ACL Rehabilitation and Return to Play Guidelines: An Evidence Based Approach

Terry L. Grindstaff, PhD, PT, ATC

@GrindstaffTL
Summary

• ACL injury has short and long-term consequences
  – Return to prior level varies
  – High reinjury rate
  – Osteoarthritis

• Progression and Return to Sport
  – Determined using battery of objective measures
    • If you don’t test you don’t know
  – Time still a factor
  – Psychology matters
Current Guidelines

ACL Epidemiology

- 200,000 per year in U.S.
  - 68.6/100,000 person-years
  - 2-3% of high school and collegiate injuries
  - Most result in ACL-R (75%)

- Higher Risk
  - Females > males in similar sports (2-6X)
  - Competition > Practice
  - Younger > Older

Sanders et al, 2016; Stanley et al, 2016; Hootman et al, 2007; Mall et al, 2014; Joseph et al., 2013
ACL-R ≠ Return to Function

- About 80% return to sport
  - Only 55-65% able to achieve prior performance level or return to competitive sport
- Declining participation even after RTP
  - Soccer: 65% able to play at same level 3 years post-op
  - Basketball: shorter career, less games, lower efficiency rating

Short-Term Considerations

- Most return to sport 6-13 months
  - 20-30% have reinjury within 2 years
- Decreased physical activity level and step count
- Increased BMI and percent body fat (females)

Common Impairments

- Joint effusion
- Range of motion
- Quadriceps strength
- Movement
  - Gait
  - Jumping
- Psychosocial and cognitive
Uncomplicated Recovery?

• Despite surgical intervention and rehabilitation 30-50% continue to have
  – Joint effusion
  – Weakness
  – Altered biomechanics
  – Decreased physical function

Urbach et al, 2001; Svantesson et al, 2005; Krishnan and Williams, 2011; Schmitt et al, 2012
Long-Term Considerations

- 3-5x greater risk of osteoarthritis (OA) following ACL injury
  - 25-33% in 5 years
  - 25-50% in 10 years

- Meniscus and chondral injury increases risk
  - Delayed surgery (> 5 months) negative impact on cartilage health

Claes et al., 2013; Frobell et al, 2013; Wellsandt et al, 2016; Lohmander et al., 2007; Ajuied et al., 2013; Barenius et. al., 2014; Janssen et al, 2013; Sri-Ram et al., 2013
Progression and Return to Activity/Play
Questions

• When is it safe to return to sport or activity?
  – How to determine?

• How can we ensure successful return to sport or activity in patients with ACL injury?
  – What is successful?
16 year-old Female

- Multiple ACL-R (10 months post-op)
  - Basketball
- VAS 2.4/10 (past week)
- IKDC 90%
Return to Play/Activity Decision

• Time based
• Subjective (knee stability)
• Objective measures (ROM, strength, hop tests, patient reported outcomes)

Barber-Westin and Noyes, 2011; Shea et al, 2015; Wright et al, 2015
Return to Play/Activity Decisions

StARRT Framework

Step 1 Assessment of Health Risk
- Tissue Health
  - Risk Assessment Process
  - Patient Demographics (e.g., age, sex)
  - Symptoms (e.g., pain, giving way)
  - Personal Medical History (e.g., recurrent injury)
  - Signs (Physical Exam) (e.g., swelling, weakness)
  - Special Tests (e.g., pain with function, x-ray, MRI)

Step 2 Assessment of Activity Risk
- Tissue Stresses
  - Type of Sport (e.g., collision, non-contact)
  - Position Played (e.g., goalie, forward)
  - Limb Dominance (e.g., MSK alignment)
  - Competitive Level (e.g., professional, playoffs)
  - Ability to Protest (e.g., padding)
  - Functional Tests (e.g., diagonal hop test)
  - Psychological Readiness (e.g., affecting play)

Step 3 Assessment of Risk Tolerance
- Risk Tolerance Modifiers
  - Timing & Season (e.g., playoffs)
  - Pressure from Athlete (e.g., desire to compete)
  - External Pressure (e.g., coach, athlete family)
  - Masking the Injury (e.g., effective analgesia)
  - Conflict of Interest (e.g., financial)
  - Fear of Litigation (e.g., if restricted or permitted)

Return-to-Play Decision

Creighton et al, 2010
Successful Outcomes Defined

- Patient return to sports
- Absence of giving way
- Strength and jumping > 90% uninvolved
- Not more than a mild knee joint effusion
- Self-reported outcomes

Failed Return to Sport

- Age
- Delayed surgery
- Strength deficit
- Unilateral hop deficit
- Knee effusion
- Lower self-reported function
- Recurrent episodes of instability
- Kinesiophobia

Di Stasi et al., 2013; Lentz et al., 2012; 2015
Successful Return to Sport

• Favorable Factors
  – Higher self-reported knee function
    • IKDC score > 93
  – No episodes of knee instability
  – No joint effusion

• Meeting all 3 criteria
  +LR= 14.5

Lentz et al, 2012
AAOS RTP Checklist

- Graft incorporation and graft strength considered
- Functional range of motion restored
- Stable knee with no pivot
- Functional strength (core, hip, quadriceps and hamstring) restored
  - Determined by clinician discretion
  - Can be measured by a variety of methods
- Functional balance restored
- Functional skills are performed adequately
- Patient is confident they are ready to return to sport
- Patient advised to participate in an ongoing ACL-prevention/movement-retraining program

http://www.aaos.org/research/Appropriate_Use/aclrtpchecklist.pdf
Quantifying Outcomes

If you don’t test you don’t know
Researchers: Quad index, hop tests, 9mos RTP
Clinicians: But is it enough?
Researchers: YOU'RE NOT EVEN DOING THAT!!!
• Not meeting discharge criteria increases risk of reinjury (4-5x more likely)
• Reinjury rate reduced 51% with 9 month vs 6 month RTP

Omaha Data

- Twenty-two unilateral ACL-R
  - Ten participants **failed all 3 tests** (<90%)
  - Four participants passed all 3 tests (>90%)
- Quadriceps LSI most common unmet criteria (15 of 22 participants)

Chaput et al, In Press JAT
Clinical Toolbox

- Effusion
- Range of motion
- Balance
- Strength
- Performance
- Patient reported outcomes
Joint Effusion

• Less joint effusion \(\rightarrow\) better function
• Assessed with stroke test
  – Good interrater reliability \((k = 0.75)\)

Stroke Test Effusion Grading Scale

<table>
<thead>
<tr>
<th>Grade</th>
<th>Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero</td>
<td>No wave produced on downstroke</td>
</tr>
<tr>
<td>Trace</td>
<td>Small wave on medial side with downstroke</td>
</tr>
<tr>
<td>1+</td>
<td>Larger bulge on medial side with downstroke</td>
</tr>
<tr>
<td>2+</td>
<td>Effusion returns to medial side after upstroke (no downstroke necessary)</td>
</tr>
<tr>
<td>3+</td>
<td>Not possible to move effusion from medial aspect</td>
</tr>
</tbody>
</table>

Sturgill et al, 2009
Balance

- SEBT (3 directions)
- Decreased anterior reach distance
  - May provide insights into muscle weakness
  - Deficits at 12 weeks → impact jumping at return to sport

Clagg et al, 2015; Garrison et al, 2015
Quadriceps Strength

- Early measures predict later
  - Presurgical
  - Early rehab
- Better strength → Better function
Isokinetic Dynamometer

- Quadriceps and hamstring
  - Most common speeds: 60°/s, 180°/s, 300°/s
Hand-Held Dynamometer

- Valid measure of strength (r= .89-.93)
  - Use strap/belt to secure
  - Maximum of 3 trials
- Compare sides (LSI)
  - Normalize to body mass

Hansen et al, 2015; Lesnak et al, In Press IJSPT
Isotonic Leg Extension

- Extend knee, hold 1 second, return weight stack in controlled manner
  - Initial load 10-20% body weight
  - Rest 2 minutes
  - Loads adjusted 2.5-30 pounds
- Target 3-5 trials
- Good agreement with isometric test ($r = .926; P < .001$)

Haff et al., 2016; Tagesson et al., 2007; Bove et al., 2016; Lesnak et al., In Review
What is Normal Strength?

- Contralateral limb may become weaker
  - LSI limitation
- Normative values
  - Normalized to body mass (Nm/kg)
Absolute Strength

- Avoids two flat bike tires comparison
  - Bilateral injury
  - Weaker contralateral
- Better predictor of function
  - Strength ≥ 3.10 Nm/kg (OR=8.15)
  - LSI ≥ 96.5 (OR=2.78)

Jumping

- Early deficits persist (6 months → 2 years)
- Predicts self-reported function
  - Good IKDC score (>85%)
    4x more likely when crossover hop LSI >95%
- Relationship with quadriceps strength (r= .45-.78)

Schmitt et al, 2012; Logerstedt et al., 2012; Mohammadi et al., 2013; Nawasreh et al, 2016
Jumping

- Unilateral tests
  - Unilateral injury → bilateral effects
  - Bilateral tasks not sensitive
- LSI versus normative values

Hewett et al., 2013; Myer et al., 2011; 2012; Schmitt et al, 2012; Zwolski et al, 2016 Gokeler et al, 2017
Common Hop Test Battery

- May not discriminate well
  - Test redundancy (r⁻.79⁻.92)
- Quantity versus quality
- Fatigue not assessed
Hop Test Battery

- Vertical jump
  - Drop
  - Bilateral
  - Unilateral
- Single leg hop
- Side hop (30s)
- Single leg hop with fatigue

Thomee et al, 2012; Gustavsson et al, 2006; Augustsson et al, 2004; White et al, 2017
Drop Vertical Jump

- 31 cm box
  - Half body height from landing area
  - Near landing area
- Jump/drop from box, land, jump as high as possible
- 2 video cameras
  - Front and side
- Movement quality
  - Landing Error Scoring System (LESS)
  - Estimate loading

Padua et al., 2010; 2015; Myer et al., 2010; 2011
Landing Error Scoring System (LESS)

- Higher score indicative of more “errors”
  - 10 items (0-15 points)
  - Trunk and lower extremity position
  - Overall impression
- Score > 5 indicates ACL injury risk (+LR 2.4)

Padua et al., 2010; 2015
Single-Leg Forward Hop

- Hop as far as possible with a controlled single limb landing
  - Success defined as maintaining position on a single leg for at least 2 seconds
  - Loss of balance or placing hands or contralateral limb on the ground counts as failure
- Three trials minimum
  - Continue until decrease in distance or 6 trials
Side Hop (30 sec)

- Two lines 40 cm apart
- Jump as many times as possible over lines
  - Approximately 30 degrees of knee flexion each jump
- Number of successful jumps performed within 30 seconds recorded
  - Unsuccessful jump defined as touching the tape, the area inside the tape, or losing balance
Fatigue Tests → Single-Leg Hop

30 Second Side Hop

2 Minute Lateral Step Down
Forward Hop After Fatigue

- Significant decrease in forward hop distance
  - Agrees with previous studies
- Magnitude smaller for ACL vs Healthy
  - ACL-R: 9-11 cm
  - Healthy: 13-29 cm
- Resistant to fatigue?

Augustsson et al, 2004; 2006; White et al., 2018; Klemetson et al, 2019 CSM
Chair to Box Test

- Two boxes 12” and 18”
  - 30-36” between boxes
- Stand up → jump to box
  - Foot in contact with ground
  - Do not push off box
- Time to completion (seconds)
  - Minimum of 3 trials
  - Continue until time is slower or 6 trials
Lateral Hurdle Hop

- 8” hurdle; 18” between hurdles
- Start jumping medially
  - Perform two times through before timer stopped
- Time to completion (seconds)
## Results

<table>
<thead>
<tr>
<th>Functional Test</th>
<th>Involved Limb</th>
<th>Uninvolved Limb</th>
<th>LSI (%)</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chair to Box</td>
<td>1.76 ± 0.66 sec</td>
<td>1.42 ± 0.37 sec</td>
<td>83.5 ± 17.0</td>
<td>0.64</td>
</tr>
<tr>
<td>Forward Hop</td>
<td>139.7 ± 25.9 cm</td>
<td>154.2 ± 26.5 cm</td>
<td>90.9 ± 11.2</td>
<td>0.52</td>
</tr>
<tr>
<td>30-second Side Hop</td>
<td>34.4 ± 14.2 reps</td>
<td>45.9 ± 11.9 reps</td>
<td>73.1 ± 19.1</td>
<td>0.84</td>
</tr>
<tr>
<td>Lateral Hurdle Hop</td>
<td>6.07 ± 2.24 sec</td>
<td>5.22 ± 1.06 sec</td>
<td>90.2 ± 16.9</td>
<td>0.49</td>
</tr>
</tbody>
</table>

Statistically significant; \(p<.05\) | Not statistically significant; \(p=0.11\)

Knight et al, In Progress
Patient Reported Outcomes

- International Knee Documentation Committee (IKDC)
- Knee injury and Osteoarthritis Outcome Score (KOOS)
- Knee Outcome Survey Activity of Daily Living (KOS-ADL)
- Global rating score of knee function
- Tampa Scale of Kinesiophobia (TSK-11)
- Knee Self-Efficacy Scale (K-SES)
- ACL-Return to Sport after Injury (ACL-RSI)
IKDC

• 19 questions
• Function and pain
• High score better (100)
  – Lower scores → strength and hop deficits likely
  – Normal scores ≠ adequate strength and hop performance
• Good Reliability (ICC= 0.95)
  – MDC 8.8 points

http://www.sportsmed.org/aossmimis/Members/Research/IKDC_Forms/Members/Research/IKDC_Forms
http://www.orthopaedicscore.com/scorepages/international_knee_documentation_comittee.html

Hambly et al, 2010; Logerstedt et al, 2014
ACL-RSI

• 12 questions
• Psychological aspects
  – Emotions
  – Confidence
  – Risk appraisal
• High score better (100)
Psychosocial

• Elevated fear (TSK-11) impacts return to sport
  – Influences function (IKDC)
  – Quadriceps weakness

• Return to sport status
  – ACL-RSI > TSK-11

Lentz et al, 2015; Webster et al, 2008; Langford et al, 2009; Muller et al, 2015
Psychosocial

• Presurgical mind set predicts postsurgical outcomes
  – High internal locus of control
  – Low level of fear of reinjury (TSK-11)
  – High self-efficacy (K-SES)

Ardern et al., 2013; te Wierike et al., 2013; Everhart et al, 2013
Summary
16 year-old Female

- Multiple ACL-R (10 months post-op)
- VAS 2.4 cm (past week)
- **IKDC 90%**
- **KOOS Sport/Rec 70%**

<table>
<thead>
<tr>
<th></th>
<th>Right (involved)</th>
<th>Left (uninvolved)</th>
<th>LSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVIC (N*m)</td>
<td>152</td>
<td>237</td>
<td>64%</td>
</tr>
<tr>
<td>Single Hop</td>
<td>169</td>
<td>176</td>
<td>96%</td>
</tr>
<tr>
<td>Triple Hop</td>
<td>467</td>
<td>471</td>
<td>99%</td>
</tr>
<tr>
<td>Cross Over Hop</td>
<td>450</td>
<td>441</td>
<td>102%</td>
</tr>
<tr>
<td>6 m Timed Hop</td>
<td>2.13</td>
<td>2.04</td>
<td>96%</td>
</tr>
</tbody>
</table>
Sample Cases
Return to Play Test Battery

- IKDC and ACL-RSI
- SEBT
- Quadriceps strength
- Hop Test
  - Vertical jump (drop, bi, uni)
  - Single leg hop
  - Side hop (30s)
Return to Sport Application

- Not meeting discharge criteria increases risk of reinjury (4-5x more likely)
- Reinjury rate reduced 51% with 9 month vs 6 month RTP

Graft incorporation and graft strength considered
Functional range of motion restored
Stable knee with no pivot
Functional strength (core, hip, quadriceps and hamstring) restored
  Determined by clinician discretion
  Can be measured by a variety of methods
Functional balance restored
Functional skills are performed adequately
Patient is confident they are ready to return to sport
Patient advised to participate in an ongoing ACL-prevention/movement-retraining program

http://www.aaos.org/research/Appropriate_Use/aclrtpchecklist.pdf
Summary

• ACL injury has short and long-term consequences
  – Return to prior level varies
  – High reinjury rate
  – Osteoarthritis

• Progression and Return to Sport
  – Determined using battery of **objective** measures
    • If you don’t test you don’t know
  – Time still a factor
  – Psychology matters