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Research Article

Early Neuromuscular Control and Its Influence on Return-to-Sport Timing After ACL Reconstruction: A Prospective Cohort Study

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Abstract

Background: Return to sport (RTS) following anterior cruciate ligament (ACL) reconstruction depends on restoring neuromuscular control, strength symmetry, and psychological readiness [1,2]. However, early-phase neuromuscular recovery markers and their predictive value for RTS timing remain underexplored [3].

Objective: To determine whether early neuromuscular control parameters within the first 12 weeks post-ACL reconstruction influence the timing and success of return to sport.

Methods: A prospective cohort of post-ACL reconstruction athletes (n = 40) were assessed for quadriceps activation (via EMG), single-leg balance, and Y-Balance Test performance at 4, 8, and 12 weeks [4]. Return-to-sport clearance and timing were recorded at 6 and 9 months.

Results: Early quadriceps activation symmetry and YBT composite score improvements between 4-12 weeks showed strong correlation with faster RTS clearance ($r = 0.68$, $p < 0.01$) [4]. Athletes achieving ≥90% limb symmetry index (LSI) in neuromuscular tests by 12 weeks returned to sport an average of 2.3 months earlier.

Conclusion: Early neuromuscular recovery parameters can serve as valuable indicators for individualized RTS prediction post-ACL reconstruction. Emphasis on early quadriceps reactivation and balance training may shorten RTS timelines safely [1-4].

Keywords: ACL Reconstruction; Neuromuscular Control; Return to Sport; Limb Symmetry Index; Physiotherapy; Rehabilitation

Introduction

ACL injuries are common in pivoting sports and often require surgical reconstruction followed by extensive rehabilitation [1]. Return to sport (RTS) depends not only on graft healing and muscle strength but also on neuromuscular control and psychological readiness [1,2]. Early restoration of neuromuscular function is critical to avoid compensatory movement patterns that may predispose to re-injury [2,3]. This study aimed to evaluate whether early neuromuscular control recovery (within 12 weeks) affects the timing of RTS after ACL reconstruction [4].

Materials and Methods

This prospective cohort study was conducted at a physiotherapy and sports rehabilitation center over 18 months [4]. Forty athletes (aged 18-35) undergoing primary ACL reconstruction were enrolled. Assessments were conducted at 4, 8, and 12 weeks for

quadriceps activation (surface EMG), Y-Balance Test (YBT) composite scores, and single-leg stance stability [4]. RTS clearance was defined as achieving ≥90% limb symmetry index (LSI), absence of swelling or instability, and an ACL-RSI score > 60 [2,3]. Data were analyzed using Pearson correlation and regression analysis ($p < 0.05$).

Results

Participants had a mean age of 24.6 ± 3.1 years (28 male, 12 female). Quadriceps activation symmetry improved from 0.48 to 0.82 ($p < 0.001$) [4]. YBT composite scores increased from 68% to 90% by week 12. Sixty-five percent of athletes were cleared for RTS by 6 months and 90% by 9 months. Week-12 LSI showed a strong negative correlation with RTS timing ($r = -0.68$) [4]. Regression analysis identified YBT composite ≥ 90% as a significant predictor ($\beta = -0.42$, $p = 0.003$).

Discussion

The findings emphasize the value of early neuromuscular restoration in expediting safe RTS following ACL reconstruction [1-3]. Previous literature supports the association between strength symmetry and functional outcomes post-ACL surgery [2,4]. Functional readiness, rather than arbitrary timeframes, should guide clearance decisions [2,3]. Integrating early quadriceps activation and proprioceptive training in rehabilitation can optimize recovery and enhance athlete confidence [1,4]. Limitations include small sample size and absence of objective dynamometry. Future research may incorporate 3D motion analysis for more robust outcomes [3,4].

Conclusion

Early neuromuscular control recovery within the first 12 weeks after ACL reconstruction significantly predicts faster and safer return to sport [1-4]. Functional and psychological assessments should complement time-based criteria for individualized rehabilitation and readiness evaluation.

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