Evidenced-Based Decision Making on Return to Play:
“Doc, Where’s the Science?”

Mohsen Hussein, MD, PhD
SUCCESSFUL RETURN

- Same or different sport
- Same competitive level
- Contact or non-contact sport
- Pivoting or non-pivoting sport
- Athlete perceive that the return is successful
DEFINITION

• A successful return to sport in the short term means a low risk of re-injury

• In the long term means that there is a low risk of developing knee (OA)
DECISION-BASED RETURN TO PLAY MODEL


- medical factors: demographics, medical history, symptoms
- sport risk modifiers: type and level of sport, for evaluating risks if the patient returns to sport
- decision modifiers: season, internal and external pressure and conflict of interest
Rehabilitation After Anterior Cruciate Ligament Reconstruction: Criteria-Based Progression Through the Return-to-Sport Phase

Rehabilitation following anterior cruciate ligament (ACL) reconstruction has undergone a relatively rapid and global evolution over the past 25 years. However, there is an absence of standardized, objective criteria to accurately assess an athlete’s ability to progress through the end stages of rehabilitation and safe return to sport. Return-to-sport rehabilitation, progressed by quantitatively measured functional goals, may improve the athlete’s integration back into sport participation. The purpose of the following clinical commentary is to introduce an example of a criteria-driven algorithm for progression through return-to-sport rehabilitation following ACL reconstruction. Our criteria-based protocol incorporates a dynamic assessment of baseline limb strength, patient-reported outcomes, functional knee stability, bilateral limb symmetry with functional tasks, postural control, power, endurance, agility, and technique with sport-specific tasks. Although this algorithm has limitations, it serves as a foundation to expand future evidence-based evaluation and to foster critical investigation into the development of objective measures to accurately determine readiness to safely return to sport following injury. J Orthop Sports Phys Ther 2006;36(6):385-402. doi:10.2519/jospt.2006.2222

Key Words: anterior cruciate ligament, knee rehabilitation, lower extremity, sport injury
FACTORS AFFECT RETURN TO SPORTS: ACLR

- pre-injury status of the athlete,
- associated knee injuries,
- time to treatment, time to surgery,
- surgical technique,
- knee kinematics after injury/surgery,
- rehabilitation protocol,
- compliance,
• The achieved level of muscle function
• psychological factors
• the patients’ ‘desired’ physical activity level
• and social factors, such as family or work career,
• functional knee stability,
• knee symptomatology
• level/intensity of the sport
• discrepancy between the patients’ self-reported results for knee symptoms/function and the results of muscle function tests

• This could indicate that the patients are not satisfied with their knee function and that the criteria for muscle strength and hop performance are insufficient
BATTERY OF MUSCLE FUNCTION TESTS


Has been shown to be reliable and to have a greater ability, compared with any single test:

• including three different tests for lower extremity muscle strength (leg extension, leg flexion and leg press)
• three different hop tests (vertical jump, hop for distance and side hop)
Systemic Review: Factors Used to Determine Return to Unrestricted Sports Activities After Anterior Cruciate Ligament Reconstruction Sue D. Barber-Westin, B.S., and Frank R. Noyes, M.D.

Arthroscopy

- Medline for all published literature from **April 2001 to April 2011** using the following key words: anterior cruciate ligament reconstruction, ACL reconstruction, ACL reconstruction rehabilitation, and ACL reconstruction results.

- **Inclusion criteria** were English language, original research report (any level of evidence), primary ACL reconstruction (any graft type), skeletally mature patients, and minimum 12 months’ follow-up.

- **Exclusion criteria** were revision ACL reconstruction; dislocated knees; major concomitant procedures such as high tibial osteotomy, meniscus allograft, or other knee ligament reconstructions; follow-up of less than 12 months; and other types of articles such as reviews, case reports, abstracts, and technical notes.
Flowchart of ACL reconstruction studies with criteria for return to athletic
The data from each study that met the inclusion criteria were abstracted for information regarding the type of ACL graft used and whether the following categories were used to release patients to athletic activities:

- (1) time postoperatively;
- (2) knee range of motion (ROM) and knee effusion;
- (3) stability, as indicated by knee arthrometer testing or results of Lachman or pivot-shift testing;
- (4) muscle strength testing (hamstring, quadriceps, hip, core) or thigh circumference measurement;
- (5) dynamic function with single-leg hop tests;
- (6) neuromuscular function with drop-jump tests;
- (7) aerobic capacity assessment for maximal oxygen uptake;
- (8) sports-specific testing that included results required to return to competition;
- (9) validated questionnaire results.
Time Postoperatively

- 158 (60%) listed the amount of time postoperatively that patients were allowed to return to sports activities (Table 2).
- In 84 studies (32%) the amount of time postoperatively was the only criterion provided.
- In 40 other studies (15%), the amount of time along with subjective criteria
- Only 35 studies (13%) noted objective criteria required for return to athletics
MUSCLE STRENGTH

- Of the 264 studies, 25 (9%) reported muscle strength criteria (Table 5) required for return to athletics.
- Recommendations ranged from greater than 80% to greater than 90% for isokinetic testing of the quadriceps and hamstrings compared with the contralateral side.
- Three other studies noted that thigh circumference measurements of less than 1 cm or less than 0.5 cm (difference between limbs) were required for return to athletics.
GENERAL KNEE EXAMINATION

• Effusion and/or ROM criteria were listed in 15 studies (6%):
  • 11 listed both factors,
  • 2 provided effusion criteria only,
  • 2 listed ROM criteria only.

In all studies no effusion and a full ROM were given as required criteria for return to sports.
STABILITY

• Only 1 study provided objective knee stability criteria (negative Lachman test), although 7 other studies noted subjective stability criteria (Table 4).

• In 1 other study, the results of knee arthrometer testing determined whether a brace was required when patients returned to sports activities
Validated Questionnaire

• Only 1 study included data from validated questionnaires in its criteria for return to sport
Dynamic Function: Single-Leg Hop Tests

- Single-leg hop testing was included in 10 studies (4%) as a criterion in their assessment for return to sports (Table 6).
- Six defined a result of greater than 90% of the distance hopped on a single-hop test compared with the opposite side as acceptable.
- One study noted that 90% or greater was required on 4 hop tests: single hop, triple hop, triple crossover hop, and timed hop.

- This was the only study that did not provide time postoperatively as an additional criterion; instead, the authors stated that progression was based on the patient achieving functional criteria.
DISCUSSION

- a lack of objective assessment methods exist in the published literature before release to unrestricted sports activities after ACL reconstruction. Only 35 (13%) of the 264 articles reviewed included some measurable objective criteria.

- a **multifactorial analysis** of knee function was determined by only 2 studies in which 3 to 4 categories (other than time postoperatively) were included for release to sports activities:
• Future studies are required to determine whether advanced rehabilitation programs that include neuromuscular retraining are effective in reducing the reinjury rate after surgery.

• Reducing the risk of reinjury after ACL reconstruction on return to athletics requires a multifaceted approach.
Finally, we believe that factors related to muscle strength, stability, neuromuscular control, and lower limb function should be measured before release to unrestricted activities.
Our criteria for release include

- less than 10% deficit in strength of the quadriceps and hamstring on isokinetic testing at 180°/s and 300°/s,
- less than 15% deficit in lower limb symmetry on single-leg hop testing (single hop, triple hop, crossover hop, and timed hop28),
- less than 3 mm of increased anterior-posterior tibial displacement on Lachman or knee arthrometer testing,
- greater than 60% normalized knee separation distance on a video drop-jump test,29
- no effusion, full knee motion, normal patellar mobility, no or only slight patellar crepitus, and no pain or swelling with all activities.
- Other tests to consider are the single-leg squat test to determine postural and lower limb control as well as hip muscular function,30,31
- the multistage fitness test to determine maximal oxygen uptake,32
- and the 60-second sit-up test33
- or other core strength measures.3
The results of this systematic review show noteworthy problems and a lack of objective assessment before release to athletics. Measurement of muscle strength, stability, neuromuscular control, and function is recommended before release to unrestricted activities.

- Van Grinsven et al. recently conducted a systematic review of the rehabilitation literature to develop an evidence-based postoperative ACL program that would allow a return to athletics within 6 months:

They recommended the following for return-to-sports criteria:
- full ROM,
- 85% or greater on strength (quadriceps and hamstrings)
- single-leg hop tests compared with the opposite leg,
- less than 15% deficit on hamstring-quadriceps strength ratio,
- no pain or swelling with sport-specific activities,
- a stable knee in active situations
Final Criteria to Return to Sport

• This is the most sports specific part of rehabilitation.
Return to High School– and College-Level Football After Anterior Cruciate Ligament Reconstruction A Multicenter Orthopaedic Outcomes Network (MOON) Cohort Study (AJSM 2012)
Return to Play Percentages for All High School and College Athletes

<table>
<thead>
<tr>
<th>Return to Play Response for Football, n (%)</th>
<th>High School (n = 68)</th>
<th>College (n = 26)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>25 (37)</td>
<td>8 (31)</td>
</tr>
<tr>
<td>Yes</td>
<td>43 (63)</td>
<td>18 (69)</td>
</tr>
</tbody>
</table>
REASONS FOR NOT RETURNING TO PLAY

<table>
<thead>
<tr>
<th>Specific Factors Negatively Affecting Return to Play, %</th>
<th>High School</th>
<th>College</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other interests(^b)</td>
<td>67</td>
<td>75</td>
</tr>
<tr>
<td>Fear</td>
<td>53</td>
<td>50</td>
</tr>
<tr>
<td>Physical symptoms</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>Advice</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>Loss of speed or strength</td>
<td>13</td>
<td>12</td>
</tr>
</tbody>
</table>
ABILITY TO RETURN TO SPORTS AFTER ACLR

![Graph showing the percentage of athletes who could return to sports after ACLR.](image-url)
<table>
<thead>
<tr>
<th>2-Year Post-ACL Outcome Scores by Return to Play and Level Status</th>
<th>IKDC</th>
<th>Marx Activity Scale</th>
<th>KOOS (Sports and Recreation)</th>
<th>KOOS (Knee-Related Quality of Life)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>25%</td>
</tr>
<tr>
<td>High school (grades 9-11)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No return to play (n = 11/13)</td>
<td>76</td>
<td>84</td>
<td>95</td>
<td>6.0</td>
</tr>
<tr>
<td>Returned to play, not level (n = 12/12)</td>
<td>78</td>
<td>86</td>
<td>95</td>
<td>9.8</td>
</tr>
<tr>
<td>Returned to play and level (n = 19/23)</td>
<td>89</td>
<td>95</td>
<td>97</td>
<td>12.0</td>
</tr>
<tr>
<td>Kruskal-Wallis rank-sum test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$P = .14$</td>
<td>$P = .36$</td>
<td>$P = .25$</td>
<td>$P = .24$</td>
</tr>
<tr>
<td>College (freshman-junior)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No return to play (n = 6/7)</td>
<td>73</td>
<td>81</td>
<td>89</td>
<td>9.2</td>
</tr>
<tr>
<td>Returned to play, not level (n = 4/7)</td>
<td>89</td>
<td>92</td>
<td>98</td>
<td>16.0</td>
</tr>
<tr>
<td>Returned to play and level (n = 9/9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wilcoxon rank-sum test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$P = .04$</td>
<td>$P &lt; .01$</td>
<td>$P = .10$</td>
<td>$P &lt; .01$</td>
</tr>
</tbody>
</table>
The prevalence of concomitant injuries

- MCL: 25% (High School), 4% (Collegiate)
- LCL: 0% (High School), 0% (Collegiate)
- PCL: 0% (High School), 0% (Collegiate)
- Articular (G2-4): 30% (High School), 36% (Collegiate)
- Meniscus: 51% (High School), 52% (Collegiate)
• Player position did not have a statistically significant effect on the ability to return to play for high school players (P = .76).
• Because of low numbers, effect of the graft on return to play was not statistically tested.
- **Kvist** reported that 56% of patients in all sports had returned to their preinjury activity level after ACLR.
- **Ardern** in a systematic review of 48 studies, identified a 44% rate of return to competitive sport.
- **Lee** reported a 62% rate of return to play over 5 years after ACLR utilizing hamstring autografts.
- **Carey** reported an approximately 80% return to play rate for NFL running backs and wide receivers after ACLR.
THE PSYCHOLOGICAL EFFECT

• 24% of 59 patients who underwent unilateral ACLR identified fear as the primary factor for not returning to play. (Kvist KSSTA 2005)

• 2 main reasons not returning to play were having an unstable knee or fear of reinjury. (Lee 2008)
CONCLUSION

• While the surgical and rehabilitation components of ACLR have undergone extensive study and evaluation, the psychological component of return to play, in particular fear of reinjury, is frequently underestimated and likely plays a critical role in preventing athletes from returning to play.
Sport participation was defined by 3 categories:

- type of sport,
- level of competition (recreational, varsity high school, varsity college/university, professional),
- and Marx activity score.
95 patients met inclusion criteria

38 declined participation

31 patients consented and participated in the study

20 patients had not returned to preinjury sport

11 patients had returned to preinjury sport†

26 were unable to be contacted*
Patient-Derived Themes

- **Fear.** The most frequently encountered reason why patients decided not to return to their preinjury level and type of sport.

- **Priorities.** Changes in family commitments, job demands, and life stages.

- **Personality.** Throughout the interviews, patients described their individual personalities.

- **Others:** surgeon’s advice, r knee pain and decreased range of motion, depressed mood, encouragement from their varsity coaches.
CONCLUSION

• sports medicine and health care professionals should invest more attention to psychological factors, individual lifestyle choices, and patient goals to (1) fully understand the community of athletes who have suffered a major injury requiring surgery and (2) more effectively address their needs
Neuromuscular Training Techniques to Target Deficits Before Return to Sport After Anterior Cruciate Ligament Reconstruction

Gregory D. Myer, 1,2 Mark V. Paterno, 1–3 Kevin R. Ford, 1,4 and Timothy E. Hewett 1,5

- there is an absence of standardized, objective criteria to accurately assess an athlete’s ability to progress through the end stages of rehabilitation and safely return to sport.

- algorithmic approach may improve the potential for athletes to return to sport after ACL reconstruction at the optimal performance level and with minimized risk of reinjury.
Stage I:
Dynamic Stabilization and FAIH Strengthening

- Single limb squat and hold symmetry (minimum of 88° knee flexion with 5 second hold)
- Auditory rhythmic foot strike patterns without gross asymmetries in visual kinematics when running (headset)
- 60 mph: 10-16 km/h
- Achievable single limb balance scores on Statheeter (Females = 2-2.2 degrees of deviation and males <3.0 degrees of deviation; knee away tested for 30 seconds at level 5)

Stage II:
Functional Strengthening

- Side-to-side symmetry in peak torque knee flexion and extension (within 15° at 180 and 300°/sec) and hip abduction peak torque symmetry (within 15° at 60 and 120°/sec)
- Planar force total loading symmetry measured during equal to 55° knee flexion ±20% discrepancy between sides
- Single limb peak landing force symmetry on a 50 cm (20 inch) box and within 10% in side-to-side measurements

Stage III:
Power Development

- Single limb hop for distance (within 15% of the uninvolved limb)
- Single limb cross over triple hop for distance (within 15% of the uninvolved limb)
- Single limb broad jump over 6 meters (within 15% of the uninvolved limb)
- Single limb vertical power hop (within 20% of the uninvolved limb)
- Single limb vertical jump (15 percentage points of improvement or an 80 point score)

Stage IV:
Sports Performance

- Drop vertical jump landing force bilateral symmetry (within 15%)
- Modified agility 1 min (9/1) test time (within 10%)
- Single limb average peak power test for 10 seconds (bilateral symmetry within 15%)
- Re-assessment of Tuck Jump (50 percentage points of improvement from initial test score of perfect 90 point score)

Reintegration to Interval Sport Participation
Final Criteria to Return to Specific Sport

• This is the most sports specific part of rehabilitation.
Soccer specific exercises

**FIGURE 1.** Male professional soccer player on swinging platform (simulation of kicking ball with nonoperated leg).

**FIGURE 2.** Block tackles at different angles and intensities, on different types of surfaces, from a soft deflated soccer ball to a harder leather medicine ball.

**FIGURE 3.** Male professional soccer player sitting on a soccer ball (and juggling another ball).

**FIGURE 4.** Star run drill. Basic setup and different drills: (a) star run, (b) star run with zigzag cutting drill, (c) star run with forward/backward ladder drills, (d) star run with running courts through poles.

**FIGURE 5.** Kicking action into pads while balancing on an unstable surface, incorporating starting balance while making contact. The use of unstable surfaces helps to promote different reactive stabilization strategies.
Ski specific programme and exercises

**Return-to-Ski Program**

1. Free skiing, as outlined by level, focusing on basic athletic stance, balance, joint angles, turn shape
2. Free skiing should begin on groomed, flat to moderate terrain
3. Work to achieve even balance on both legs with trust and confidence on both skis
4. Free ski in sections, working up to long/full-length runs
5. Nonacning to arcing turns

**Progression 2: Drills (Below Are Examples)**
1. Skiing to be performed on groomed, flat to mild terrain
2. Sideslipping into smooth stop on fall line
3. Sideslipping into distinctive stop on fall line
4. Sideslipping diagonally across fall line and switching sides
5. Sideslipping to edge-set and carving across fall line
6. Diagonal skiing, carving
7. Diagonal skiing, carving with flattening of ski
8. Sliding turn in natural-stance position
9. Sliding turn in squat position
10. Sliding turn in squat position with squat pumps
11. Single-leg sliding turns, “heel lift” opposite ski
13. Sliding short to medium turns with pole plant
14. Sliding short to medium turns without pole plant
15. Turns with 1 leg lifted
16. Turns with 1000-ft stepping (stepping back and forth throughout the turn)
17. Turns with small hops

**TABLE 3: Return-to-Ski Program: Levels 1 to 5**

<table>
<thead>
<tr>
<th>Level</th>
<th>Weeks</th>
<th>Progression</th>
<th>Intensity</th>
<th>Duration</th>
<th>Activity Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-2</td>
<td>1 and 2</td>
<td>50%</td>
<td>1-3 h</td>
<td>Progress to following phase after 2 weeks in the absence of symptoms.</td>
</tr>
<tr>
<td>2</td>
<td>2-4</td>
<td>1 and 2</td>
<td>75%</td>
<td>2-4 h</td>
<td>Progress to following phase after the fourth week in the absence of symptoms.</td>
</tr>
<tr>
<td>3</td>
<td>6-8</td>
<td>Slalom and giant slalom drills using brushes</td>
<td>75% to 90%</td>
<td>3-5 h</td>
<td>Progress to following phase after the sixth week in the absence of symptoms.</td>
</tr>
<tr>
<td>4</td>
<td>6-8</td>
<td>All disciplines in all conditions</td>
<td>75% to 100% of maximal</td>
<td>4-6 h</td>
<td>Increase intensity, duration, and frequency as tolerated.</td>
</tr>
<tr>
<td>5</td>
<td>8 and beyond</td>
<td>Free ski terrain park and half-pipe</td>
<td>50% to 100% of maximal levels, depending on tricks</td>
<td>2-4 h</td>
<td>Progress to full ski session with teams/coaches.</td>
</tr>
</tbody>
</table>