KNEE MICROFRACTURE CLINICAL PRACTICE GUIDELINE

Disclaimer

The following rehabilitation guidelines are specific to patients who have undergone a knee microfracture surgical procedure. Please refer to the Ohio States Sports Medicine website for rehabilitation guidelines specific to other procedures and conditions, as appropriate.

Progression is criterion-based and dependent on soft tissue healing, patient demographics, and clinical evaluation. The time frames identified for each phase of rehabilitation are approximate times for the average patient and not recommended as guidelines for progression for the individual patient. It is recommended that progression is based upon the achievement of functional criteria demonstrating readiness for progression, noted at the end of each phase.

Background

Knee microfracture surgery is an arthroscopic surgical procedure to restore full thickness cartilage defects of the knee. During the procedure, multiple small holes, or “microfractures”, are made in the bone exposed by the cartilage defect. This releases stem cells which form a fibrous clot that covers the area of exposed bone. As this area matures and heals, it will turn into a smooth and durable repair tissue. The goal during the healing process is to avoid harmful forces to the site of cartilage repair. Improving tissue mechanical properties and protection of the tissue is done through early and controlled weight bearing, early and protected range of motion, and gradually progressing forces during different phases of rehabilitation.

Summary of Recommendations

General	• It is important to be aware of lesion size and location • ***Please refer to the "post-op plan" section of the operative note for clarification on post-operative precautions***
Weight Bearing Guidelines	Weight bearing status is largely dependent on lesion size. Please refer to operative note for post-operative weight bearing precautions.
Range of Motion Progression	• Symmetrical knee extension should be achieved by post-op week 4 • Full ROM should be achieved by post-op week 8
Outcome Tools	Collect the LEFS at each visit *You may choose to include IKDC, KOOS, ACL-RSI, Tegner or other questionnaires specific to your patient's needs*.
Strength Testing	• Isometric testing: 12 weeks • Isokinetic testing: 4, 6, 9 and 12 months • Functional hop testing: once 80% LSI is achieved on isokinetic testing
Criteria to Discharge Assistive Device	1. ROM: Full active knee extension; no pain on passive overpressure 2. Strength: Able to perform strong quad isometric with full tetany and superior patellar glide and able to perform 20 SLR without quad lag 3. Effusion: 1+ or less is preferred (2+ acceptable if all other criteria are met) 4. Weight Bearing: Demonstrates pain-free ambulation without visible gait deviation
Criteria to Discharge NMES	<20% quadriceps deficit on isometric or isokinetic testing (can use HHD for isometric testing) **OR- If testing equipment is not available:** 1. 20 SLR without quad lag 2. Normal gait 3. 10 heel taps to 60 degrees with good quality 4. 10 rep max on LP and similar effort bilaterally 5. Inability to break quad MMT
Criteria to Initiate Running and Jumping	1. ROM: full, pain-free knee ROM, symmetrical with the uninvolved limb 2. Strength: Isokinetic testing 80% or greater for hamstring and quad at 60º/sec and 300º/sec 3. Effusion: 1+ or less 4. Weight Bearing: normalized gait and jogging mechanics 5. Neuromuscular Control: Pain-free hopping in place without dynamic knee valgus
Criteria for Return to Sport	1. ROM: full, pain-free knee ROM, symmetrical with the uninvolved limb 2. Strength: Isokinetic testing 90% or greater for hamstring and quad at 60º/sec and 300º/sec 3. Effusion: No reactive effusion ≥ 1+ with sport-specific activity 4. Weight Bearing: normalized gait and jogging mechanics 5. Neuromuscular control: appropriate mechanics and force attenuation strategies with high level agility, plyometrics, and high impact movements 6. Functional Hop Testing: LSI 90% or greater for all tests 7. Physician Clearance
Return to Sport Expectation	6-12 months

RED/YELLOW FLAGS

Red Flags
 	
Require immediate referral for re-evaluation
	• Signs of DVT→ *Refer directly to ED*
	  ○ Localized tenderness along the distribution of deep venous system
	  ○ Entire LE swelling
	  ○ Calf swelling >3cm compared to asymptomatic limb
	  ○ Pitting edema
	  ○ Collateral superficial veins
	• Lack of full knee extension by 4 weeks post-op→*Refer to surgeon for re-evaluation*
	• Mechanical block or clunk→*Refer to surgeon for re-evaluation*
	• Reported episode of instability→*Refer to surgeon for re-evaluation*

Yellow Flags *Require modifications to plan of care*	• Persistent reactive effusion or pain following therapy or ADLs ○ *Decrease intensity of rehab interventions, continue effusion management, educate patient regarding activity modifications until symptoms resolve*

Early Post-Operative Phase (0 – 6 weeks)

Appointments	Post-operative evaluation should be performed 3-5 days following surgery. Follow-up PT appointments 1-2x per week, depending on progression towards goals.
Pain and Effusion	Goal is ≤ 2+ (using Modified Stroke Test) Cryotherapy and compression
ROM	Extension: Emphasis on achieving full knee extension immediately following surgery. If full extension is not achieved by 4 weeks, contact surgeon regarding ROM concerns. Flexion: Progressive flexion ROM, with full flexion achieved by post-op week 8 ***Please refer to the "post-op plan" section of the operative note for clarification on post-operative precautions***
Weight Bearing	Refer to operative note for precautions

Suggested Interventions	• Extension PROM: bag hangs (Appendix A) or prone hangs
	• Flexion: wall slides, heel slides, upright bike
	• Patellar mobilization: superior, inferior, medial, lateral
	• Quad Isometrics
	• SLR 4-way
	• Prone TKE
	• Open Chain Knee Extension:
	  ○ Unresisted LAQ: week 4-6
	  ○ Modified range SL knee extension machine: week 6-8
	• Open chain hamstring : prone hamstring curls, hamstring curl machine
	• Shuttle press
	  ○ Partial range: week 4
	  ○ Full range: week 6
	• SL balance (pending WBing status)
	• Heel raises (pending WBing status)
	• Begin Neuromuscular re-education using electrical stimulation (NMES) - see below for set up and parameters
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NMES Parameters at 60º *Appendix B*	• NMES pads are placed on the proximal and distal quadriceps • Patient: Seated in long sitting (knees extended) until able to achieve 90° knee flexion. Progress to seated at 60° knee flexion once they are able to easily obtain 90° • 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 • 10 seconds on/ 50 seconds off x 15 min
Blood Flow Restriction training *Appendix D*	• Blood Flow Restriction (BFR) training can be initiated as soon as sutures are removed • Ensure patient has no contraindications (Appendix F) 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 2-5 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). *BFR should never be performed during a plyometric exercise.* • Training Load: 20-40% 1 RM (Estimated, or use OMNI-RES, see Appendix F) • Limb Occlusion Pressure= 80% (see Appendix F 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.
Criteria to Progress to Middle Phase of Rehab	ROM: Symmetrical knee extension and flexion > 125°. If full AROM knee extension is not achieved by 4 weeks, contact surgeon regarding ROM concerns. Strength: Quadriceps set with normal superior patellar translation, 20x SLR without extensor lag Effusion: 1+ or less with Modified stroke test – Appendix C

Middle Phase of Rehabilitation (6-16 weeks)

Appointments	Goal to increase lower extremity strength and regain flexion ROM. 1-2 visits per week with emphasis on patient compliance with resistance and ROM training as part of HEP
Weight Bearing	• Refer to operative note for WBing precautions. • Goal: all patients should be FWBing without assistive device by 8 weeks, unless otherwise outlined in operative note
Criteria to Discharge Assistive Device	• ROM: Full active knee extension; no pain on passive overpressure • Strength: Able to perform strong quad isometric with full tetany and superior patellar glide and able to perform 20 SLR without quad lag • Effusion: 1+ or less is preferred (2+ acceptable if all other criteria are met) • Weight Bearing: Demonstrates pain-free ambulation without visible gait deviation
Pain and Effusion	Cryotherapy/compression as needed for effusion – effusion should be 1+ or less
ROM	Symmetrical ROM by week 8

Suggested Interventions and timelines	• Multi-angle knee isometrics
	• Progress gluteal and lumbopelvic strength and stability
	• Progress single leg balance and proprioceptive exercises
	• Open chain knee extension:
	  ○ Modified range SL knee extension machine: week 6-8
	  ○ Full range SL knee extension machine: week 8

	• Leg press machine: week 8
	• Single leg dead lifts
	• Squats:
	  ○ 0-45°: week 6
	  ○ 0-90°: week 8
	• Heel taps: week 6
	• Step ups: week 6
	• Lunges: week 10
	• Elliptical: week 10
	• Early exercises: heel taps, step ups, squats: 0-45 degrees, open chain knee extension with modified range SL knee extension machine
	• Late exercises (8-10 weeks): leg press machine, full range SL knee extension machine, squats 0-90 degrees; lunges and elliptical (week 10)
	• NMES: progress to seated with 60˚ of knee flexion (Appendix B)
	• Continue effusion management strategies
	• BFR (continue as in early phase, adding appropriate exercises)

Strength Testing	Isometric testing: 12 weeks Isokinetic testing: 16 weeks
Criteria to Discharge NMES	• <20% quadriceps deficit on isometric testing (can use HHD for isometric testing) **OR- If testing equipment is not available:** 1. 20 SLR without quad lag 2. Normal gait 3. 10 heel taps to 60 degrees with good quality 4. 10 rep max on leg press and similar effort bilaterally 5. Inability to break quad MMT
Criteria to Progress to Late Phase of Rehab	1. ROM: Maintain full, pain-free AROM including patellofemoral mobility 2. Effusion: 1+ or less with Modified Stroke Test and no reactive effusion with progressions 3. Strength: Isometric quadriceps and hamstrings strength >/= 80% 4. Weight Bearing: Able to tolerate therapeutic exercise program, including PWB plyometrics, without increased pain or >1+ effusion 5. Neuromuscular Control: Demonstrates proper lower extremity mechanics with all therapeutic exercises (bilaterally)

Late Phase of Rehabilitation (weeks 16 - RTS)

Appointments	Increased frequency from previous stage to 1-2x per week when appropriate to initiate plyometric training and return to running program.
Criteria to initiate Running and Jumping	1. ROM: full, pain-free knee ROM, symmetrical with the uninvolved limb 2. Strength: Isokinetic testing 80% or greater for hamstring and quad at 60º/sec and 300º/sec 3. Effusion: 1+ or less 4. Weight Bearing: normalized gait and jogging mechanics 5. Neuromuscular Control: Pain-free hopping in place
Pain and Effusion	Effusion may increase with increased activity, ensure ≤1+ and/or non-reactive effusion for progression of plyometrics
ROM	Full, symmetrical to contralateral limb, and pain-free with overpressure

Strength Testing	• Isokinetic testing: 4, 6, 9 and 12 months
	• Hop testing (Appropriate after 80% symmetry achieved on isokinetic testing)
	  ○ SL hop for distance
	  ○ Triple hop

	○ Cross over hop ○ Timed 6m hop **Functional strength testing and hop testing should be reserved for patients returning to high level activity**
	•
Suggested Interventions	• Performance of the quadriceps, hamstrings and trunk dynamic stability • Initiate walk-jog program once 80% LSI is achieved on isokinetic testing • Muscle power generation and absorption via plyometrics • Sport- and position-specific activities Therapeutic Exercise/Neuromuscular Re-education • Squats, leg extension, leg curl, leg press, deadlifts, lunges (multi-direction), rotational trunk exercises on static and dynamic surfaces, resisted side steps, monster walks • Single-leg squats on BOSU, Single-leg BOSU balance with manual perturbation to trunk or ball, single-leg BOSU Romanian deadlift Agility – begin at 50-75% effort initially • Side shuffling, carioca, figure 8, zig-zags, resisted jogging (Sport Cord) in straight planes, backpedaling, ladder drills Plyometrics • PWB to FWB jumping, DL to SL, progressing by altering surfaces, external and internal perturbations • Single-leg hop downs from increasing height (up to 12" box), Single-leg hop-holds, Double and single-leg hopping onto unstable surface, Double and single-leg jump-turns, Repeated tuck jumps
Criteria for Return to Sport	1. ROM: full, pain free knee ROM, symmetrical with the uninvolved limb 2. Strength: Isokinetic testing 90% or greater for hamstring and quad at 60º/sec and 300º/sec 3. Effusion: No reactive effusion and ≤ 1+ with sport-specific activity 4. Weight Bearing: normalized gait and jogging mechanics 5. Neuromuscular control: appropriate mechanics and force attenuation strategies with high level agility, plyometrics, and high impact movements 6. Functional Hop Testing: LSI 90% or greater for all tests 7. Physician Clearance

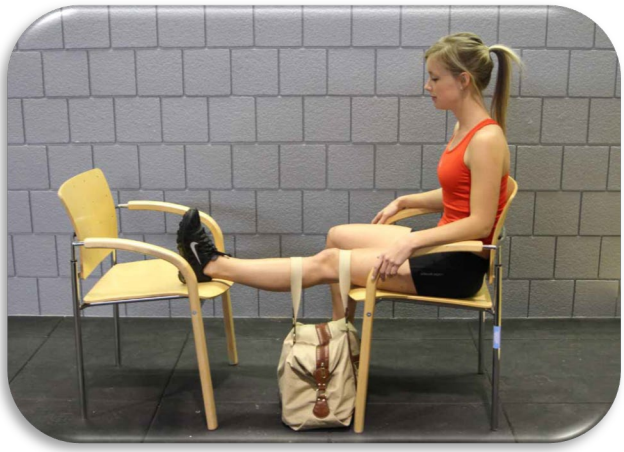
Activities that generate high compression, shear and rotational loads are to be avoided until 4-6 months, or as directed by orthopaedic surgeon

Full RTS expected between 6-12 months postoperatively depending on location and size of lesion

Appendix A: Bag Hang

Emphasis on low load, long duration stretching

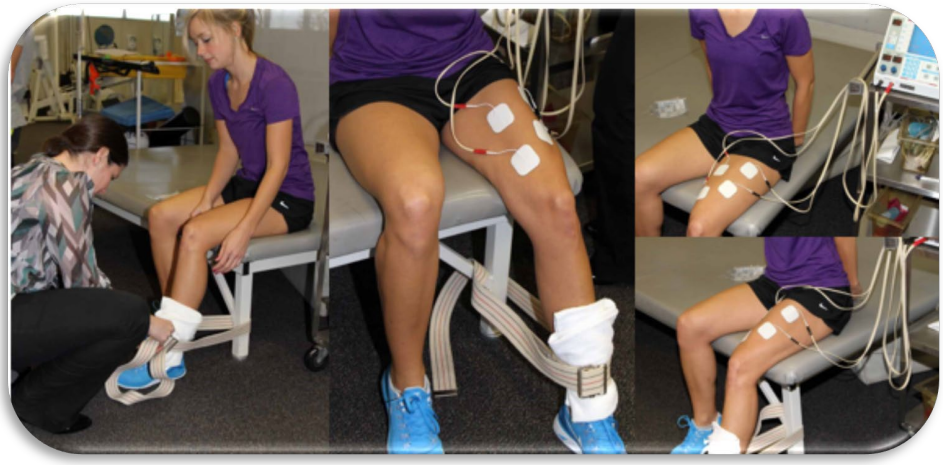
- *Goal: 60 minutes of bag hang time total per day.*
- *Ideally: 4x15 minutes (or greater) per day*



Appendix B: NMES Set Up

2 or 4 pad set-up is appropriate

- NMES pads are placed on the proximal and distal quadriceps
- Patient: Seated with the knee in at least 60º 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
- 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
- 10-20 seconds on/ 50 seconds off x 15 min



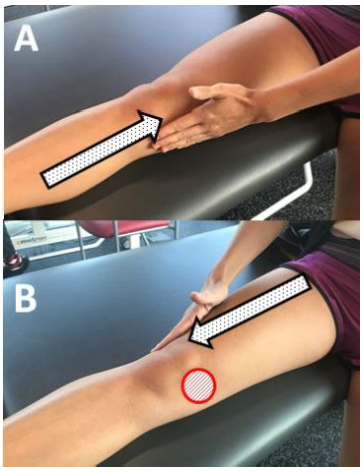
Appendix C: Stoke Test / Swelling Assessment

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 during the downstroke.



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+

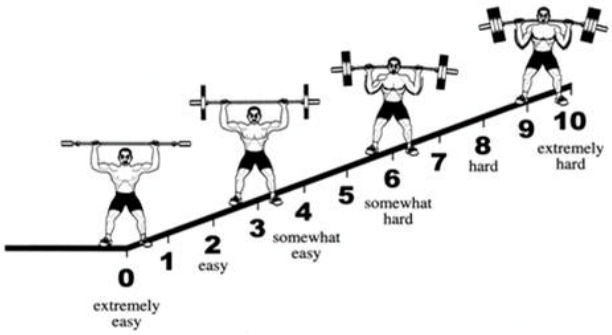
Indications for Activity

3+ or 2+	1+	Trace or Zero
Red Light	**Yellow Light**	**Green Light**
• 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)	• 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)	• 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
▪ 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 claudification ▪ 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	▪ 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

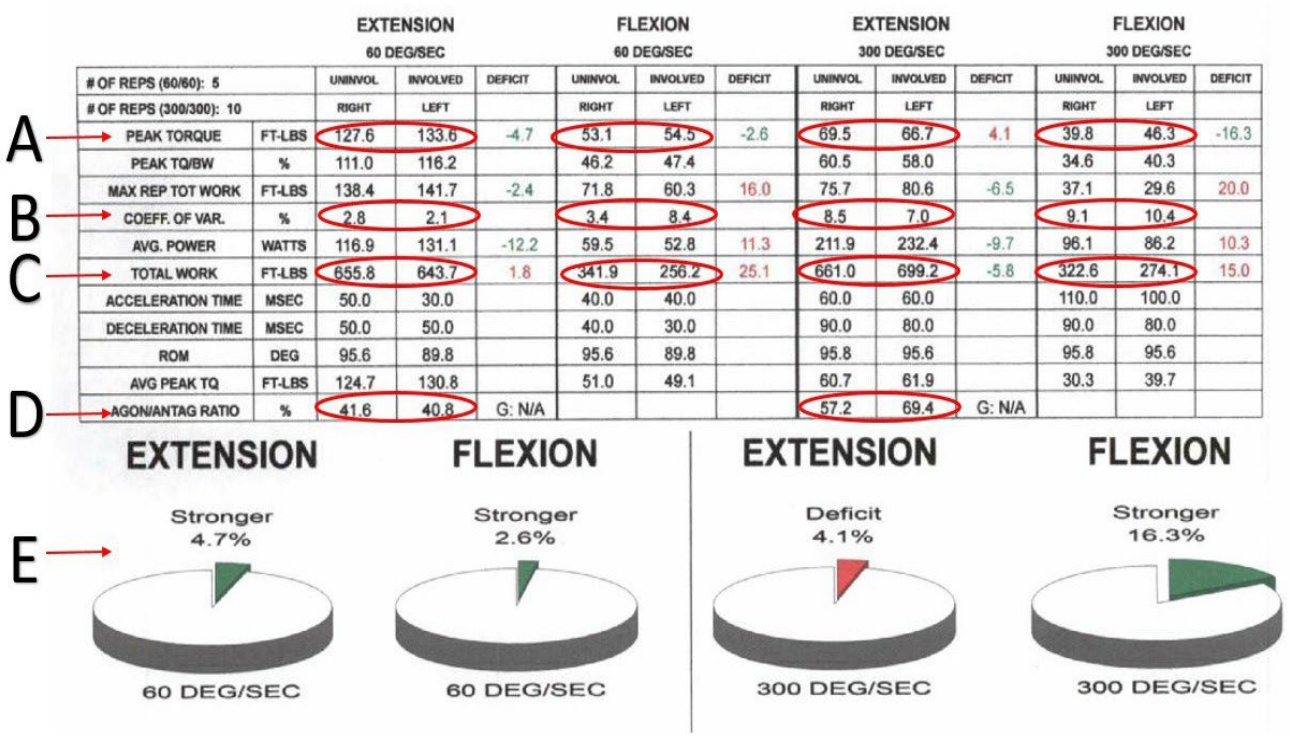
Training Intensity: 20-40% 1RM or use the Omnibus Resistance Exercise Scale (below). Patient chooses weight/resistance that corresponds to 2-3



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



		EXTENSION 60 DEG/SEC			FLEXION 60 DEG/SEC			EXTENSION 300 DEG/SEC			FLEXION 300 DEG/SEC		
# OF REPS (60/60): 5		UNINVOL	INVOLVED	DEFICIT	UNINVOL	INVOLVED	DEFICIT	UNINVOL	INVOLVED	DEFICIT	UNINVOL	INVOLVED	DEFICIT
# OF REPS (300/300): 10		RIGHT	LEFT		RIGHT	LEFT		RIGHT	LEFT		RIGHT	LEFT	
A → PEAK TORQUE	FT-LBS	127.6	133.6	-4.7	53.1	54.5	-2.6	69.5	66.7	4.1	39.8	46.3	-16.3
PEAK TQ/BW	%	111.0	116.2		46.2	47.4		60.5	58.0		34.6	40.3	
MAX REP TOT WORK	FT-LBS	138.4	141.7	-2.4	71.8	60.3	16.0	75.7	80.6	-6.5	37.1	29.6	20.0
B → COEFF. OF VAR.	%	2.8	2.1		3.4	8.4		8.5	7.0		9.1	10.4	
AVG. POWER	WATTS	116.9	131.1	-12.2	59.5	52.8	11.3	211.9	232.4	-9.7	96.1	86.2	10.3
C → TOTAL WORK	FT-LBS	655.8	643.7	1.8	341.9	256.2	25.1	661.0	699.2	-5.8	322.6	274.1	15.0
ACCELERATION TIME	MSEC	50.0	30.0		40.0	40.0		60.0	60.0		110.0	100.0	
DECELERATION TIME	MSEC	50.0	50.0		40.0	30.0		90.0	80.0		90.0	80.0	
ROM	DEG	95.6	89.8		95.6	89.8		95.8	95.6		95.8	95.6	
AVG PEAK TQ	FT-LBS	124.7	130.8		51.0	49.1		60.7	61.9		30.3	39.7	
D → AGON/ANTAG RATIO	%	41.6	40.8	G: N/A				57.2	69.4	G: N/A			

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

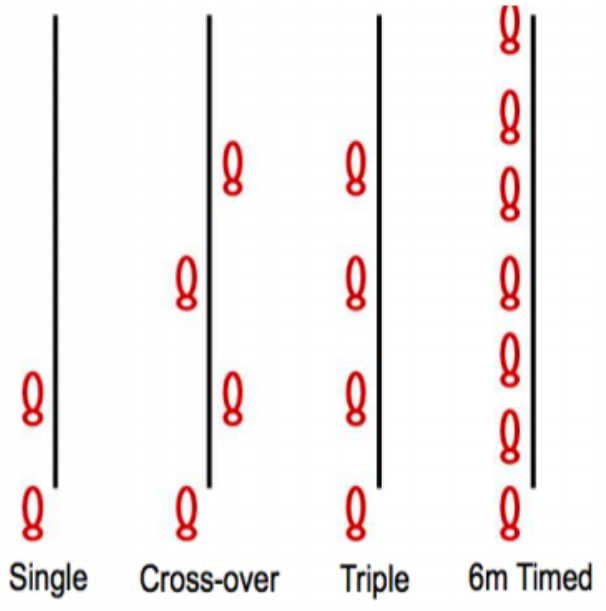
Appendix F: Isokinetic Testing and Appropriate Alternatives

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.

Isokinetic Dynamometry		• Considered the "gold standard" • 60°/sec for strength and power assessment • 300°/second for speed and endurance assessment
Hand Held Dynamometry with Static Fixation at 90°		• Appropriate alternative • Results may overestimate quadriceps strength symmetry: be cautious with data interpretation
SL 1RM Knee Extension Machine: 90°- 45°		• 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
SL 1RM Leg Press		• Fair alternative • Results in significant overestimation of quadriceps strength symmetry due to compensation from other LE muscle groups
SL 1RM Knee Extension Machine: 90°- 0°		• 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: Involved limb distance/Uninvolved limb distance X 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: Involved limb distance/Uninvolved limb distance X 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: Involved limb distance/Uninvolved limb distance X 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: Involved limb time/Uninvolved limb time X 100%.



Authors: Tiffany Marulli, PT, DPT, OCS and Sarah Depp, PT, DPT, OCS
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