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# ANTERIOR CRUCIATE LIGAMENT (ACL) REHABILITATION PROTOCOL

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Return to participation → Sport or Activity → Performance

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*Glen Sather Sports Medicine Clinic Interdisciplinary Knee Team*

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**PHASE 6** INJURY PREVENTION  
> 1 year



**PHASE 1** POST SURGERY OR ACUTE ACL INJURY  
0-6 weeks



**PHASE 2** STRENGTH TRAINING  
6 wks - 2 yr



# ACL REHAB

A CRITERION AND GOAL BASED APPROACH TO KNEE REHAB



**PHASE 5** RETURN TO ACTIVITY OR SPORT  
> 9 months



**PHASE 4** SPORT SPECIFIC TRAINING  
> 6 months



**PHASE 3** DYNAMIC TRAINING  
> 3-4 months



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**"ELEVATING ACL REHAB THROUGH RESEARCH AND CLINICAL EXPERTISE"** **GSSMC ACL PROTOCOL**  
Edited April 10, 2017

# Background

The Glen Sather Sports Medicine Clinic (GSSMC) is an interdisciplinary clinic located in Edmonton, Alberta, Canada. The primary clinic objectives are to educate and provide excellent patient care based on current evidence and clinical expertise.

To optimize patient care following anterior cruciate ligament (ACL) injury, the GSSMC has developed an evidence-based protocol to guide patients and physical therapists during the rehabilitation process. This protocol is suited for patients who have undergone ACL reconstruction (ACLR) as well as patients who have opted for non-operative management. Furthermore, these guidelines may also be applied after other traumatic knee injuries if approved by an orthopaedic knee surgeon or sports medicine physician or physical therapist.

## **The protocol emphasizes criterion-based progression versus time-based progression.**

The ultimate goal of ACL rehabilitation is successful return to sport (RTS) or return to activity (RTA) while minimizing the risk of a re-injury. To ensure success and safety, patients must complete specific goals to advance from one stage of rehabilitation to the next. This shift away from time-based progression places responsibility on patients and physical therapists to achieve certain physical and psychological qualities before introducing more difficult tasks. For those undergoing surgery, meeting these criteria will also ensure the ACL graft is not excessively stressed during the healing phases. A criterion-based progression allows physical therapists to understand each patient's abilities and subsequently create individualized treatments in every stage of rehabilitation.

### **Did you know?**

- Failure to complete a rehabilitation program before return to sport increases risk of ACL graft rupture by **4 times**<sup>1</sup>
- **65%** of athletes return to pre-injury level of sport or activity after ACLR<sup>2</sup>
- **55%** of athletes return to competitive level of sport or activity after ACLR<sup>2</sup>

# ACL Protocol

## STAGE 1

Post-operative ACL reconstruction or acute ACL injury

0 to 6 weeks

- **Goals: reduce inflammation, control pain and restore full range of motion**
- Restore quadriceps activation, normal gait and terminal knee extension
- Introduce low impact cardio - e.g. stationary biking, rowing, straight-line swimming using pull buoy
- Encourage symmetrical weight bearing with exercises

- Weight bearing and early range of motion is not detrimental and should be encouraged immediately following surgery or injury<sup>3 4</sup>



# ACL Protocol

## STAGE 2

### Strength and neuromuscular training

6 weeks to 2 years

- **Goals: increase strength and introduce neuromuscular training**
- Introduce body weight strengthening and progress to weight lifting as tolerated
- Encourage hypertrophy and development of quadriceps
- Caution heavy loading of hamstring exercises with ACLR using hamstring autograft in the first 6-8 weeks
- Use quadriceps symmetry index (QSI) as a measure to assess symmetry of quadriceps strength - be aware that the contralateral leg will also have strength deficits following surgery or injury
- **Longest phase and most imperative to complete to ensure appropriate development of strength**

- Must achieve adequate strength prior to return to sport or activity <sup>5</sup>
- Patients with quadriceps deficits pre-operatively had worse knee function following ACLR and displayed strength deficits up to 2 years after surgery <sup>6 7</sup>



# ACL Protocol

## STAGE 3

### Dynamic neuromuscular training

3 to 4 months

- **Goals: Introduce plyometric and agility training (e.g., running, jumping, ladder drills)**
- Demonstrate sufficient strength and control required to running and jumping
- Provide a gradual return to jogging program that minimizes possibility of knee soreness and worsening of effusion
- Teach proper movement patterns and strategies to reduce risk of re-injury
- Continue strength training and addressing areas of weakness in lower extremity
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• **Do not commence dynamic training prior to 12 weeks post-ACLR** to allow the ACL graft sufficient time to heal <sup>8</sup>

# ACL Protocol

## STAGE 4

### Sport specific training

6 months or greater

- **Goals: introduce ‘sport specific movements’ in controlled environment**
- Sport specific movements include accelerating, decelerating, changing direction and pivoting
- Progress by increasing speed and combining multiple skills in a single exercise
- Add reactionary or decision-making drills to mimic sport or activity scenarios when running skills are performed with proper technique even if fatigued
- Limb symmetry index (LSI) measured through functional hops and QSI should both be used to assess strength and function of the injured leg
- Introduce and maintain cardiovascular fitness (aerobic or anaerobic) for the desired sport or activity

- Objective strength and functional tests should be nearly symmetrical and within 10% difference compared to the un-injured leg prior to progressing to the next phase <sup>5</sup>

# ACL Protocol

## STAGE 5

### Gradual return to sport or activity

9 months or greater

- **Goals: gradual return to practice, followed by sport or activity**
- Add specific skill of the desired sport or activity to sport specific movements learned in prior stage
- Introduce contact drills when sport specific skills are performed with proper movement control
- Discuss and address any psychological barriers that may prevent RTS (e.g., fear of re-injury)
- LSI should be  $\geq 90\%$  for all strength and functional tests - ideally aim for 100% symmetry
- Return to sport before 9 months may not be realistic due to both biological healing and knee function

- All patients that returned to their sport within 6 months of surgery suffered an ACL graft rupture <sup>5</sup>
- Between 6- and 9-months post-operative, each month of delayed return to sport decreased the risk of re-injury by 51% <sup>5</sup>
- Symmetrical quadriceps strength substantially reduced re-injury <sup>5</sup>
- On average, NFL players require 11 months of rehabilitation before return to sport after ACLR <sup>9</sup>
- Complete ligamentization of the ACL graft takes up to at least 1 year following surgery <sup>8</sup>



# ACL Protocol

## STAGE 6 Injury prevention

up to 3 years

- **Goals: educate about various injury prevention strategies**
- FIFA 11+ - 68% reduction in lower extremity injuries with high compliance to program <sup>12</sup>
- Prevent Injury and Enhance Performance (PEP) Program from Santa Monica - 41% reduction in ACL injury rate <sup>13</sup>
- Emphasize maintenance of strength and neuromuscular training

- 30% of athletes with ACLR sustain a re-injury in the same or opposite knee within the first 20 athletic exposures and 50% sustain a re-injury within the first 72 exposures <sup>10 11</sup>
- Up to 30% of patients with ACLR will suffer a re-injury to the same or contralateral leg if returning to high risk pivoting sport (ex. soccer, football, basketball) <sup>10</sup>

STAGES	EARLY POST-OPERATIVE or POST-INJURY	STRENGTH	DYNAMIC NEUROMUSCULAR TRAINING	SPORT-SPECIFIC TRAINING	RETURN TO SPORT/ACTIVITY	INJURY PREVENTION
EST. TIME POST OP	Day 1 to 6 weeks	6 weeks and ongoing	3-4 months	6 months or greater	9 months or greater	On-going after RTS/RTA
RESTRICTION OR PRECAUTION	Monitor for DVT and infection ACL graft is weakest from 4-12 weeks	No running before 12 weeks due to ACL graft healing	Regardless of time, appropriate strength and control is needed with all exercises prior to entering this stage		Complete several full practices prior to return to game	
GOALS & EXPECTATIONS	<ul style="list-style-type: none"> <li>Restore full and symmetrical range of motion (including hyperextension)</li> <li>Reduce effusion and pain</li> <li>Restore symmetrical quadriceps activation</li> <li>Restore normal gait</li> </ul>	<ul style="list-style-type: none"> <li>Restore strength to the lower extremity <b>Primary:</b> glutes, quadriceps, hamstrings <b>Secondary:</b> core, hip flexor, calf</li> <li>Encourage proper vertical alignment of hip, knee, ankle</li> <li>Encourage symmetrical weight bearing</li> <li>Encourage body weight squat to 90° (unless restrictions)</li> <li>Gradual introduction to strength training (higher loads and lower reps)</li> <li>Maintain upper body strength and cardiovascular fitness</li> </ul>	<ul style="list-style-type: none"> <li>Progress towards jogging program</li> <li>Introduce plyometrics starting with 2 leg jumps and progressing towards 1 leg jumps</li> <li>Start agility training</li> <li>Continue to encourage proper movement mechanics</li> <li>Ensure no reactive effusion after exercises</li> <li>Continue strength training and address specific strength deficits</li> </ul>	<ul style="list-style-type: none"> <li>Introduce <b>sport-specific movements</b> under supervision: acceleration, deceleration, change of direction drills (plant and cut, pivoting)</li> <li>Progress running/agility drills to higher intensity</li> <li>Integrate reaction and decision-making exercises</li> <li>Integrate perturbations exercises</li> <li>Begin individual technical work for sport or activity</li> <li>Maintain strength</li> </ul>	<ul style="list-style-type: none"> <li>Return to controlled practices: progression from technical skills to game-like, unpredictable drills</li> <li>Begin with larger field of play and progress to smaller field</li> <li>Progress to contact drills</li> <li>Lastly, progress to full scrimmage with equipment</li> <li>Maintain strength</li> <li>Train appropriate energy systems needed for activity</li> </ul>	<ul style="list-style-type: none"> <li>Return to or above pre-injury level</li> <li>Introduce injury prevention program (see appendix)</li> </ul>



<p><b>CRITERIA FOR PROGRESSION TO NEXT PHASE</b></p>	<ul style="list-style-type: none"> <li>• Pain under control</li> <li>• Normal gait</li> <li>• No to moderate effusion; effusion should not increase with ADLs</li> <li>• Near full range of motion (including full and symmetrical hyperextension)</li> <li>• Full terminal knee extension in supine and standing</li> <li>• Able to demonstrate quadriceps activation with a straight leg raise (SLR)</li> </ul>	<ul style="list-style-type: none"> <li>• Able to squat past 90° with weight</li> <li>• Quadriceps and hip flexor strength relatively symmetrical with manual muscle testing</li> <li>• Limb Symmetry Index (LSI) for quadriceps/hamstrings strength <math>\geq 85\%</math> on hand held dynamometer (HDD)</li> <li>• At least 25 <u>single leg squats</u> to 90° of knee flexion with adequate control and quality</li> </ul>	<ul style="list-style-type: none"> <li>• Able to jump in all directions on 2 legs</li> <li>• Able to hop on 1 leg with good control and technique</li> <li>• Able to run forward, backward and side shuffle</li> <li>• Adequate cardiovascular endurance</li> <li>• No to minimal effusion with dynamic program</li> <li>• Quad Symmetry Index <math>\geq 90\%</math></li> <li>• Limb Symmetry Index (LSI) <math>\geq 80\%</math> for functional hops</li> </ul>	<ul style="list-style-type: none"> <li>• Able to demonstrate the above movements of their sport with proper mechanics and confidence</li> <li>• No effusion post exercises</li> <li>• LSI <math>\geq 95\%</math></li> <li>• Symmetrical strength of lower extremity with Quad Symmetry Index <math>\geq 95\%</math></li> <li>• No secondary injuries</li> <li>• Objective clinical tests passed</li> </ul>	<ul style="list-style-type: none"> <li>• Able to fully participate in practice with no knee restrictions or secondary injuries</li> <li>• Symmetrical measures for objective clinical tests</li> <li>• Confident mentally and physically for RTS/RTA</li> </ul>	
<p><b>CLINICAL OUTCOMES</b></p>	<ul style="list-style-type: none"> <li>• Range of motion</li> <li>• Swipe effusion test</li> <li>• Quadriceps activation in supine, standing, and SLR</li> <li>• Proper lower extremity (LE) alignment with exercises</li> <li>• Pain (VAS)</li> <li>• KOOS</li> </ul>	<ul style="list-style-type: none"> <li>• Strength testing: 3 RM of quadriceps (squat/leg press) and hamstrings (deadlifts)</li> <li>• HDD</li> <li>• Single leg squat test</li> <li>• Proper LE alignment with exercises</li> <li>• Pain (VAS)</li> <li>• KOOS</li> </ul>	<ul style="list-style-type: none"> <li>• Same outcomes as previous stage</li> <li>• Vertical jump test</li> <li>• Functional jump tests (2 leg broad jump, 1 to 1 leg broad jump)</li> <li>• KOOS</li> </ul>	<ul style="list-style-type: none"> <li>• Same outcomes as previous stage</li> <li>• Triple single leg hop test, triple cross over hop test, timed lateral hops</li> <li>• Agility tests (T-test, 5-10-5 test)</li> <li>• KOOS</li> <li>• ACL-RSI</li> <li>• TSK-11/Reinjury-anxiety scale</li> </ul>	<ul style="list-style-type: none"> <li>• Same outcomes as previous stage with goal to be symmetrical</li> <li>• KOOS</li> <li>• ACL-RSI</li> <li>• TSK-11/Reinjury-anxiety scale</li> </ul>	<ul style="list-style-type: none"> <li>• Sport performance</li> <li>• Coach feedback</li> <li>• Confident on return (use psychological measures)</li> </ul>
<p><b>FUNCTIONAL GOALS</b></p>		<ul style="list-style-type: none"> <li>• LSI <math>\geq 85\%</math> for strength</li> <li>• Single leg squat test to failure (<math>\geq 20</math> (non-athletic population) or <math>\geq 25</math> (athletic population) and numbers are nearly symmetrical between both legs</li> </ul>	<ul style="list-style-type: none"> <li>• LSI <math>\geq 90\%</math> for strength</li> <li>• Single leg squat test <math>\geq 25</math></li> <li>• LSI <math>\geq 80\%</math> for broad jumps</li> <li>• 2 leg broad jump <math>85\% \geq</math> patient's height</li> </ul>	<ul style="list-style-type: none"> <li>• LSI <math>\geq 90\%</math> for all jumps and strength</li> <li>• 2 leg broad jump <math>\geq</math> patient's height</li> </ul>	<ul style="list-style-type: none"> <li>• Same as previous goal of LSI <math>\geq 100\%</math> for all jumps</li> <li>•</li> </ul>	<p>Maintain or improve on functional goals</p>

# Appendix

*Clinical outcomes should be used in conjunction with a patient's clinical exam to determine if a patient is ready to progress to the next phase. All tests are to be completed on both legs.*

## **Functional strength and hop tests:**

### 1. Single leg squat test

Goal: quantify strength and neuromuscular control

- How: perform as many single leg squats to 90° as possible until failure
- Record quantity but also note quality in both sagittal and coronal planes
- Limit upper extremity help by placing hands on hips or over chest
- Use a metronome set to 40 BPM to help patients maintain a standardized pace
- Patients are allowed 3 errors, if unable to correct then the test is stopped
- If patients can do  $\geq 50$  reps, then the test is stopped

### 2. 3 repetition max testing (squat, deadlift)

Goal: quantify quadriceps or hamstrings strength

- How: assess how heavy a lift can be performed in 3 repetitions with proper technique
- First set should be 8 reps with the bar as a warm up
- Second set should be 5 reps at roughly the weight they normally push at for 5 reps
- Third set onwards should be 3 reps, increasing weight until they hit their 3 rep max (i.e., fatigue and cannot perform 3 reps with proper technique)

### 3. Broad jumps

Goal: quantify power, neuromuscular control and confidence during a dynamic activity

- How: jump as far as possible from standing - must stick the landing for 2 seconds in order for the trial to count
- Measure the distance from the standing position to the back of the heel where the patient landed
- Record distance but also note quality of jump (e.g., landing with knee valgus, lack of absorption when landing)
- Perform 2 foot to 2 foot jump (see figure 2), 1 foot to 2 foot jump (see figure 3) and 1 foot to 1 foot jump (see figure 4)



Figure 2: 2 foot to 2 foot standing long jump

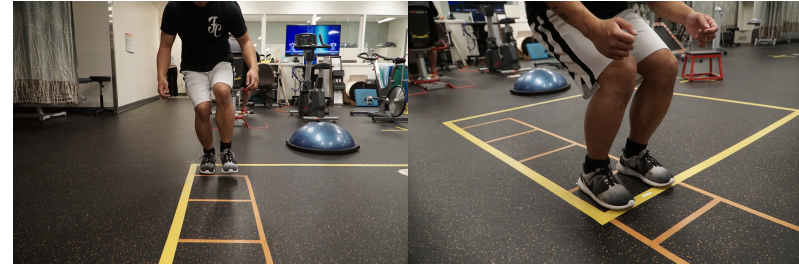


Figure 3: 1 foot to 2 foot standing long jump

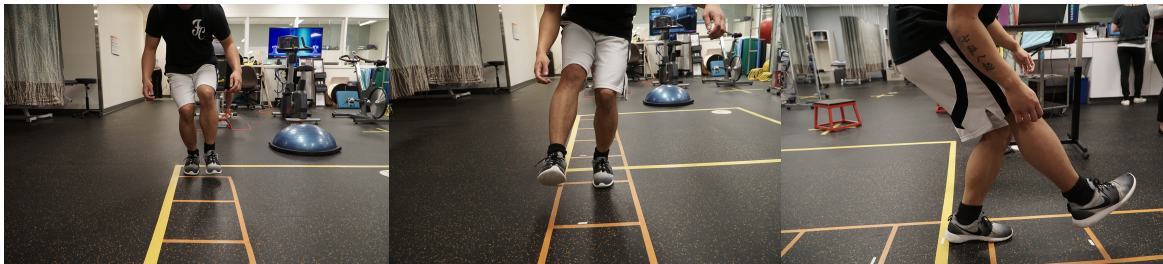


Figure 4: 1 foot to 1 foot standing long jump

#### 4. Triple single leg hop test/triple single leg cross over hop test

Goal: assess plyometric power

- How: jump as far as possible three times consecutively on a single leg - must stick the last jump for 2 seconds in order for the trial to count
- Measure the distance from the standing position to the back of the heel where the patient landed
- Record distance but also note quality of jump
- Crossover hop test is performed the same way with the addition of alternately crossing over a line

#### 5. Additional hop tests: vertical jump test, lateral timed hop tests

### Agility Tests:

1. T-agility test (<https://www.acefitness.org/ptresources/pdfs/TestingProtocols/T-Test.pdf>)

2. 5-10-5 test (<https://www.nasca.com/education/articles/kinetic-select/assessing-agility-using-the-t-test-5-10-5-shuttle-and-illinois-test/>)

### **Psychosocial and quality of life questionnaires:**

1. Knee injury and Osteoarthritis Outcome Score (KOOS):  
<http://www.koos.nu>
2. Anterior Cruciate Ligament-Return to Sport after Injury (ACL-RSI) - can be downloaded on Apple or Android
3. Anterior Cruciate Ligament Quality of Life (ACL QOL) Questionnaire
4. Tampa Scale for Kinesiophobia (TSK-11)

### **Injury prevention programs:**

1. FIFA 11+: <http://f-marc.com/11plus/home>
2. Santa Monica PEP: <http://smsmf.org/smsf-programs/pep-program>
3. GET SET app: <http://fittoplay.org/archive/free-get-set-app-for-download/>

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