SLJ) and further

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declined to approximately 77% during the Single-Leg Drop Jump (SLDJ). These findings suggest that the SLJ and SLDJ are more sensitive in detecting residual functional deficits in ACL-reconstructed athletes, whereas relying solely on the SLH as a criterion for rehabilitation assessment may mask underlying kinematic and kinetic asymmetries, potentially leading to an overestimation of recovery and premature return-to-sport decisions.

4. Discussion

4.1 Strengths

From a scientific perspective, this study systematically compared three distinct single-leg jump tasks and clearly demonstrated that the horizontal jump was less sensitive in detecting asymmetries, whereas the vertical jump tasks provided more precise and discriminative results. The methodological design represents another strength of the study. The use of an internationally recognized Vicon optical motion capture system, synchronized with force plates, ensured high accuracy and reliability in both kinematic and kinetic data collection. Such a rigorous setup minimized measurement errors and enhanced the reproducibility of the findings. In terms of clinical and practical implications, the results offer new and scientifically grounded indicators for evaluating return-to-sport readiness in athletes following ACL reconstruction. By identifying more sensitive tasks, this research contributes to reducing the risk of re-injury and improving the precision of rehabilitation assessments, thereby supporting safer and more evidence-based clinical decision-making.

4.2 Limitations

Despite its strengths, several limitations should be acknowledged. First, the sample consisted exclusively of adult male athletes, lacking representation of female or adolescent populations with different physical and neuromuscular characteristics. This limited sample diversity reduces the generalizability of the findings. Second, the external validity of the study is constrained, as the standardized laboratory-based movement tasks may not fully replicate the dynamic and unpredictable demands of actual sports performance. Third, the study adopted a cross-sectional design, without long-term follow-up data, making it impossible to determine whether the observed asymmetries could predict the risk of secondary ACL injuries. Lastly, the evaluation was confined to jump-based tasks, without incorporating other functional or multidimensional measures such as electromyography (EMG) or psychological readiness assessments. As a result, important factors related to neuromuscular control and mental preparedness for return to play may have been overlooked.

4.3 Future Directions

Future research should aim to expand the sample size and include more diverse populations, particularly female and youth athletes, to explore potential gender- and age-related differences in functional symmetry. Longitudinal studies are also recommended to track recovery progression and verify whether the jump-based assessments can reliably predict secondary ACL injuries over time. Additionally, integrating multiple assessment dimensions—such as combining the Vicon system with EMG recordings or wearable motion sensors—could yield a more comprehensive understanding of lower-limb function and neuromuscular performance. Finally, applying these assessment protocols in real-world or simulated sport environments would enhance ecological validity and improve the practical applicability of the findings to actual athletic settings.

5. Conclusion

This study aimed to investigate the task-specific sensitivity of different single-leg jump assessments—including the Single-Leg Hop for Distance (SLH), Single-Leg Vertical Jump (SLJ), and Single-Leg Drop Jump (SLDJ)—in detecting residual knee functional deficits among athletes returning to sport (RTS) after anterior cruciate ligament (ACL) reconstruction. The results revealed that limb symmetry between the reconstructed and contralateral sides was significantly lower in the SLJ and SLDJ compared to the SLH, suggesting that reliance solely on distance-based hop tests such as the SLH may obscure underlying functional impairments. Further analysis indicated that vertical and drop jump tasks were more effective in capturing

deficits related to knee stiffness regulation and landing kinetics, thereby supporting the initial hypothesis that tasks with higher neuromechanical demands—such as the SLJ and SLDJ—offer greater sensitivity for RTS decision-making.

By identifying the limitations of the SLH-based symmetry index and proposing the SLJ and SLDJ as more sensitive indicators of post-ACL reconstruction function, this study contributes new theoretical insights to the field. The findings expand existing knowledge by demonstrating that a multidimensional RTS assessment model—integrating multiple jump tasks and standardized thresholds—provides a more accurate reflection of true neuromechanical recovery than traditional single-task paradigms. In doing so, the research addresses a critical gap in the literature regarding task-dependent sensitivity differences in post-ACL functional evaluation.

Clinically, these results have direct implications for sports medicine and rehabilitation practices. They support the inclusion of SLJ and SLDJ, along with measures of strength symmetry and psychological readiness, as part of a comprehensive, standardized RTS assessment protocol. Such an evidence-based, multi-dimensional approach could reduce the risk of secondary ACL injury, enhance return-to-play safety, and improve long-term athletic performance outcomes.

Nevertheless, several limitations should be acknowledged. The relatively small sample size, inclusion of only male participants, and cross-sectional, laboratory-based design may restrict the generalizability of the findings. Moreover, the absence of electromyography (EMG) data, wearable motion sensors, or psychological assessment measures limits the comprehensiveness of the functional recovery evaluation.

Future studies should consider large-scale, multicenter, and prospective cohort designs that include female and adolescent athletes to examine group-specific differences. Integrating EMG, wearable sensor technology, and psychological scales such as the ACL-Return to Sport after Injury (ACL-RSI) could facilitate the development of predictive models for secondary injury risk. Furthermore, future research may employ ecologically valid, sport-specific or simulated competition scenarios to test the predictive thresholds of different jump tasks. The research team also plans to expand the assessment framework to include measures of strength endurance, reactive strength index, and perceptual-cognitive load to establish a composite RTS scoring system.

In conclusion, this study provides new insights into the task-specific identification of residual functional deficits following ACL reconstruction and underscores the limitations of relying solely on distance-based hop assessments. By highlighting the superior sensitivity of vertical and drop jump tasks in detecting subtle functional asymmetries, the present work lays a foundation for developing an evidence-based, multidimensional RTS evaluation framework aimed at minimizing re-injury risk and enhancing the safety and success of athletic return.

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