



Anterior Cruciate Ligament Reconstruction: Delayed Rehabilitation Protocol*

This rehabilitation protocol was developed for patients who have anterior cruciate ligament (ACL) reconstruction and one of the following:

- Concomitant meniscal repair, complex or in avascular region
- Concomitant ligament reconstruction
- Concomitant patellofemoral realignment procedure
- Significant articular cartilage lesion
- ACL revision reconstruction
- Marked physiological laxity (expect high ACL forces postoperatively)

The protocol is divided into 7 phases according to postoperative weeks (for instance, Phase I = Postoperative Weeks 1-2). Each phase has several categories including:

- *General observation* of the patient's condition (weight bearing, pain, hemarthrosis, muscle control)
- *Evaluation* of specific variables with *goals* identified for each
- Treatment and exercise program, according to *frequency* and *duration*
- *Rehabilitation goals* which must be achieved to enter into the next phase

The **overall goals** of the reconstruction and rehabilitation are to:

- Control joint pain, swelling, hemarthrosis (minimal or none)
- Regain normal knee flexion and extension
- Regain a normal gait pattern and neuromuscular stability for ambulation
- Regain normal quadriceps, hamstring lower extremity muscle strength
- Regain normal proprioception, balance, and coordination for desired activities
- Achieve optimal functional outcome based on orthopaedic and patient goals

The supervised rehabilitation program is supplemented with a *home self-management program* which the patient performs on a daily basis. The therapist must evaluate the patient thoroughly to implement the enclosed protocol and should see the patient in the clinic for therapeutic procedures and modality treatments which are required for rehabilitation. The majority of this protocol can be accomplished at home provided patient cooperation and follow through are present. The approximate number of rehabilitation visits required for each phase are provided. Additional supervision may be required if a complication develops.

Important postoperative signs to monitor include:

- Swelling of the knee joint or soft tissues
- Abnormal pain response
- Abnormal gait pattern with or without assistive device
- Insufficient flexion or extension motions, limited patellar mobility
- Weakness (strength/control) of the lower extremity, especially the quads/hamstrings
- Insufficient lower extremity flexibility
- Abnormal AP displacement (joint arthrometer testing > 3 mm) early postoperatively

The patient is placed into one of four **sports activity** and **occupational activity categories** based on the following scales. It is expected that patients who follow this protocol desire to return to sports activity levels I or II, or very heavy/heavy occupations.

1. Cincinnati Knee Rating System Sports Activity Scale

(check one)

- Level I - jumping, hard pivoting, cutting sports (basketball, volleyball, football, gymnastics, soccer)
- Level II - running, twisting, turning (tennis, racquetball, handball, ice/field hockey, skiing, wrestling)
- Level III - light recreational sports (bicycling, swimming - no running, twisting, jumping)
- Level IV - no sports, activities of daily living only

2. Cincinnati Knee Rating System Occupational Rating Scale

Factor 1 sitting	Factor 2 standing/ walking	Factor 3 walking on uneven ground	Factor 4 squatting	Factor 5 climbing	Factor 6 lifting/ carrying	Factor 7 pounds carried
0 <input type="checkbox"/> 8-10 hrs/day	0 <input type="checkbox"/> 0 hrs/day	0 <input type="checkbox"/> 0 hrs/day	0 <input type="checkbox"/> 0 times/day	0 <input type="checkbox"/> 0 times/day	0 <input type="checkbox"/> 0 times/day	0 <input type="checkbox"/> 0-5 lbs
1 <input type="checkbox"/> 6-7 hrs/day	2 <input type="checkbox"/> 1 hrs/day	2 <input type="checkbox"/> 1 hrs/day	1 <input type="checkbox"/> 1-5 times/day	2 <input type="checkbox"/> 1 flight 2 times/day	1 <input type="checkbox"/> 1-5 times/day	1 <input type="checkbox"/> 6-10 lbs
2 <input type="checkbox"/> 4-5 hrs/day	4 <input type="checkbox"/> 2-3 hrs/day	4 <input type="checkbox"/> 2-3 hrs/day	2 <input type="checkbox"/> 6-10 times/day	4 <input type="checkbox"/> 3 flights 2 times/day	2 <input type="checkbox"/> 6-10 times/day	2 <input type="checkbox"/> 11-20 lbs
3 <input type="checkbox"/> 2-3 hrs/day	6 <input type="checkbox"/> 4-5 hrs/day	6 <input type="checkbox"/> 4-5 hrs/day	3 <input type="checkbox"/> 11-15 times/day	6 <input type="checkbox"/> 10 flights/ ladders	3 <input type="checkbox"/> 11-15 times/day	3 <input type="checkbox"/> 21-25 lbs
4 <input type="checkbox"/> 1 hrs/day	8 <input type="checkbox"/> 6-7 hrs/day	8 <input type="checkbox"/> 6-7 hrs/day	4 <input type="checkbox"/> 16-20 times/day	8 <input type="checkbox"/> ladders with weight 2-3 days/week	4 <input type="checkbox"/> 16-20 times/day	4 <input type="checkbox"/> 26-30 lbs
5 <input type="checkbox"/> 0 hrs/day	10 <input type="checkbox"/> 8-10 hrs/day	10 <input type="checkbox"/> 8-10 hrs/day	5 <input type="checkbox"/> > 20 times/day	8 <input type="checkbox"/> ladders daily with weight	5 <input type="checkbox"/> > 20 times/day	5 <input type="checkbox"/> > 20 lbs

_____ points x 2 = _____ total points

Occupation Rating

Total Points

- Disabled 0
- Very light 1-20
- Light 21-40
- Moderate 41-60
- Heavy 61-80
- Very heavy > 80

Physical Therapy Visit Timeline*

Phase	Weeks Postoperative	Minimum # Visits	Maximum # Visits
1	1-2	2	4
2	3-4	2	4
3	5-6	1	2
4	7-8	1	2
5	9-12	1	2
6	13-26	2	3
7	27-52	2	4
Total		11	21

***Physician Notification**

The physician will be notified if the patient (1) fails to meet the expected goals for each phase of the protocol, (2) has a persistent joint effusion, (3) develops a chronic pain syndrome, (4) develops abnormal AP displacement on arthrometer testing (> 3 mm difference), (5) complains of giving-way, (6) has difficulty with ambulation, or (7) has a limitation of knee motion or patellar mobility.

These problems could result in a modification of this protocol and necessitate further visits to the physical therapist.

Discharge Criteria (If goals for sports and occupation place patient into different categories, use category with highest functional demand criteria. For symptoms, use Symptom Rating Form found on next page.)

*Sports Activity Level I or Heavy/Very Heavy Occupational Rating**

No pain, swelling, giving-way with level 10 on Symptom Rating Form

KT-2000 < 3 mm (I-N, 134 N, total A/P)

Biodex strength testing: quadriceps & hamstrings strength \geq 85% of opposite limb

Function testing: 2 hop tests, limb symmetry \geq 85%

*Sports Activity Level II or Moderate Occupational Rating**

No pain, swelling, giving-way with level 8 on Symptom Rating Form

KT-2000 < 3 mm (I-N, 134 N, total A/P)

Biodex strength testing: quadriceps & hamstrings strength \geq 80% of opposite limb

Function testing: 2 hop tests, limb symmetry \geq 85%

Sports Activity Level III or Light Occupational Rating

No pain, swelling, giving-way with level 6 on Symptom Rating Form

KT-2000 3-5 mm (I-N, 134 N, total A/P)

Biodex strength testing: quadriceps & hamstrings strength \geq 70% of opposite limb

Function testing: 2 hop tests, limb symmetry \geq 75%

Sports Activity Level IV (ADL) or Very light Occupational Rating

No pain, swelling, giving-way with level 4 on Symptom Rating Form

KT-2000 3-5 mm (I-N, 134 N, total A/P)

Biodex strength testing: quadriceps & hamstrings strength < 70% of opposite limb

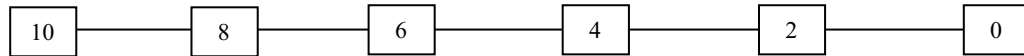
Function testing: 2 hop tests, limb symmetry < 75%

*patients desiring to return to sports or strenuous work activities may require 4-6 more physical therapy visits during postoperative weeks 25-52 for advanced neuromuscular, strength, and activity-specific training to prevent reinjury.

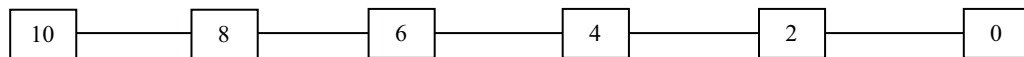
Cincinnati Knee Rating System Symptom Rating Form

Scale	Description
10	Normal knee, able to do strenuous work/sports with jumping, hard pivoting
8	Able to do moderate work/sports with running, turning and twisting; symptoms with strenuous work/sports
6	Able to do light work/sports with no running, twisting or jumping; symptoms with moderate work/sports
4	Able to do activities of daily living alone; symptoms with light work/sports
2	Moderate symptoms (frequent, limiting) with activities of daily living
0	Severe symptoms (constant, not relieved) with activities of daily living

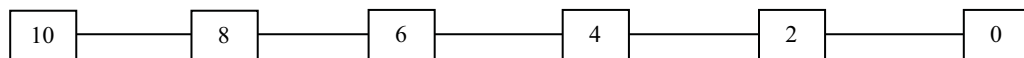
1. PAIN (circle one)



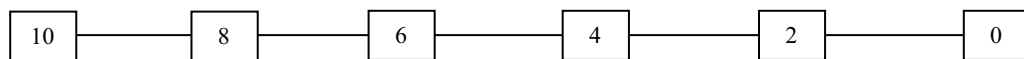
2. SWELLING (circle one)



3. PARTIAL GIVING-WAY (circle one) (partial knee collapse, no fall to the ground)



4. FULL GIVING-WAY (circle one) (knee collapse occurs with actual falling to the ground)



Return to Activities Warning

Return to strenuous activities after major knee ligament surgery carries the definite risk of a repeat injury or the potential of compounding the original injury. These risks cannot always be scientifically assessed. Patients are warned to return to athletic activities carefully and to avoid any activity in which pain, swelling, or a feeling of instability is present.

References

- Noyes FR, Barber-Westin SD: Anterior cruciate ligament revision reconstruction: Results using a quadriceps tendon-patellar bone autograft. *Am J Sports Med* 34, 2006.
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- Noyes FR, Berrios-Torres S, Barber-Westin SD, and Heckmann TP: Prevention of permanent arthrofibrosis after anterior cruciate ligament reconstruction alone or combined with associated procedures: A prospective study in 443 knees. *Knee Surgery, Sports Traumatology, Arthroscopy* 8: 196-206, 2000.
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- Noyes FR and Barber-Westin SD: Anterior cruciate ligament reconstruction with autogenous patellar tendon graft in patients with articular cartilage damage. *Am. J. Sports Med*. 25: 626-634, 1997.
- Noyes FR and Barber-Westin SD: A comparison of results in acute and chronic anterior cruciate ligament ruptures of arthroscopic-assisted autogenous patellar tendon reconstruction. *Am J Sports Med* 25: 460-471, 1997.
- Noyes FR and Barber-Westin SD: Reconstruction of the anterior and posterior cruciate ligaments after knee dislocation. Use of early protected postoperative motion to decrease arthrofibrosis. *Am. J. Sports Med*. 25: 769-778, 1997.
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Cincinnati Sportsmedicine and Orthopaedic Center

Rehabilitation Protocol Summary for Delayed ACL Reconstruction

	Postoperative Weeks					Postoperative Months			
	1-2	3-4	5-6	7-8	9-12	4	5	6	7-12
Brace: postoperative & functional	X	X	X	X	X			X	X
Range of motion minimum goals: 0°-90° 0°-120° 0°-135°		X	X	X					
Weight bearing: Toe touch 1/4 - 1/2 body weight 3/4 - Full	X	X	X						
Patella mobilization	X	X	X						
Modalities: Electrical muscle stimulation (EMS) Pain/edema management (cryotherapy)	X X	X X	X X	X X		X X	X X	X X	X X
Stretching: Hamstring, gastroc-soleus, iliotibial band, quadriceps	X	X	X	X	X	X	X	X	X
Strengthening: Quad isometrics, quad-ham isometrics co-contraction, straight leg raises, active knee extension Closed-chain: gait retraining, toe raises, wall sits, mini-squats Knee flexion hamstring curls (90°) Knee extension quads (90°-30°) Hip abduction-adduction, multi-hip Leg press (70°-10°)	X X	X X	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X
Balance/proprioceptive training: Weight-shifting, cup walking, BBS BBS, BAPS, perturbation training, balance board, mini-trampoline	X	X	X	X	X X	X X	X X	X X	X X
Conditioning: UBC Bike (stationary) Aquatic program Elliptical machine Swimming (kicking) Walking Stair climbing machine Ski machine		X	X X	X X X		X X X X X X X	X X X X X X X	X X X X X X X	X X X X X X X
Running: straight								X	X
Cutting: lateral carioca, figure 8's									X
Plyometric training									X
Full sports									X

BAPS = Biomechanical Ankle Platform System (Camp, Jackson, MI), BBS = Biodex Balance System (Biodex Medical Systems, Inc, Shirley, NY), UBC = upper body cycle (Biodex Medical Systems, Inc, Shirley, NY).

**Cincinnati Sportsmedicine and Orthopaedic Center Rehab Protocol: ACL – Delayed
Phase 1. Weeks 1-2 (Visits: 2-4)**

Cincinnati Sportsmedicine and Orthopaedic Center Rehab Protocol: ACL – Delayed
Phase 2. Weeks 3-4 (Visits: 2-4)

General Observation	<ul style="list-style-type: none"> ■ 50% weight bearing when: <ul style="list-style-type: none"> - Pain controlled - Hemarthrosis controlled - Voluntary quadriceps contraction achieved 	
Evaluation	<ul style="list-style-type: none"> ■ Pain ■ Effusion ■ Patellar mobility ■ ROM minimum ■ Quadriceps contraction & patella migration ■ Soft tissue contracture ■ Joint arthrometer (3 weeks, 20 lbs) 	<p align="center">Goals</p> Controlled Mild Good 0°-90° Good None < 3 mm
<p>Frequency 3-4 x/day 10 minutes</p> <p>2-3 x/day 20 minutes</p> <p>2 x/day 10 minutes</p> <p>As required</p>	<p>Range of motion ROM (passive, 0°-90°) Patella mobilization Ankle pumps (plantar flexion with resistance band) Hamstring, gastroc-soleus stretches</p> <p>Strengthening Straight leg raises (flexion, extension, adduction) Isometric training: Multi-angle (0°, 60°) Active quadriceps (full extension) Quad/ham co-contraction with EMS Toe raises/heel raises Knee extension (90°-45°, no resistance) Knee flexion (active, 0°- 90°) Multi-hip machine (flexion, extension, abduction, adduction) Leg press (70°-10°) Closed-chain - Mini-squats (0°-45°, 50% weight bearing) - Wall sits - Wall sits with EMS</p> <p>Aerobic conditioning UBC</p> <p>Modalities Electrical muscle stimulation Cryotherapy</p>	<p align="center">Duration</p> 5 reps x 30 secs 3 sets x 10 reps 1 set x 10 reps 3 sets x 10 reps 3 sets x 10 reps 3 sets x 10 reps 3 sets x 10 reps 3 sets x 10 reps 3 sets x 20 reps to fatigue 20 minutes 20 minutes
Goals	<ul style="list-style-type: none"> ■ ROM 0°-110° ■ Control inflammation, effusion ■ Adequate quadriceps contraction ■ 50% weight bearing 	

Cincinnati Sportsmedicine and Orthopaedic Center Rehab Protocol: ACL – Delayed
Phase 4. Weeks 7-8 (Visits: 1-2)

General Observation	<ul style="list-style-type: none"> ■ Independent ambulation when: - Pain controlled - Effusion controlled - ROM 0°-120° - Muscle control throughout ROM - Dynamic control varus/valgus 	
Evaluation	<ul style="list-style-type: none"> ■ Pain ■ Effusion ■ Patellar mobility ■ ROM ■ Muscle control ■ Inflammatory response ■ Gait ■ Joint arthrometer (8 weeks) 	<p align="center">Goals</p> <p>No RSD Minimal Good 0°-135° 4/5 None Symmetrical < 3 mm</p>
<p>Frequency 2 x/day 10 minutes</p> <p>2 x/day 20 minutes</p> <p>3 x/day 5 minutes</p> <p>2 x/day 10 minutes</p> <p>As required</p>	<p>Range of motion Hamstring, gastroc-soleus stretches</p> <p>Strengthening Straight leg raises (ankle weight, < 10% body weight) Straight leg raises, rubber tubing Isometric training: multi-angle (90°, 60°, 30°) Heel raise/toe raise Hamstring curls (active, 0°-90°) Knee extension with resistance (90°-45°) Leg press (70°-10°) Closed-chain - Wall sits - Mini-squats (rubber tubing, 0°-30°) - Lunge Multi-hip machine (flexion, extension, abduction, adduction) Leg press (70°-10°)</p> <p>Balance training Balance board/2 legged Lateral step-ups: 2-4"</p> <p>Aerobic conditioning (patellofemoral precautions) UBC Stationary bicycling Water walking Stair machine (low resistance, low stroke) Ski machine (short stride, level, low resistance) Elliptical machine (low resistance)</p> <p>Modalities Cryotherapy</p>	<p align="center">Duration</p> <p>5 reps x 30 secs</p> <p>3 sets x 10 reps 3 sets x 30 reps 3 sets x 20 reps 3 sets x 10 reps 3 sets x 10 reps 3 sets x 10 reps 3 sets x 10 reps</p> <p>3 sets x 20 reps to fatigue x 3</p> <p>3 sets x 10 reps 3 sets x 10 reps</p> <p>20 minutes</p>
Goals	<ul style="list-style-type: none"> ■ ROM 0°-135° ■ Full weight bearing, normal gait ■ Control inflammation, effusion ■ Muscle endurance ■ Recognize complications (motion loss, RSD, increased AP displacement) ■ Recognition patellofemoral changes 	

Cincinnati Sportsmedicine and Orthopaedic Center Rehab Protocol: ACL – Delayed
Phase 5. Weeks 9-12 (Visits: 1-2)

General Observation	<ul style="list-style-type: none"> ■ Full weight bearing ■ ROM 0°-135° ■ No effusion, painless ROM, joint stability ■ Performs ADL, can walk 20 minutes without pain 	
Evaluation	<ul style="list-style-type: none"> ■ Manual muscle test Hamstrings, quadriceps, hip abductors/adductors/flexors/extensors ■ Swelling ■ Joint arthrometer (12 weeks) ■ Patellar mobility ■ Crepitus 	<p align="center">Goals</p> <p>4/5</p> <p>None</p> <p>3 mm</p> <p>Good</p> <p>None/slight</p>
<p>Frequency</p> <p>2 x/day 10 minutes</p> <p>2 x/day 20 minutes</p> <p>3 x/day 5 minutes</p> <p>1-2 x/day 15-20 minutes</p> <p>As required</p>	<p>Range of motion Hamstring, gastroc-soleus, quad, ITB stretches</p> <p>Strengthening Straight leg raises, rubber tubing Hamstring curls (active, 0°-90°) Knee extension with resistance (90°-45°) Leg press (70°-10°) Closed-chain - Wall sits - Mini-squats (rubber tubing, 0°-40°) - Lunge Multi-hip machine (flexion, extension, abduction, adduction)</p> <p>Balance training Balance board/2 legged Single leg stance – unstable platform Perturbation training</p> <p>Aerobic conditioning (patellofemoral precautions) Stationary bicycling Water walking Swimming (straight leg kicking) Walking Stair machine (low resistance, low stroke) Ski machine (short stride, level, low resistance) Elliptical machine (low resistance)</p> <p>Modalities Cryotherapy</p>	<p align="center">Duration</p> <p>5 reps x 30 secs</p> <p>3 sets x 30 reps</p> <p>3 sets x 10 reps</p> <p>3 sets x 10 reps</p> <p>3 sets x 10 reps</p> <p>3 sets x 20 reps to fatigue x 3</p> <p>3 sets x 10 reps</p> <p>3 sets x 10 reps</p> <p>20 minutes</p>
Goals	<ul style="list-style-type: none"> ■ Increase strength and endurance 	

Cincinnati Sportsmedicine and Orthopaedic Center Rehab Protocol: ACL – Delayed
Phase 6. Weeks 13-26 (Visits: 2-3)

General Observation	<ul style="list-style-type: none"> ■ No effusion, painless ROM, joint stability ■ Performs ADL, can walk 20 minutes without pain ■ ROM 0°-135° 	
Evaluation	<ul style="list-style-type: none"> ■ Isometric test (% difference quads & hams) ■ Swelling ■ Joint arthrometer ■ Patellar mobility ■ Crepitus 	<p align="center">Goals</p> <p>30 None < 3 mm Good None/slight</p>
Frequency		Duration
2 x/day 10 minutes	<p>Range of motion Hamstring, gastroc-soleus, quad, ITB stretches</p>	5 reps x 30 secs
2 x/day 20 minutes	<p>Strengthening Straight leg raises, rubber tubing Hamstring curls (active, 0°-90°) Knee extension with resistance (90°-45°) Leg press (70°-10°) Multi-hip machine (flexion, extension, abduction, adduction) Closed-chain: Wall sits Mini-squats Lateral step-ups (2-4" block)</p>	<p>3 sets x 30 reps 3 sets x 10 reps 3 sets x 10 reps 3 sets x 10 reps 3 sets x 10 reps</p>
3 x/day 5 minutes	<p>Balance training Balance board/2 legged Single leg stance – unstable platform Plyoback – ball toss Perturbation training</p>	<p>5 reps 3 sets x 20 reps 3 sets x 10 reps</p>
3 x/week 15-20 minutes	<p>Aerobic conditioning (patellofemoral precautions) Stationary bicycling Water walking Swimming (kicking) Walking Stair machine (low resistance, low stroke) Ski machine (short stride, level, low resistance)</p>	
3 x/week 10 minutes	<p>Running program (6 months, straight, 30% deficit isometric test) Jog Walk Backward run</p>	<p>1/4 mile 1/8 mile 20 yards</p>
As required	<p>Modalities Cryotherapy</p>	20 minutes
Goals	<ul style="list-style-type: none"> ■ Increase strength and endurance 	

Cincinnati Sportsmedicine and Orthopaedic Center Rehab Protocol: ACL – Delayed
Phase 7. Weeks 27-52 (Visits: 2-3)

General Observation	<ul style="list-style-type: none"> ■ No effusion, painless ROM, joint stability ■ Performs ADL, can walk 20 minutes without pain 	
Evaluation	<ul style="list-style-type: none"> ■ Isokinetic test (isometric + torque 300°/sec, % diff quads & hams) ■ Swelling ■ Joint arthrometer ■ Patellar mobility ■ Crepitus ■ Single-leg function tests (9 mos: hop distance, timed hop, % inv/uninv) 	<p align="center">Goals</p> <p>10-15 None 3 mm Good None/slight 85</p>
<p>Frequency</p> <p>2 x/day 10 minutes</p> <p>1 x/day 20-30 minutes</p> <p>3 x/day 5 minutes</p> <p>3 x/week 20-30 minutes</p> <p>3 x/week 15-20 minutes</p> <p>3 x/week</p> <p>3 x/week</p> <p>As required</p>	<p>Range of motion Hamstring, gastroc-soleus, quad, ITB stretches</p> <p>Strengthening Straight leg raises, rubber tubing (high speed) Hamstring curls (active, 0°-90°) Knee extension with resistance (90°-45°) Leg press (70°-10°) Multi-hip machine (flexion, extension, abduction, adduction)</p> <p>Balance training Balance board/2 legged Single leg stance Perturbation training</p> <p>Aerobic conditioning (patellofemoral precautions) Stationary bicycling Water walking Swimming (kicking) Walking Stair machine (low resistance, low stroke) Ski machine (short stride, level, low resistance)</p> <p>Running program (straight,) Jog – interval training (20, 40, 60, 100 yards) Walk Backward run</p> <p>Cutting program – lateral, carioca, figure 8's (20% deficit isokinetic test)</p> <p>Functional training Plyometric training: box hops, level, double-leg Sport specific drills (10-15% deficit isokinetic test)</p> <p>Modalities Cryotherapy</p>	<p align="center">Duration</p> <p>5 reps x 30 secs</p> <p>3 sets x 30 reps 3 sets x 10 reps 3 sets x 10 reps 3 sets x 10 reps 3 sets x 10 reps</p> <p>1/4 mile 1/8 mile 20 yards 20 yards</p> <p>15 secs, 4-6 sets</p> <p>20 minutes</p>
Goals	<ul style="list-style-type: none"> ■ Increase function ■ Maintain strength, endurance ■ Return to previous activity level 	