Performance Consistency in Functional Testing Predicts ACL-RSI Score after ACL Reconstruction in Collegiate Athletes

Christian Zirbes, Aaron Daniel Therien, Ryon Yu, Shrishti Jain, Ian Halliday, Michael P Reiman, Brian Lau, John Ryan Magill

INTRODUCTION:

Return to sport (RTS) after anterior cruciate ligament (ACL) reconstruction remains challenging due to a lack of consensus on optimal criteria. While psychological readiness and functional outcomes are important considerations, the interplay is still unknown. This study examined a novel metric – the coefficient of variation (CV) in single leg hop testing – as a potential marker of fatigue and motor control, and its correlation with psychological readiness as measured by the ACL-Return to Sport after Injury (ACL-RSI) tool. A lower CV indicates more consistent performance across trials, while a higher CV may reflect greater variability due to pain, fatigue, or poor motor control. We hypothesized that CV may provide additional insight to performance beyond conventional peak or mean values.

METHODS:

The clinical records of all athletes at a Division I National Collegiate Athletic Association school who underwent an ACL reconstruction between August 2021 and May 2025 were retrospectively reviewed. Demographic data, surgical records, and postoperative rehabilitation details were recorded. For each three-trial hop test, CV was calculated as (CV = standard deviation/mean * 100). Chi-Squared Automatic Interaction Detection (CHAID) decision tree analysis was used to identify independent predictors of ACL-RSI score, with Bonferroni correction utilized for multiple comparisons. Alpha was set at 0.05.

RESULTS:

Eighty-seven athletes (70.1% female, mean age 19.9 ± 1.3 years) completed hop testing at a mean of 9.0 months postoperatively (Table 1). The 6-meter timed hop test (6MTH) CV was the strongest predictor of ACL-RSI score ($P <$ .001, Figure 1). Athletes with a 6MTH CV ≤ 7.435 demonstrated significantly higher predicted ACL-RSI scores (Node 1: 87.38) compared to those with higher variability (Node 2: 50.59). Among low-variability athletes, single hop (SH) CV, time since surgery, and sex also influenced predicted readiness. The highest ACL-RSI score (Node 7: 96.05) was observed in patients with SH CV ≤ 5.84 and > 8.9 months postoperatively. Males exhibited higher predicted readiness than females, particularly in the moderate single hop cohort (Node 8 vs. Node 9, p = .024). Graft type was not an independent predictor of ACL-RSI. The model had moderate-to-strong predictive performance (r = 0.744, mean absolute error = 8.5, standard deviation = 12.7)

DISCUSSION AND CONCLUSION:

In this cohort of collegiate athletes, low variability over three trials in the 6-meter timed hop test and single hop tests were the most predictive of higher ACL-RSI score, regardless of demographic subgroup. Greater time since surgery (> 8.8 months), and male sex were also associated with higher ACL-RSI scores in low- and moderate-variance subgroups only. These findings support the potential utility of functional test CV as a return-to-play decision making tool, as CV captures consistency of performance which is not reflected in current RTS analysis. Athletes demonstrating more consistent performance may experience greater confidence and more accurate risk appraisal, factors not captured by existic metrics. Prospective studies are needed to evaluate whether CV correlates with reduced reinjury risk and successful return to preinjury   levels   of   competitiveness.
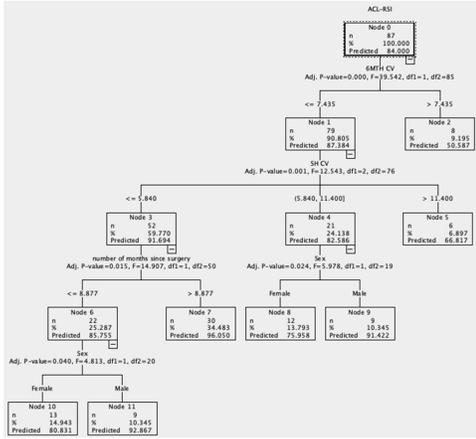
Figure 1. *Chi-Squared Automatic Interaction Detection (CHAID) decision tree analysis results. ACL-RSI (N=87). The tree created four levels and seven terminal nodes. The first level, two distinct coefficients of variance (CVs) were identified for the 6-meter timed hop (6MTH) test, each statistically significant in ACL-RSI values. The second level, Single Hop (SH) CV, was predictive of ACL-RSI scores for the sample with decreased 6MTH CV. The third and fourth levels continue to predict ACL-RSI for the sample of reduced variance of the SH samples, based on demographic variables. In each case, males and increased time from surgery predicted increased ACL-RSI scores.*

Table 1. Study Population Characteristics (N=87)

Variable	Value
Female sex, n (%)	61 (70)
Mean Age	19.9 ± 1.3
BMI	24.9 ± 5.1
Months since surgery	9.0 ± 3.9
Graft Type, n (%)	
BTB	55 (63)
QTA	19 (22)
HSA	12 (13)
Allograft	1 (1)
SH CV	6.09 ± 4.88
6MTH CV	4.62 ± 2.32
TH CV	3.80 ± 2.64
TCH CV	5.32 ± 3.52
ACL-RSI	84.00 ± 18.98

Legend. Values presented as mean ± SD for continuous variables and number (percentage) for categorical variables. BMI = Body Mass Index; BTB= patella tendon autograft; CV = Coefficient of Variance; HAS = hamstring autograft; QTA = quadriceps tendon autograft; SH = single hop test; TCH = triple crossover hop test; TH = triple hop test = ; 6MTH = 6-meter timed hop test.