

Original Research

# Evaluation of Reactive Strength Index During Single-Limb Vertical Jumps and Isokinetic Strength Five to Eight Months After Anterior Cruciate Ligament Reconstruction

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### Background

Reactive strength index (RSI) derived from single-leg vertical continuous jumps (SVCJ) is a low-cost method to assist in making return-to-sport (RTS) decisions after anterior cruciate ligament reconstruction (ACLR); however, its relationship with isokinetic knee strength at different postoperative time points remains unclear. The purpose of this study was to explore the relationship between the RSI during SVCJ and isokinetic knee muscle strength in patients five to eight months after ACLR.

### Study design

Retrospective cohort study

### Methods

Patients who had undergone primary ACLR with hamstring tendon autografts were enrolled. At five, seven, and eight months postoperatively, the participants performed 15 SVCJ recorded on an iPad at 240 fps. RSI was calculated as jump height divided by ground contact time, with flight time and contact time derived from video analysis using a validated smartphone/tablet application. Isokinetic peak knee extension and flexion torques were measured bilaterally at 60°/s using the Biodex System 3. Limb symmetry index (LSI) was calculated for both isokinetic knee strength and RSI as (operated limb value / non-operated limb value) × 100 (%). Time effects were analyzed using repeated-measures analysis of variance, and Pearson correlations assessed associations between RSI and knee strength.

### Results

Twelve competitive athletes (mean age, 34.3 ± 11.3 years), participating in cutting- and jumping-based sports were analyzed. Isokinetic knee flexion peak torque significantly improved from five to eight months ( $p < 0.05$ ) postoperatively. The extension-strength LSI was 75% at eight months, whereas the flexion-strength LSI increased from 84.5% at five months to 93.5% at eight months. The RSI LSI reached 83.1% at eight months. Correlations between RSI and knee extension strength were strong and significant at five months ( $r = 0.81$ ,  $p < 0.01$ ) and seven months ( $r = 0.91$ ,  $p < 0.01$ ) but were weak and not significant at eight months ( $r = 0.36$ ,  $p = 0.26$ ).

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## Conclusion

RSI may serve as a surrogate for isokinetic knee extension strength during midterm rehabilitation after ACLR, later reflecting higher-order explosive performance; smartphone/tablet-based assessment supports staged RTS decision making.

## Level of Evidence

2b

## INTRODUCTION

Anterior cruciate ligament (ACL) injuries are common in athletes, and successful reconstruction with sufficient functional recovery is essential for timely return-to-sport (RTS).<sup>1</sup> RTS decisions after ACL reconstruction (ACLR) typically incorporate isokinetic knee-strength testing and single-leg hop test limb symmetry index (LSI  $\geq 90\%$ ) as benchmarks.<sup>2</sup> However, the hop-test LSI often reaches the commonly used threshold of 90% at an early stage, which may overestimate functional recovery because neuromuscular control or biomechanical deficits can persist despite meeting this criterion.<sup>3</sup> Isokinetic dynamometry requires expensive equipment and specialized expertise, resulting in adoption rates below 20% in clinical and sports settings.<sup>4</sup> Consequently, simpler, more cost-effective, and multifaceted functional evaluation tools are urgently needed.

Given the limitations of isokinetic strength- or LSI-based assessments, evaluating lower limb reactive performance and stretch-shortening cycle (SSC)-related function is important. The reactive strength index (RSI), defined as jump height (computed from flight time) divided by ground contact time, provides an indirect measure of an athlete's ability to rapidly produce force during plyometric actions involving rapid eccentric-concentric transitions.<sup>5,6</sup> Because patients with ACLR frequently demonstrate persistent deficits in explosive or reactive movements despite meeting the strength criteria, the RSI may offer additional insight into functional recovery beyond traditional LSI-based hop tests.

Although RSI can be calculated from various jump tasks—including countermovement, drop, and repeated hopping movements—the single-leg vertical continuous jump (SVCJ) was used in this study. The SVCJ requires rapid and repeated SSC actions on a single limb, which places higher demands on reactive strength, neuromuscular control, and limb-loading symmetry than single-effort tasks such as the countermovement jump or drop jump. These characteristics make the SVCJ particularly relevant for evaluating functional recovery after ACLR, as deficits in repeated plyometric tasks requiring rapid force production and short ground contact times often persist despite achieving conventional strength or hop test symmetry. In addition, previous studies have demonstrated that RSI derived from SVCJ shows excellent reproducibility in patients after ACLR (intraclass correlation coefficient = 0.83–0.96), supporting its use as a reliable clinical assessment tool.<sup>3</sup> Moreover, RSI can be measured using smartphone applications or simple wearable sensors, minimizing cost and space requirements and facilitating implementation in diverse settings.<sup>7</sup>

Previous studies have demonstrated a correlation between single-leg vertical jump height and isokinetic knee-extension strength.<sup>8</sup> However, investigations specifically examining the relationship between RSI during the SVCJ and isokinetic knee strength are limited. Hirohata et al. analyzed 75 athletes at a mean of  $8.8 \pm 4.1$  months post-ACLR and reported that RSI-LSI accounted for 36.4% of the variance in knee-extension strength LSI (strong correlation).<sup>9</sup> By contrast, another study regarding the recovery of knee extensor strength has reported that in patients who underwent ACLR with autologous hamstring grafts, only 43% achieved a knee extension strength LSI of 85% or higher at six months postoperatively. Reported quadriceps LSI values remain limited throughout mid- to late-phase rehabilitation, generally ranging from approximately 70% to 85% between six and 12 months after ACLR.<sup>10,11</sup> Furthermore, although hamstring strength temporarily decreased in the early postoperative phase, it recovered relatively quickly. A systematic review and meta-analysis published in 2023 has reported that knee flexor strength LSI reached an average of approximately 89%–91% at six months postoperatively.<sup>12</sup> By contrast, the LSI of RSI during SVCJ remains approximately 81%, even at 12 months postoperatively.<sup>3</sup> Additionally, fewer than 30% of individuals who achieved  $\geq 90\%$  symmetry on conventional hop tests at that time also achieved  $\geq 90\%$  on the RSI, indicating that RSI recovery generally lags behind even after strength and standard hop performance have recovered.<sup>3</sup>

Although these findings highlight important aspects of post-ACLR recovery, evidence describing how the relationship between RSI and isokinetic knee muscle strength evolves across postoperative time points remains limited.

Therefore, the purpose of this study was to explore the relationship between the RSI during SVCJ and isokinetic knee muscle strength in patients five to eight months after ACLR.

## MATERIALS AND METHODS

### ETHICAL APPROVAL

The study protocol adhered to the Declaration of Helsinki and was approved by the institutional ethics committee (05-09). Because this was a retrospective analysis of anonymized data, the requirement for informed consent was waived by the ethics committee.

### PARTICIPANTS

This retrospective study was conducted at a general acute-care hospital with a dedicated orthopedic and rehabilita-

tion department. All participants had undergone primary arthroscopic ACLR performed by a single fellowship-trained orthopedic sports surgeon using a standardized single-bundle hamstring autograft technique.<sup>13</sup> In all cases, the semitendinosus tendon was harvested, with the gracilis tendon added only when additional graft length or diameter was required. Concomitant meniscal lesions were treated with repair or partial meniscectomy based on intraoperative findings. Patients were eligible if they underwent ACLR between August 2020 and February 2023. Eligible participants were individuals who planned to return to impact or cutting sports (e.g., basketball, soccer, and badminton) and demonstrated a Modified Tegner Activity Scale score > five prior to injury. Patients were required to have medical clearance to resume jumping activities five months postoperatively and to have completed bilateral assessments of RSI and isokinetic knee strength at five, seven, and eight months postoperatively. The postoperative time points of five, seven, and eight months were selected because (1) five months represents the earliest clinically permitted time to resume jumping, (2) seven months corresponds to an intermediate rehabilitation phase in which substantial improvements in quadriceps strength and SSC function typically occur, and (3) eight months is commonly used as an early RTS evaluation stage. These three points allowed the authors to capture the transitional changes in reactive performance during mid- to late-stage rehabilitation.

Participants with a Modified Tegner Activity Scale score > five before injury intended to return to sports at a competitive level. In this study, “competitive level” was defined as participation in organized team or club sports with regular practice (≥three days/week) and participation in official league competitions or tournaments.

Patients were excluded if they had bilateral ACL injuries, revision ACLR, or significant concomitant injuries (e.g., lumbar spine pathology or additional ligament injuries). Individuals with a history of surgery on the contralateral knee or those who did not intend to return to sports postoperatively were excluded.

## POSTOPERATIVE REHABILITATION

Postoperative rehabilitation was performed under the supervision of physical therapists specializing in sports orthopedics at the study institution following a standardized criteria-based protocol. During the early phase (weeks one to two), rehabilitation focused on swelling control, restoration of knee range of motion, and quadriceps activation through isometric and closed-chain tasks. The patients progressed to low-impact functional activities as tolerated, with close monitoring of joint irritability.

Jogging was permitted approximately three months postoperatively once the patient demonstrated the ability to perform a pain-free, well-controlled, single-leg squat, reflecting adequate lower-limb alignment and neuromuscular control. Plyometric progression began with bilateral jump tasks, and single-leg jump training was introduced approximately five months after confirming sufficient shock-absorption capacity and limb-loading tolerance. From six months postoperatively, patients progressed to

sport-specific drills, defined as planned and submaximal sport-related movements performed under controlled conditions. Clearance to higher-level activities, defined as advanced plyometric and reactive sport-specific tasks performed at higher speed or intensity, required meeting predefined objective criteria as follows: an isokinetic knee extension strength LSI > 85% and an SVCJ-RSI LSI > 80% with no pain, swelling, or episodes of instability.

Rehabilitation compliance was high in this cohort. All included patients consistently attended supervised rehabilitation sessions, which was scheduled once or twice weekly until five months postoperatively, and transitioned to monthly follow-up sessions at six, seven, and eight months. Only individuals who completed all scheduled rehabilitation and testing sessions were included in the analysis; no participants were excluded because of noncompliance.

## OUTCOME MEASURES

### RSI

Participants performed 15 consecutive SVCJ after completing a standardized warm-up consisting of ten min of ergometer cycling at 40 W and practice jumps. Verbal instructions emphasized “jump as high as possible and minimize ground contact time.” Lateral video footage was recorded at 240 fps using an iPad, and the middle five jumps were analyzed.

The flight time was defined as the interval from toe-off to landing. Jump height was calculated from flight time using the following standard equation:

$$\text{jump height (m)} = 9.81 \times \text{flight time}^2 / 8$$

For analysis, jump height was converted from meters to centimeters. The RSI was calculated as the ratio of jump height to contact time, using the following equation:

$$\text{RSI} = \text{jump height (cm)} / \text{contact time (s)}.$$

Flight and contact times were measured using a smartphone or tablet application (Hudl Technique, UberSense Inc.). All measurements and analyses were performed by multiple physical therapists from the sports orthopedic team, who were trained using the same standardized scoring procedure to ensure consistency.

### ISOKINETIC KNEE MUSCLE STRENGTH

Strength testing was performed on the same day as the RSI assessment. All participants completed the RSI test first, followed by a rest period sufficient to eliminate any signs of fatigue before initiating strength testing. Examiners allowed participants to rest until visible fatigue and compensatory movements had resolved (typically five to ten min, as judged clinically).

A Biodex System 3 dynamometer (Biodex Medical Systems, Shirley, NY, USA) was used to measure the peak torque during knee extension and flexion at 60°/s. Participants were seated with the distal thigh secured, and five maximal concentric contractions were performed through their available range of motion. No verbal encouragement

was provided during testing to ensure that the data reflected voluntary effort alone.

During isokinetic testing, the contralateral limb was assessed only after the examiner confirmed that the participant had fully recovered from exertion during the first limb trial, to minimize fatigue-related bias.

Peak torque values for knee extension and flexion were normalized to body weight and expressed as a percentage of body weight (%BW), following the standard output of the Biodex system. The LSI was calculated as (involved limb torque/uninvolved limb torque)  $\times$  100 (%) and was used as the primary metric for between-limb strength comparison.

## STATISTICAL ANALYSIS

The sample size was determined by including all consecutive patients who met the eligibility criteria and completed the RSI and isokinetic measurements at five, seven, and eight months postoperatively. No a priori sample size or power calculation was performed because of the retrospective nature of the study.

To compare the operated limb RSI and isokinetic knee extensor and flexor strength across postoperative months five, seven, and eight, a one-way repeated-measures analysis of variance was performed. When a significant main effect was detected, Bonferroni-corrected post hoc pairwise comparisons were conducted, and F- and p-values were reported. The relationships between the RSI and isokinetic peak torque of the knee extensors and flexors on the surgical side were analyzed using Pearson's correlation coefficients. All statistical analyses were conducted using IBM SPSS Statistics at each time point with the significance level set at  $p < 0.05$ .

## RESULTS

### PARTICIPANT CHARACTERISTICS

Twelve patients (mean age,  $34.3 \pm 11.3$  years; 7 men and 5 women) who underwent ACLR were included in the analysis. Two participants (16.7%) presented with concomitant meniscal pathology, including one medial meniscectomy and one lateral meniscal repair. The participant demographics are shown in [Table 1](#).

### CHANGES IN OPERATED-LIMB STRENGTH AND RSI OVER TIME

Changes in knee extension and flexion strength and RSI of the operated limb at five, seven, and eight months postoperatively are summarized in [Table 2](#), and repeated-measures comparisons across these three time points are shown in [Table 3](#).

Regarding LSI progression, knee extension LSI remained between 72% and 75% across all time points, falling short of the commonly referenced 90% benchmark for returning to sports. The knee flexion LSI improved from 84.5% at five months to 93.5% at eight months. The RSI ranged from 76.1% to 83.1% over the same period.

**Table 1. Participants' demographic data**

| Athletes with ACLR                     | n = 12                 |
|----------------------------------------|------------------------|
| Age (years)†                           | 34.3±11.3(14–51)       |
| Sex, n (%)                             |                        |
| Male                                   | 7(58.3)                |
| Female                                 | 5(41.6)                |
| Height (cm)†                           | 168.3±9.5(150.0–187.0) |
| Weight(kg)†                            | 67.0±10.5(49.4–77.0)   |
| Modified Tegner activity score, point† | 7.17±1.53(5–9)         |
| Meniscal injury, n (%)                 |                        |
| Yes                                    | 3(25.0)                |
| No                                     | 9(75.0)                |

ACLR, anterior cruciate ligament reconstruction.

† Reported as mean  $\pm$  standard deviation (range).

There were no significant differences in knee extension strength or RSI of the operated limb across the time points. However, knee flexion strength significantly improved between five and eight months postoperatively ( $p < 0.05$ ).

### CORRELATION BETWEEN RSI AND OPERATED-LIMB MUSCLE STRENGTH

As shown in [Table 4](#), the RSI demonstrated strong positive correlations with knee extensor strength and moderate correlations with flexor strength at five and seven months postoperatively. By eight months, these associations had weakened and were no longer statistically significant. The detailed correlation coefficients are listed in [Table 4](#).

## DISCUSSION

This study primarily aimed to explore the relationship between RSI and lower limb muscle strength during mid- to late-stage rehabilitation after ACLR. Quadriceps, rather than hamstring, recovery may be a major factor associated with RSI performance. As summarized in [Table 3](#), the RSI showed strong correlations with knee extensor strength at five and seven months postoperatively, whereas these associations diminished by eight months as the quadriceps deficits decreased. By contrast, correlations with knee flexion strength were consistently weaker. Overall, RSI may primarily reflect rapid extensor force generation during the SSC, which aligns with previous work demonstrating that quadriceps output is the principal determinant of hopping and jumping biomechanics after ACLR.<sup>9,14</sup>

Quadriceps weakness remained notable throughout the study period, with knee extension LSI still  $<80\%$  at eight months. This pattern may appear to be consistent with previous literature, indicating that quadriceps deficits frequently persist in the late stages of rehabilitation and can act as a barrier to functional recovery and return to sports.<sup>11</sup> The similarly gradual improvement in the RSI observed in this cohort may parallel the trajectory of quadri-

**Table 2. Isokinetic strength and RSI results**

|                                  |                    | Timepoint                |                          |                          |
|----------------------------------|--------------------|--------------------------|--------------------------|--------------------------|
|                                  |                    | 5 months postoperatively | 7 months postoperatively | 8 months postoperatively |
| Knee extension peak torque (%BW) | Operative side     | 166.5 ± 59.3             | 191.5 ± 57.9             | 196.5 ± 58.7             |
|                                  | Non-operative side | 219.9 ± 61.7             | 263.3 ± 56.9             | 257.3 ± 56.9             |
| Knee flexion peak torque (%BW)   | Operative side     | 74.7 ± 29.9              | 94.9 ± 30.2              | 107.8 ± 33.2             |
|                                  | Non-operative side | 88.6 ± 33.2              | 111.3 ± 33.6             | 116.0 ± 32.6             |
| RSI                              | Operative side     | 24.2 ± 13.6              | 29.4 ± 12.9              | 30.6 ± 12.0              |
|                                  | Non-operative side | 34.1 ± 19.2              | 38.7 ± 18.6              | 38.5 ± 16.4              |
| LSI (%)                          | Extension          | 75.5 ± 19.2              | 72.3 ± 10.3              | 75.7 ± 14.7              |
|                                  | Flexion            | 84.5 ± 13.9              | 86.7 ± 15.6              | 93.5 ± 7.4               |
|                                  | RSI                | 76.1 ± 30.7              | 80.2 ± 25.4              | 83.1 ± 14.9              |

RSI, reactive strength index; LSI, limb symmetry index.

† Reported as % of body weight.

† Reported as mean ± standard deviation.

**Table 3. Repeated-Measures ANOVA Results for Isokinetic Strength and RSI (Operated Limb)**

| Outcome Variable           | F-value | p-value | Significant Pairwise Comparisons (Bonferroni-adjusted) |         |         |
|----------------------------|---------|---------|--------------------------------------------------------|---------|---------|
|                            |         |         | 5 vs. 7                                                | 7 vs. 8 | 5 vs. 8 |
| Knee Extension Peak Torque | 1.38    | 0.27    | 0.58                                                   | 0.46    | 0.98    |
| Knee Flexion Peak Torque   | 3.51    | 0.04    | 0.26                                                   | 0.57    | 0.03    |
| RSI                        | 0.77    | 0.47    | 0.61                                                   | 0.48    | 0.97    |

RSI, reactive strength index

**Table 4. Correlation analysis results**

| Timepoint                | Variables compared                 | Correlation coefficient (r) | p-value |
|--------------------------|------------------------------------|-----------------------------|---------|
| 5 months postoperatively | RSI vs. knee extension peak torque | 0.810                       | <0.001  |
|                          | RSI vs. knee flexion peak torque   | 0.767                       | 0.004   |
| 7 months postoperatively | RSI vs. knee extension peak torque | 0.909                       | <0.001  |
|                          | RSI vs. knee flexion peak torque   | 0.695                       | 0.012   |
| 8 months postoperatively | RSI vs. knee extension peak torque | 0.355                       | 0.257   |
|                          | RSI vs. knee flexion peak torque   | 0.545                       | 0.067   |

RSI, reactive strength index.

\*  $p < 0.005$ .

ceps recovery, supporting the interpretation that extensor strength is an important contributor to SSC capability.

Arthrogenic muscle inhibition (AMI), a reflexive reduction in the quadriceps motor drive triggered by joint inflammation, pain, or mechanical irritation, has been identified as a major factor that delays quadriceps recovery after ACL injury and surgery.<sup>15,16</sup> Inflammatory changes and fibrosis within the infrapatellar fat pad (IFP) may further exacerbate AMI by increasing nociceptive input and restricting anterior knee mobility. Nakagawa et al. have demonstrated

that patients with pronounced IFP fibrosis at three months postoperatively exhibited lower knee extension strength ratios, persistent pain, and motion loss.<sup>17</sup> Reduced IFP flexibility has been associated with heightened AMI responses and greater anterior knee pain, whereas medial meniscal extrusion progression may prolong joint irritation and afferent input.<sup>18,19</sup>

Given that RSI performance depends on rapid force generation, residual AMI, particularly during the midterm postoperative period, offers a plausible neurological ex-

planation for the observed association between quadriceps strength and RSI in this study. By contrast, these inhibitory pathways did not substantially affect hamstring function, which is consistent with the weak correlation between flexion strength and RSI.

Knee flexion strength displayed a relatively rapid recovery pattern, surpassing an LSI of 90% by eight months. This is consistent with reports that semitendinosus tendon regeneration begins several months after harvesting and progressively restores structure and function.<sup>20,21</sup> However, despite these improvements, flexion strength showed a limited association with RSI throughout rehabilitation, suggesting that hamstring recovery may not be a major determinant of muscular performance during single-leg continuous jumps. This interpretation is further supported by prior work demonstrating that functional hop and SSC tasks are primarily driven by the quadriceps, whereas the hamstrings contribute less to vertical reactive tasks.<sup>21</sup>

Given the strong association between quadriceps strength and RSI at five and seven months, RSI may be used as a practical surrogate for extensor function in clinical environments in which isokinetic dynamometry is unavailable. Because the RSI captures both force production and neuromuscular efficiency during repeated loading/unloading movements, suboptimal RSI values may help identify residual deficits that may not be evident in simple strength symmetry assessments. The accessibility of smartphone-based RSI measurement further increases its practicality in outpatient or field-based settings, and prior work supports the reliability of mobile application-based RSI measurement in patients undergoing ACLR.<sup>7</sup>

The disappearance of strength–RSI correlations at eight months, along with RSI LSI plateauing at approximately 83%, suggests a transition from a strength-limited phase to a skill-limited performance phase. Once the foundational level of quadriceps strength is restored, further improvements in RSI are likely to depend more heavily on neuromuscular coordination, rapid force development, and task-specific technical proficiency rather than on maximal strength capacity alone.

This interpretation aligns with the established evidence related to neuromuscular performance showing that late-phase explosive performance is increasingly driven by the rate of force development, stiffness regulation, and intermuscular coordination rather than by isolated strength measures.<sup>22</sup> Studies examining plyometric and stretch–shortening cycle–dependent tasks further suggest that advanced explosive performance relies on efficient neuromechanical interactions and rapid force transmission during coordinated eccentric–concentric actions, rather than on concentric strength capacity alone.<sup>23,24</sup>

Findings from ACLR cohorts reinforce this shift: despite progressive gains in strength, many patients continue to demonstrate impaired reactive or biomechanical function well into late rehabilitation, indicating that neuromuscular and coordinative factors remain limiting even when strength symmetry approaches conventional thresholds.<sup>25</sup>

Additionally, residual AMI may persist in some individuals after ACLR and may continue to attenuate high-velocity

quadriceps activation, even as peak torque improves, potentially making later-stage plyometric tasks that rely on SSC function more dependent on neuromuscular precision than on maximal strength alone.<sup>26</sup> Together, these factors may explain why the RSI may cease to correlate with isokinetic strength once athletes enter the later stages of recovery.

The dissociation between strength and RSI in the later rehabilitation stages suggests that RSI may serve as a complementary tool for RTS assessment. Although isokinetic testing remains important for identifying persistent strength deficits, RSI may detect ongoing limitations in explosive neuromuscular control that strength testing alone may not reveal. This notion is consistent with recent RTS frameworks that emphasize the integration of neuromuscular- and SSC-specific performance metrics, such as RSI, repeated jump performance, and other plyometric measures, rather than relying solely on LSI-based strength or hop tests, to guide safe and effective RTS decision making.<sup>27</sup>

## LIMITATIONS

This study had several limitations. First, the sample size was relatively small, limiting statistical power, particularly for multivariate analyses. Future studies should recruit larger cohorts to enable more robust statistical analyses. Second, all participants underwent the same surgical technique and postoperative rehabilitation protocol at a single institution, which may have limited the generalizability of the findings. Therefore, caution is warranted when applying these results to patients treated with different surgical methods or rehabilitation regimens at other facilities, particularly those involving quadriceps tendon or patellar tendon grafts. External validation in diverse clinical settings is required. Third, the age range of the cohort was relatively wide (14–51 years), and age-related differences in strength recovery or jumping performance were not adjusted for. Accordingly, the magnitude of the observed correlations between RSI and isokinetic strength should be interpreted with caution. Future studies with larger samples should stratify participants by age group or include age as a covariate. Fourth, RSI was assessed using a single commercially available smartphone/tablet application (Hudl Technique). Thus, the present findings may be specific to this measurement method, and results could differ when alternative applications or devices are used, introducing a potential source of measurement-related bias. Finally, adherence to home exercise programs, frequency of self-directed training, and involvement with external trainers were not controlled for or documented, all of which may have contributed to variability in muscle strength and RSI outcomes. In addition, participants were instructed to “minimize ground contact time” during RSI testing, which is consistent with commonly used plyometric and reactive training principles. However, this instruction may have influenced jump strategy by prioritizing shorter contact times at the expense of jump height, potentially affecting RSI values. As a result, RSI outcomes may partially reflect task-specific instructional effects rather than neuromuscular performance

alone. Future studies should further examine how instructional wording and jump strategy influence the reliability and interpretability of SVCJ-derived RSI across different stages of rehabilitation.

## CONCLUSION

In athletes after ACLR, a strong positive correlation between knee extension strength and RSI was observed during the midterm postoperative period (five to seven months); however, this relationship was not observed by eight months postoperative. This pattern suggests that, as strength deficits narrow, RSI may increasingly reflect factors beyond maximal strength, such as SSC-related neuromuscular function and coordination. Additionally, the RSI LSI failed to reach 90% at any time point, indicating persistent asymmetry in most participants. Therefore, even af-

ter achieving adequate strength levels, interventions aimed at enhancing explosive jump capacity, such as plyometric training, are warranted to improve function. Moreover, smartphone application-based RSI measurement, as used in this study, may offer a low-cost, field-friendly alternative to force plates and may be an effective evaluation tool in settings where traditional force platforms are unavailable. Overall, RSI can be employed in the mid-term postoperative phase as a convenient surrogate for isokinetic strength testing and in the later phase as a metric of higher-order functional performance in patients who have undergone hamstring graft ACLR.

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