

MULTIPLE LIGAMENT KNEE INJURIES (ACL AND PCL RECONSTRUCTION) CLINICAL PRACTICE GUIDELINE

Background

ACL and PCL Reconstruction occurs after a multi-ligamentous knee injury, most often sustained during a contact force causing a knee dislocation. This accounts for <0.02% of all orthopedic injuries. Surgery may be delayed or staged for optimal outcomes. Surgery uses an allograft or autograft to reconstruct the torn ACL and PCL ligaments, and may repair the MCL, LCL, and/or posterolateral corner of the knee if needed as well. Long-term complications after surgery include chronic pain, knee instability, arthrofibrosis, and loss of knee flexion ROM. Research finds that only 1/3rd of athletes return to sport at prior level of function. If return to sport is possible, it is expected to take 9-12 months depending on comorbidities and nature of the sport.

Disclaimer

Progression is time and criterion-based, dependent on soft tissue healing, patient demographics and clinician evaluation. If you are working with an Ohio State Sports Medicine patient and questions arise, please call 614-293-2385.

Summary of Recommendations

Weight Bearing Guidelines	<ol style="list-style-type: none"> 1. Non-weight bearing for 2 weeks, brace locked in extension 2. TTWB - 25% at 2 weeks, brace locked in extension 3. PWB 25-50% at 5-6 weeks, brace locked in extension 4. WBAT at 7 weeks, gradually unlock and wean from brace 	
ROM Guidelines	<ol style="list-style-type: none"> 1. No knee flexion >90° for 6 weeks 2. No active hamstring /OKC flexion exercises for 8 weeks 3. No resistive OKC hamstring exercise for 12 weeks 4. Do not allow proximal tibia to rest unsupported for 12 weeks 	
Concomitant Pathology	<ol style="list-style-type: none"> 1. <u>MCL Repair</u>: <ol style="list-style-type: none"> a. Femoral origin or mid-stance lesion will need more accelerated ROM b. Tibial insertion lesion will need more cautious progression of ROM 	<ol style="list-style-type: none"> 2. <u>LCL/Posterolateral Corner Repair</u>: <ol style="list-style-type: none"> a. No extension past 0° for 12 weeks b. Use slight valgus force during PROM flexion for 12 weeks c. Ensure no hyperextension/varus thrust when return to ambulation
Outcome Tools	<p>Collect at least one of the following at initial evaluation, every 6 weeks, and discharge. Be consistent with which outcome tool is collected each time.</p> <ol style="list-style-type: none"> 1. IKDC 2. KOOS 3. ACL-RSI 4. Tegner 	
Criteria to Discharge Assistive Device	<ol style="list-style-type: none"> 1. <u>ROM</u>: Full active knee extension; no pain on passive overpressure 2. <u>Strength</u>: Able to perform strong quad isometric with full tetany and superior patellar glide and able to perform 20 SLR without quad lag 3. <u>Effusion</u>: 1+ or less is preferred (2+ acceptable if all other criteria are met) 4. <u>Weight Bearing</u>: Demonstrates pain-free ambulation without visible gait deviation 	
Criteria to Discharge NMES	<ol style="list-style-type: none"> 1. <20% quadriceps deficit on isometric or isokinetic testing (can use HHD for isometric testing) <p>OR- If testing equipment is not available:</p> <ol style="list-style-type: none"> 1. 20 SLR without quad lag 2. Normal gait 3. 10 heel taps to to 60 degrees with good quality 4. 10 rep max on LP and similar effort bilaterally 5. Inability to break quad MMT 	
Strength Testing	<ol style="list-style-type: none"> 1. Isometric testing no earlier than 12 weeks- fixed at 60° knee flexion 2. Isokinetic testing no earlier than 16 weeks 	
Criteria to Initiate Running and Jumping	<ol style="list-style-type: none"> 1. <u>ROM</u>: full, pain-free knee ROM, symmetrical with the uninvolved limb 2. <u>Strength</u>: Isokinetic testing 80% or greater for hamstring and quad at 60°/sec and 300°/sec 3. <u>Effusion</u>: 1+ or less 4. <u>Weight Bearing</u>: normalized gait and jogging mechanics 5. <u>Neuromuscular Control</u>: Pain-free hopping in place 	
Criteria for Return to Sport	<ol style="list-style-type: none"> 1. <u>ROM</u>: full, pain-free knee ROM, symmetrical with the uninvolved limb 2. <u>Strength</u>: Isokinetic testing 90% or greater for hamstring and quad at 60°/sec and 300°/sec 3. <u>Effusion</u>: No reactive effusion and ≤ 1+ with sport-specific activity 4. <u>Weight Bearing</u>: normalized gait and jogging mechanics 5. <u>Neuromuscular control</u>: appropriate mechanics and force attenuation strategies with high level agility, plyometrics, and high impact movements 6. <u>Functional Hop Testing</u>: LSI 90% or greater for all tests 7. <u>Physician Clearance</u> 	



Weeks 0-4

Weight Bearing	<ol style="list-style-type: none"> 1. Non-weight bearing for 2 weeks, in brace locked in extension 2. TTWB - 25% at 2 weeks with brace locked in extension
ROM	<ol style="list-style-type: none"> 1. Begin Passive ROM (no flexion beyond 90° for 6 weeks) <ul style="list-style-type: none"> o Goal of achieving full terminal knee extension (stop at 0° if PLC repaired) o Prone knee flexion with 10# manual anterior drawer force to protect PCL o Use varus/valgus force during PROM to protect MCL/LCL repair if needed 2. Patellar mobilizations 3. Edema control 4. ROM 6-8 times daily
Strengthening	<ol style="list-style-type: none"> 1. Quad Sets 2. Flexion and abduction SLR with brace on; emphasis on eliminating extensor lag 3. NO active strengthening with knee flexion for 8 weeks
NMES Parameters	<ol style="list-style-type: none"> 1. NMES pads are placed on the proximal and distal quadriceps 2. Patient: Sitting with knee straight in long-sitting position with back supported. Towel roll under proximal tibia to prevent posterior translation. 3. The patient is instructed to relax while the e-stim generates at least 50% of their maximal volitional contraction OR maximal tolerable amperage without knee joint pain 4. 10 seconds on/ 50 seconds off x 15 min. 2 second ramp up and down. Frequency= 75pps. Pulse Width= 400microseconds
Blood Flow Restriction Training <i>Appendix D</i>	<ul style="list-style-type: none"> • Blood Flow Restriction (BFR) training can be initiated as soon as sutures are removed • Ensure patient has no contraindications (Appendix D) and if patient has any listed precautions or are at risk for a DVT, clear with physician before initiating BFR • Use BFR twice weekly for up to 10 weeks; use for 2-3 exercises per session • Can be used with any exercise that is safe for patient to perform depending on time since surgery (ex. SLR 4-way, prone TKE). <i>BFR should never be performed during a plyometric exercise.</i> • Training Load: 20-40% 1 RM (Estimated, or use OMNI-RES, see Appendix D) • Limb Occlusion Pressure= 80% (see Appendix D if patient unable to tolerate) • 4 sets for each exercise with reps of 30-15-15-15 (75 total) with a 30 second rest break between sets, keeping cuff inflated the entire duration of each exercise. Deflate between exercises, or every 8 minutes.
Stretching	<ol style="list-style-type: none"> 1. Calves
Goals to Progress to Next Phase	<ol style="list-style-type: none"> 1. Able to perform strong quad isometric with full tetany and superior patellar glide 2. SLR with no extensor lag 3. Good patellar mobility 4. PROM 0-70°

Weeks 4-6

Weight Bearing	1. WB 25-50% at 5-6 weeks, brace locked in extension
ROM	1. Continue prone PROM; do not force ROM 2. Patellar mobilizations 3. Edema control
Strengthening	1. Continue NMES 2. Increase duration of Quad Sets 3. SLR with eyes open and closed; fast and slow 4. Core, Glutes 5. BFR (continue as in early phase, adding appropriate exercises)
Goals to Progress to Next Phase	1. PROM 0-90°: if not achieved refer back to MD 2. Tolerance of partial weight bearing without residual pain or reactive joint effusion 3. ≤ 2+ joint effusion (Appendix C) 4. 20 repetitions SLR with no extensor lag

Weeks 6-8

Weight Bearing	1. WBAT at 7 weeks, gait training and wean from brace if 20 SLR without extensor lag 2. Ensure no knee hyperextension/varus thrust with ambulation
Criteria to Discharge Assistive Device	1. <u>ROM</u> : Full active knee extension; no pain on passive overpressure 2. <u>Strength</u> : Able to perform strong quad isometric with full tetany and superior patellar glide and able to perform 20 SLR without quad lag 3. <u>Effusion</u> : 1+ or less is preferred (2+ acceptable if all other criteria are met) 4. <u>Weight Bearing</u> : Demonstrates pain-free ambulation without visible gait deviation
ROM	1. Gradual advancement of prone passive knee flexion 2. Stationary bicycle avoiding deep knee flexion 3. Maintain passive knee extension
Strengthening	1. CKC (Shuttle) PWB Eccentrics within protected range (10°-40°) 2. Weights shifts and progression to single leg balance 3. Active OKC Resisted Knee Extension within protected range (60°-30°) 4. BFR (continue as in early phase, adding appropriate exercises)
New NMES Parameters	1. NMES pads are placed on the proximal and distal quadricep 2. Patient: Seated with the knee at 60° flexion, shank secured with strap and back support with thigh strap preferred. The ankle pad/belt should be two finger widths superior to the lateral malleoli. 3. If this position creates knee pain, continue NMES in long-sitting 4. The patient is instructed to relax while the e-stim generates at least 50% of their max volitional contraction against a fixed resistance OR maximal tolerable amperage without knee joint pain 5. 10 seconds on/ 50 seconds off x 15 min. 2 second ramp up and down. Frequency= 75pps. Pulse Width= 400 microseconds
Goals to Progress to Next Phase	1. Normalized gait mechanics without assistive device 2. PROM 0-110° 3. Completion of exercises without exacerbation of symptoms or reactive effusion 4. ≤ 2+ joint effusion



Weeks 8-12

ROM	1. Progress prone flexion to achieve full symmetrical ROM
Strength	<ol style="list-style-type: none"> 1. Gradual increased depth of CKC strengthening (0-70°) 2. Sub-max knee extension isometrics at 45° if pain-free 3. Step ups/downs with correct movement patterns 4. Progress single leg stance activities to compliant surfaces 5. Proprioceptive training for knee angle replication. Move uninvolved knee into various degrees of flexion and patient has to match angle with involved knee; perform in prone throughout ROM and short sitting (90-30 degrees only if pain-free). 6. CKC Hamstring exercises 7. Active prone knee flexion for hamstring 8. Continue NMES to quadriceps 9. BFR (continue as in early phase, adding appropriate exercises)
Goals to Progress to Next Phase	<ol style="list-style-type: none"> 1. Increased strength/stability/proprioception with therapeutic exercise without exacerbation of symptoms 2. No reactive instability or effusion with WB activity 3. ≤ 1+ joint effusion 4. PROM 0-130° <ol style="list-style-type: none"> a. If flexion <125° refer back to MD 5. Ability to perform reciprocal stair ascent and descent without compensation or deficit

Weeks 12-16

ROM	<ol style="list-style-type: none"> 1. ROM as needed 2. Progression to elliptical and stair stepper use with proper mechanics
Strength	<ol style="list-style-type: none"> 1. Progress CKC 0°-90° 2. Resisted OKC knee extension 90°-30° 3. Progress neuromuscular strength, balance, and stability exercise (Squats, lunges, heel taps, etc) 4. Perturbation training (slow to fast and proactive to reactive) 5. Initiate landing mechanics exercise and light plyometric activity in PWB
Criteria to Discharge NMES	<ol style="list-style-type: none"> 1. <20% quadriceps deficit on isometric or isokinetic testing (can use HHD for isometric testing) <p>OR- If testing equipment is not available:</p> <ol style="list-style-type: none"> 1. 20 SLR without quad lag 2. Normal gait 3. 10 heel taps to to 60 degrees with good quality 4. 10 rep max on LP and similar effort bilaterally 5. Inability to break quad MMT
Goals to Progress to Next Phase	<ol style="list-style-type: none"> 1. ≤ 1+ joint effusion 2. Full symmetrical flexion and extension ROM 3. Appropriate landing mechanics and no instability with PWB plyometric activities 4. Met criteria to discharge NMES

Weeks 16-24 (4-6 months)

Strength	<ol style="list-style-type: none"> 1. Increase resistance and endurance with all exercises 2. OKC knee flexion exercises (0-90°) 3. Resisted OKC knee extension 90°-10° 4. Progress landing mechanics to full WB 5. Initiate walk-jog progression at 5-6 months if criteria below is met
Criteria to Initiate Running and Jumping	<ol style="list-style-type: none"> 1. <u>ROM</u>: full, pain-free knee ROM, symmetrical with the uninvolved limb 2. <u>Strength</u>: Isokinetic testing 80% or greater for hamstring and quad at 60°/sec and 300°/sec 3. <u>Effusion</u>: 1+ or less 4. <u>Weight Bearing</u>: normalized gait and jogging mechanics with no gross visual compensation 5. <u>Neuromuscular Control</u>: Pain-free hopping in place with appropriate landing mechanics
Criteria to Progress to Next Phase	<ol style="list-style-type: none"> 1. Met criteria for running and jumping 2. No reactive effusion or instability with FWB plyometrics

Weeks 24+ (6-12 months)

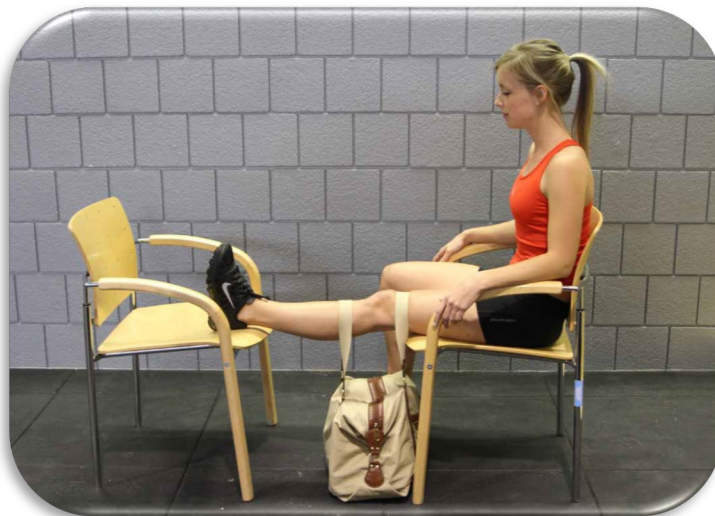
Strength	<ol style="list-style-type: none"> 1. Increased resistance and endurance with all exercises 2. Progress landing mechanics from sagittal to frontal/transverse/diagonal planes 3. Begin agility exercises at 50% at 8 months <ul style="list-style-type: none"> ○ Side shuffling ○ Carioca ○ Figure 8 ○ Cutting ○ Backward running ○ Ladder drills 4. Sport specific drills- use equipment, shoes, and specific surface 5. Incorporate power/acceleration training 6. Return to Sport no sooner than 10-12 months if criteria below is met
Criteria for Return to Sport	<ol style="list-style-type: none"> 1. <u>ROM</u>: full, pain-free knee ROM, symmetrical with the uninvolved limb 2. <u>Strength</u>: Isokinetic testing 90% or greater for hamstring and quad at 60°/sec and 300°/sec 3. <u>Effusion</u>: No reactive effusion and ≤ 1+ with sport-specific activity 4. <u>Weight Bearing</u>: normalized running mechanics 5. <u>Neuromuscular control</u>: appropriate mechanics and force attenuation strategies with high level agility, plyometrics, and high impact movements 6. <u>Functional Hop Testing</u>: LSI 90% or greater for all tests 7. <u>Physician Clearance</u>



Appendix A: Bag Hang

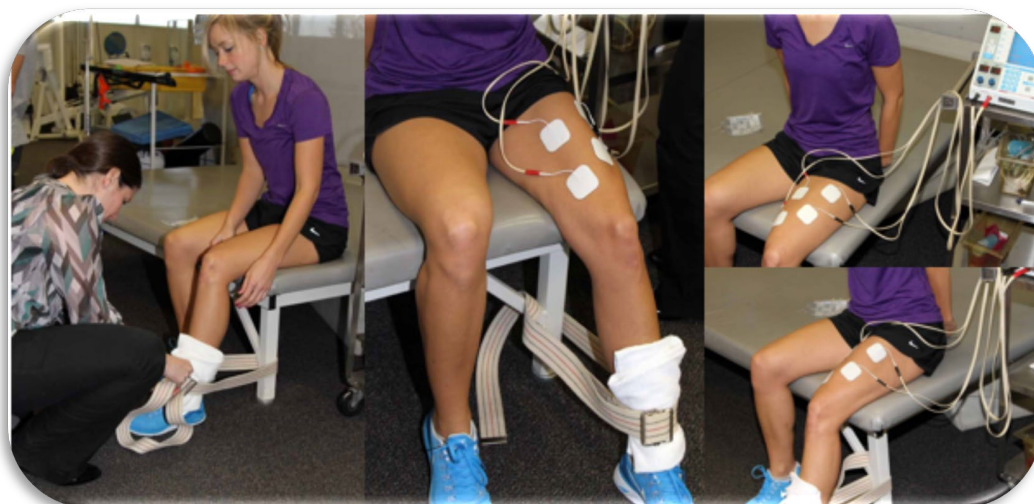
Emphasis on low load, long duration stretching.

Goal: 60 minutes TOTAL per day (4x15 minutes, 2x30minutes, etc)



Appendix B: NMES Set Up

2 or 4 pad set-up is appropriate



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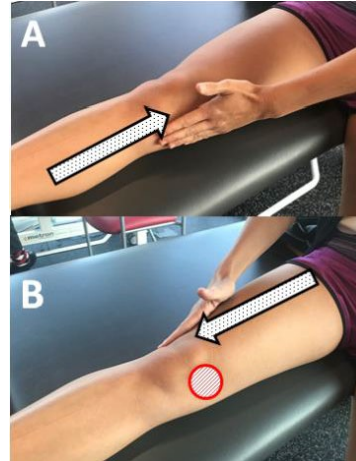
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Appendix C: Stoke Test / Swelling Assessment

The Stroke Test

The stroke test is a great way to assess your swelling independently. The results of this assessment will help you decide what exercises are appropriate.

- A. Using one hand, gently sweep the inside portion of your knee 2-3 times (pushing toward the hip joint).
- B. On the outside portion of the knee, immediately sweep downward (toward the ankle). Watch the inside portion of the knee (indicated by hashed circle in photo) for a wave of fluid to appear






Grading System

(Table adapted from Sturgill L et al, Journal of Orthopaedic & Sports Physical Therapy, 2009)

Test Result	Grade
No wave produced on downstroke	Zero
Small wave on inside aspect of knee with downstroke	Trace
Large bulge on inside aspect of knee with downstroke	1+
Swelling spontaneously returns to inside aspect of knee after upstroke (no downstroke necessary)	2+
So much fluid that it is not possible to move the swelling out of the inside aspect of the knee	3+

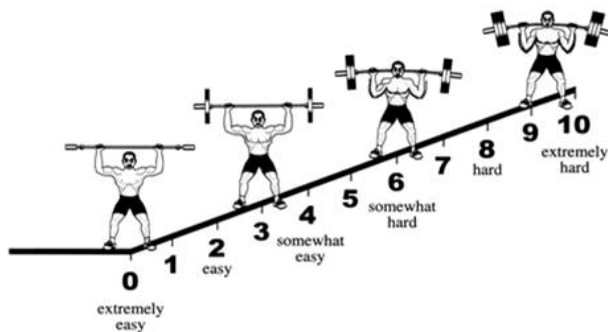
Indications for Activity

3+ or 2+ 	1+ 	Trace or Zero 
Red Light <ul style="list-style-type: none"> No running, jumping or cutting or heavy lifting until swelling decreases to 1+ or less Do not progress program until you speak with your therapist Utilize swelling management strategies (ice, compression, elevation, NSAIDs) 	Yellow Light <ul style="list-style-type: none"> Proceed with caution You may participate in running, jumping and normal lifting routine. Check effusion before and after workouts Utilize swelling management strategies (ice, compression, elevation, NSAIDs) 	Green Light <ul style="list-style-type: none"> May participate in running, jumping and normal lifting routine without restriction Continue to monitor swelling after activity

Appendix D: Blood Flow Restriction Training

Precautions (must get permission from MD)	Contraindications
<ul style="list-style-type: none"> ▪ Patients with poor circulatory systems (Indicators: shining or scaly skin, brittle dry nails, extremity hair loss, increased capillary filling time, and presence of varicose veins) ▪ Patients who are obese or with limb tissue that is loose ▪ Arterial claudication ▪ Abnormal clotting times ▪ Diabetes ▪ Sickle cell trait ▪ Tumor ▪ General infection ▪ Hypertension ▪ Cardiopulmonary conditions ▪ Renal compromise ▪ Clinically significant acid-base imbalance ▪ Atherosclerotic vessels ▪ Taking anti-hypertensive medications 	<ul style="list-style-type: none"> ▪ Venous thromboembolism ▪ Impaired circulation or peripheral vascular compromise ▪ Previous revascularization of the extremity ▪ Extremities with dialysis access ▪ Acidosis ▪ Sickle cell anemia ▪ Extremity infection ▪ Tumor distal to the tourniquet ▪ Medications/supplements known to ↑ clotting risk ▪ Open fracture ▪ Increased intracranial pressure ▪ Open soft tissue injuries ▪ Post-traumatic hand reconstructions ▪ Severe crushing injuries ▪ Severe hypertension ▪ Elbow surgery with excessive swelling ▪ Skin grafts in which all bleeding points distinguished ▪ Secondary or delayed procedures after immobilization ▪ Vascular grafting lymphectomies ▪ Cancer

Training Intensity: 20-40% 1RM or use the Omnibus Resistance Exercise Scale (below). Patient chooses weight/resistance that corresponds to 2-3



Exercise Prescription:

- If Patient achieves:
 - 75 repetitions: continue with training, re-assess intensity within 1-3 sessions and change as strength improves
 - 60-74 repetitions: continue with training, but extend rest period between sets 3 and 4 to 45 seconds until 75 repetitions is completed
 - 45-59 repetitions: continue with training, but extend rest period between all sets to 45-60 seconds
 - <44 repetitions: reduce load by approximately 10% until repetitions are achieved
- If patient is forced to stop before 75 repetitions due to undue pain, soreness, or general uncomfortable feeling underneath the cuff → reduce tourniquet pressure by 10mmHg at each training session until cuff tolerance is achieved. Ramp cuff pressure back up by 10 mmHg to target limb occlusion pressure if patient can tolerate.




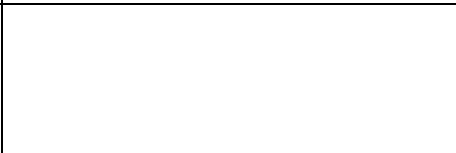



Appendix E: Isokinetic Data Interpretation



	Definition	Clinical Impact	What to do
Peak Torque (ft-lbs)	Peak torque during repetitions	Symmetry criteria (see 'E'- is the data represented in pie charts)	<80%; continue unilateral, high resistance strength training
Coefficient of Variance (%)	Between repetition variability	Goal: < 15%	>15%, consider retest
Total Work (ft-lbs)	Torque over all repetitions	Possible indicator of fatigue	>10%; consider high volume training
Agonist/Antagonist Ratio (%)	Hamstring/Quadriceps Ratio	Goal: >60%	<60%; ensure 1:1 quadriceps:hamstring exercise ratio
Asymmetry Pie Charts	Strength relative to involved limb	Goal: <10% asymmetry (either direction- deficit OR stronger on involved limb)	<80%, continue NMES in addition to strength training <90%, continue unilateral > bilateral strength training emphasis

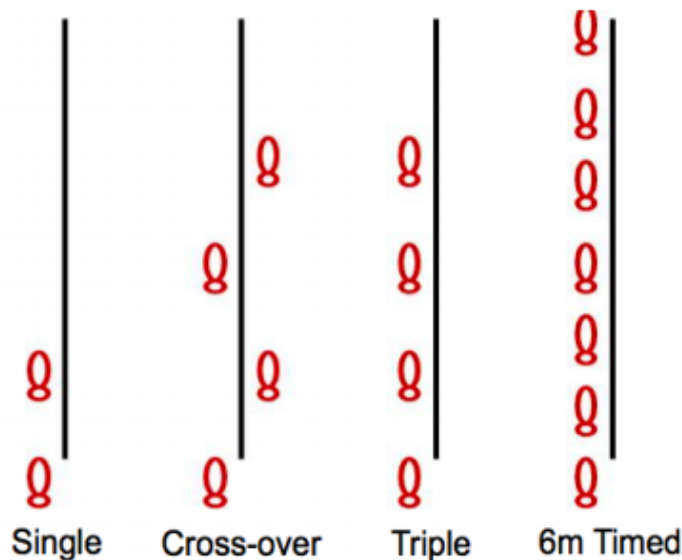
Appendix F: Isokinetic Testing Alternatives

Sinacore, J. A., Evans, A. M., Lynch, B. N., Joreitz, R. E., Irrgang, J. J., & Lynch, A. D. (2017). Diagnostic accuracy of handheld dynamometry and 1-repetition-maximum tests for identifying meaningful quadriceps strength asymmetries. *Journal of orthopaedic & sports physical therapy*, 47(2), 97-107.

<p>Isokinetic Dynamometry</p>		<ul style="list-style-type: none"> • Considered the “gold standard” • 60°/sec for strength and power assessment • 300°/second for speed and endurance assessment
<p>Hand Held Dynamometry with Static Fixation at 90°</p>		<ul style="list-style-type: none"> • Appropriate alternative • Results may overestimate quadriceps strength symmetry: be cautious with data interpretation
<p>SL 1RM Knee Extension Machine: 90°- 45°</p>		<ul style="list-style-type: none"> • Appropriate alternative • Recommended to decrease stress on PF joint and limit strain on reconstructed ACL for up to 6 months • Results may overestimate quadriceps strength symmetry: be cautious with data interpretation
<p>SL 1RM Leg Press</p>		<ul style="list-style-type: none"> • Fair alternative • Results in significant overestimation of quadriceps strength symmetry due to compensation from other LE muscle groups
<p>SL 1RM Knee Extension Machine: 90°- 0°</p>		<ul style="list-style-type: none"> • Fair alternative • May be uncomfortable and/or inappropriate due to PF stress

Appendix G: Single Leg Hop Series

- 1) **Single hop for distance:** Have the subject line their heel up with the zero mark of the tape measure, wearing athletic shoes. The subject then hops as far as he/she can, landing on the same push off leg, for at least 3 seconds. The arms are allowed to move freely during the testing. Allow him/her to perform 2 practice hops on each leg. Then, have the subject perform 2 testing trial, recording each distance from the starting point to the back of the heel. Average the distanced hopped for each limb. The Limb Symmetry Index: $\text{Involved limb distance} / \text{Uninvolved limb distance} \times 100\%$.
- 2) **Cross-over hop for distance:** The subject lines their heel up with the zero mark of the tape measure and hops 3 times on one foot, crossing fully over the center line each time. Each subject should hop as far forward as he/she can on each hop, but only the total distance hopped is recorded. The arms are allowed to move freely during the testing. Allow him/her to perform 2 practice hops on each leg. Then, have the subject perform 2 testing trial, recording each distance from the starting point to the back of the heel. Average the distanced hopped for each limb. The Limb Symmetry Index: $\text{Involved limb distance} / \text{Uninvolved limb distance} \times 100\%$.
- 3) **Triple hop for distance:** The subject lines their heel up with the zero mark of the tape measure and hops 3 times on one foot. Each subject should hop as far forward as he/she can on each hop, but only the total distance hopped is recorded. The arms are allowed to move freely during the testing. Allow him/her to perform 2 practice hops on each leg. Then, have the subject perform 2 testing trial, recording each distance from the starting point to the back of the heel. Average the distanced hopped for each limb. The Limb Symmetry Index: $\text{Involved limb distance} / \text{Uninvolved limb distance} \times 100\%$.
- 4) **Timed 6-meter hop:** The subject lines their heel up at the zero mark of the tape measure and hops, on cue with the tester, as fast as they can the length of the 6-meter tape. The arms are allowed to move freely during the testing. Allow him/her to perform 2 practice hops on each leg. Then, have the subject perform 2 testing trial, recording each distance from the starting point to the back of the heel. Average the distanced hopped for each limb. The Limb Symmetry Index: $\text{Involved limb time} / \text{Uninvolved limb time} \times 100\%$.



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Reviewer: John DeWitt, PT, DPT, SCS
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