

ValleyOrtho Rehabilitation Playbook Series

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Surgical Procedure: ACL Reconstruction

The intent of this information is to inform the treating clinician on the evidence-based considerations to be used as a guideline regarding the surgery noted above. This is not a substitute for appropriate clinical decision making, but a supplement to that effect. If at any time a clinician feels uncertain about a given phase discrepancy or patient presentation they are strongly encouraged to discuss this with the referring physician and his/her team.

****It is the responsibility of the therapist to read the operative report before providing care to the patient to improve treatment communication***.*

Therapeutic Activity Progression Disclaimer: Progression to the next phase should be strongly based on meeting clinical criteria (not solely based on the post-operative timeframes) as appropriate and in collaboration with the referring surgeon. Exercise prescription should be clinically directed by pain and performance absent of detrimental movement patterns with respect to proper biomechanics of the spine, hip, knee and ankle.

Communication Recommendations from Therapist to Surgical

Team: When a treating therapist feels the need to reach out to Dr. Liotta, or a member of his team, at any point for any reason they are strongly encouraged to do so. All concerns are not explicitly written and clinical judgement is paramount. Below is a handful of reasons and suggested methods of contact to promote communication:

Urgent Red Flag Communication: the patient is in clinic and an action is required as directed by referring staff office

- Uncontrollable and unremitting pain.
- Signs of infection at incision or treated limb.
- Severe palpation tenderness, swelling, tachycardia (UE or LE DVT).
- Labored breathing (PE).
- Drastic improvement or decline in ROM (failed component/repair).
- After a fall/trauma, or near fall/trauma, resulting in a clinical change.

Preferred Contact Method: 1. Immediate call to MD or PA Cell.
2. Office phone call to request consult with MD/PA/MA/ATC until answer.

Other Patient Concerns: During Clinic Hours M-TH 9am-5pm F 9-3pm

- Abnormal pain, comorbidities or complications that may prevent attainment of established discharge criteria.
- Patient is noncompliant with rehabilitation process.
- Excessive muscle guarding/motion phobia after 1-2 outpatient visits.
- Adverse work or home practices negatively impacting recovery.
- Patient expresses discontent or concerns with the current POC established by PT and/or by MD/PA

Preferred Contact Method: non-emergent office or cell phone call for verbal discussion with MD &/or PA

Preferred Updates before checkup visits with MD/PA

During Clinic Hours M-TH 9am-5pm F 9am-3pm

- Information regarding adherence/participation in rehabilitation process.
- Comments on progress and trend of the patient's rehab course.

Preferred Contact Method: 1. Use Telmediq Chat (informal) Text to MD and/or PA. Use patient name & DOB in subject and body of text.
2. Complete a Progress note in Cedaron.

Administrative Needs

- Rehabilitation Prescription needed or specific prescription change requests.
- Appointment needed with the physician office, or medication refill.

Preferred Contact Method: 1. Create Athena Patient Case Request
2. Phone call to MA/ATC



1



Phase 0: Pre-Operative Preparation

Goals:

- Optimize post-surgical outcome and return to recreational activity potential^{2, 19, 27}
- Restore ROM, decrease swelling and improve quad function³⁴

Precautions:

- Avoid WB activities that may further damage meniscus/articular cartilage.
- Self-optimism, self-confidence and motivation lead to improved return to sport likelihood⁷ avoid negative and fear provoking language.

Phase 0 Therapeutic Activities:

- Establish estimated pre-injury capacity (EPIC)³⁵: Perform the RTS testing below on uninvolved LE as described in appendices B-E and G-I.
- Administer ACL-RSI (see Appendix J): <45% = poor self-confidence + high fear³. Needs increased encouragement/support for RTS⁷
- Manual work for swelling management and education for home care²
- Patient education for initial post op exercises, rehabilitation expectations and post op cryotherapy^{19, 27, 34}
 - 15 minutes every hour x24-72 hours until active inflammation is controlled then 3x/day for 15 minutes²⁷
- Gait training and crutch education^{19, 27}
- A/PROM^{2, 27}
- NMES to quad if necessary for proper activation^{14, 19, 24, 27}
- Controlled CKC with quadriceps > HS focus^{19, 27}
- See Appendix K for BFR Preconditioning protocol for improved quad endurance and protected micro vascularity in the 1st 4 weeks s/p ACL reconstruction⁴²

Ideal Pre-Surgical Criteria:

- AROM 0-120^{2, 34}
- Little to no swelling vs uninvolved^{2, 27, 34}
- 20 repetitions of a SLR ≠ quad lag²⁷
- Standing march ≠ extension lag: Standing on involved knee, without UE support, patient is able to perform 10 march repetitions of uninvolved hip maintaining full knee extension on involved knee ≠ lag²
- Normal heel to toe gait pattern without AD^{10, 27}

Phase 1: Quadriceps, WB and ROM Recovery (weeks 1 - 2)

Goals:

- ↓ pain/swelling (to decrease quad inhibition³⁴) and protect the graft^{10, 27}
- 0° A/PROM knee EXT^{10, 19, 24, 27, 34} Gradual flexion¹⁰ to ≈ 110°²⁷
- Normalize quadriceps activation/control^{10, 14, 19, 24, 27, 34}

Precautions/Restrictions:

- WBAT ≠ brace²⁷
- **AROM/RROM: CKC is the preferred LE loading strategy**^{10, 11, 19, 34, 43}

CKC: ≤90° knee flexion wk 0-3¹⁰

OKC Knee Ext: in knee flexion ROM 90-45 deg until wk 6, Weight of leg AROM only until week 2³⁸ then RROM OK ≤5# resistance⁴³ wk 2-6¹⁹ (delay any OKC until wk 4 for HS/ allograft^{11, 19, 43}) Then can progress OKC EXT as the knee tolerates at wk 6^{10, 11, 19, 24, 27, 34}

RROM OKC Flexion: Delay until wk 8 with HS graft^{34, 43}

- Avoid pivot/twisting training until week 12¹⁰, No plyometrics^{10, 22, 27, 34}
- **See Meniscal Repair Playbook & RX** when involved for more restrictions
- **With PCL/LCL/MCL/PLC REPAIR:** limit flexion to 120° until week 6¹⁰

Phase 1 Therapeutic Activities:

- Heel to toe gait progression from bilateral crutches to single crutch ≠ limp^{14, 19} d/c AD once 20 SLR + 10 TKE stance marches is possible ≠ lag
- **Strengthening:** CKC HS, calf, and TKE focused Quad^{10, 11, 14, 19, 24, 27, 34}, CKC/OKC Hip²⁷. CKC preferred due to decreased graft strain^{34, 43} SLR in all planes ≠ quad lag. Knee OKC within restrictions mentioned above. Isometric knee ext at 90° and 60° knee flexion angles³⁴
- NMES to quad with volitional contraction as needed^{14, 19, 24, 27, 34}
- Manual & self-management for flexibility, swelling and ROM
- Uninvolved LE or UE aerobics help to maintain fitness in weeks 1-6¹⁴
- Scar mobilizations on healed incisions²⁷
- BFR can be combined with phase appropriate ACL activity (isometrics, concentric/eccentric, OKC or CKC) using ≈ 20-30% of a 1 Rep Max^{39, 40, 41}
- BFR occlusion periods range from 3-5 minutes with rest periods of 45 seconds to 3 minutes⁴⁰ Using individualizing occlusion pressures based on % of total arterial occlusion between 60-80% has important implications for safety and effectiveness⁴⁰

Criteria for Progression to Phase 2:

- 0° EXT¹⁰, ≥ 110° Flexion (meniscus repair flexion only to 90°)^{27, 38}
- 20 SLR²⁷ and 10 standing marches² ≠ Quad Lag
- Normalize Gait ≠ AD and WB tolerance ≈ Day 10^{11, 14, 19}



Phase 2: Total LE Strengthening & Balance (weeks 3 - 5)

Goals:

- Restore 100% LSI knee A/PROM and normalize balance²⁷
- Restore complete patellar mobility³⁴
- Improve LE^{10, 27} and core strength/control^{2, 28}

Precautions:

- **AROM/RROM: CKC is the preferred LE loading strategy**^{10,11,19,34,43}
- **OKC Knee Ext:** endurance focus only¹¹ ≤ 5# resistance⁴³; BPTB/QT 90°-45°^{11, 34, 43} (delay until wk 4 for HS/allograft^{11, 19, 43}) then all grafts can progress OKC EXT as the knee tolerates at wk 6^{10, 11, 19, 24, 27, 34}
- **RROM OKC Flexion:** Delay until wk 8 with HS graft^{34, 43} or Allograft
- Avoid pivot/twisting training until week 12¹⁰, No plyometrics^{10, 22, 27, 34}
- See Meniscal Repair Playbook & RX when involved for more restrictions
- With PCL/LCL/MCL/PLC REPAIR: limit flexion to 120° until week 6¹⁰

Phase 2 Therapeutic Activities:

- Bike/elliptical warm ups^{10, 27} can do stair master training²⁷
- Reduced BW Leg press or reduced WB Eccentric focused CKC quad training^{11, 14, 19, 24} slow eccentric control out of 0° TKE.
- Exercises with knee alignment focus²: Step ups^{2, 10, 27} and resisted walking forwards, backwards, and lateral as tolerated.
- Can begin RROM OKC knee flexion with BPTB/QT¹⁴
- Core strength and control,²⁸ Side plank progressions²
- Scar mobilizations²⁷ and patellar superior tilt mobilizations³⁴
- Manual for flexibility, swelling and ROM improvements as appropriate to normalize LE Flexibility²⁷
- BFR can be combined with phase appropriate ACL activity (isometrics, concentric/eccentric, OKC or CKC) using ≈ 20-30% of a 1 Rep Max^{39, 40, 41}
- Continue BFR use if patient is only tolerating low load activity as moderate to high loads with BFR showed less additional benefit vs control groups using moderate to high loads without BFR⁴¹
- Balance with altered surfaces/balance boards^{10, 27} and perturbations³⁴
- Resisted side stepping with gluteal focus¹⁰

Criteria for Progression to Phase 3:

- Full Knee A/PROM^{10, 27, 34}
- No Swelling^{10, 27}
- Performing functional ADLs without discomfort^{10, 27}

Phase 3: Single Leg & Core Stability & Strength (weeks 6 - 11)

Goals:

- Be prepared for return to running/jumping activity in BPTB ≈ week 12²² HS graft delay ≈ week 16³⁴
- Improve strength, coordination, confidence and biomechanical control with single leg activity¹⁰
- Improve cardiovascular endurance on bike/elliptical/stepper^{10, 27}
- **In prepubescent patients:** focus Primarily on form control and movement patterns instead of muscle hypertrophy as their bodies will not put on muscle growth as in older patients^{2, 28}

Precautions:

- Accelerated OKC programs with HS graft has potential to widen graft tunnels¹¹ Use caution with progressions that add strain/shear to ACL.
- **RROM:** No OKC Flexion until week 8 with HS autograft^{34, 43}
- Avoid pivot/twisting training until week 12¹⁰
- Avoid full BW single leg plyometrics until return to running criteria is met^{22, 27} Delay until week 16 with HS autograft³⁴
- See Meniscal Repair Playbook & RX when involved for more restrictions

Phase 3 Therapeutic Activities:

- Can begin slow progressive double leg plyometrics.
- Single leg CKC with proper knee alignment up to 90° as tolerated^{10, 27}
- Front and side plank variations²⁸
- Posterior chain²⁸ and pronation control³⁴ emphasized for knee control
- Perturbation single leg stance training to proper form tolerance^{10, 27, 28, 34}
- ↓ BW Double to single leg jumping and landing progressions^{6, 10, 27} Delay HS graft to start at 10 weeks³⁴
- Continue BFR use if patient is only tolerating low load activity as moderate to high loads with BFR showed less additional benefit vs control groups using moderate to high loads without BFR⁴¹
- Reduced BW Sub-max impact activities with dynamic valgus control¹⁰

Criteria for Phase 4 & Initiation of Straight Line Jogging:

****Do not progress test sequence if pain is experienced with test****

1. Knee AROM ≤ 0° EXT and flexion to 95% LSI²²
2. Stork test LSI ≥ 70%^{5, 6, 25, 27} (page 5 & Appendix A).
3. Isometric leg press² at 60° of knee flexion LSI ≥ 70% (See Appendix G).
4. Isometric quad and HS LSI ≥ 70% at 60° of flexion^{5, 6, 22} without pain¹⁰
□ 12 weeks with HS autograft¹⁹ / meniscus repair (See Appendices H & I).
5. Timed Single Leg Squat Test 0°-60°: LSI ≥ 70% (page 5 & Appendix B).
6. Single leg hop test LSI ≥ 70%²² (described on page 5 & Appendix C).



Phase 4: Advanced Training & Plyometrics (weeks 12 - 15)

Goals:

- Increase confidence and form with jumping and landing²⁷
- Straight line running and figure 8 running without pain^{6, 10, 27}
- Improve total LE strength and coordination^{10, 27}

Precautions:

- No swelling or pain >2/10 with 10 minutes of jogging²²
- **Be Aware:** Vascularization to autografts increases between 3-6 months leading to a weaker graft tensile strength, with allografts this process starts at 6 months¹⁶ Form and control with training are extremely important.
- Can begin RROM OKC EXT with HS Autograft¹⁹ and allografts^{8, 13, 21}
- MENISCUS REPAIR: No squats past $\approx 90^\circ$ for 24 weeks¹⁰

Phase 4 Therapeutic Activities:

- Sport specific drills/patterns at 50% effort²⁷
- Easy single leg plyometric progressions without valgus^{6, 10, 27}
- Ladder drills and progressive agility at 50-75% effort as tolerated^{10, 27}
- High level balance training^{10, 27}
- Continue core strengthening^{10, 27, 28}

Criteria for Progression to Phase 5:

- Double leg jump $\geq 75\%$ patient height^{5, 6, 10, 27}
- Single leg hop testing $\geq 75\%$ LSI^{5, 6, 10, 27}
- Able to run at 50-75% effort in straight line and figure 8 pattern without discomfort^{5, 6, 10, 27}

Phase 5: Return to Sport Prep and Final HEP(weeks 16 – 24)

Goals:

- Increasing strength.
- Optimize biomechanics at the hip, knee and ankle.
- Establish patient self-confidence with RTS activity.
- Establish patient specific HEP relative to resources and goals.

Precautions:

- MENISCUS REPAIR: No squats past $\approx 90^\circ$ for 24 weeks¹⁰

Phase 5 Therapeutic Activities:

- Administer ACL-RSI: $<56\%$ = poor self-confidence + high fear³. Needs increased encouragement/support for RTS⁷
- Increase in unplanned tasks watching for dynamic valgus control^{1, 5, 6}
- Plyometrics as tolerated^{10, 27}
- Increase cutting/pivot and decelerating intensity as tolerated^{5, 10, 27, 28}
- Continue total lower extremity strengthening based on remaining deficits.

Criteria for RTS Testing (Phase 6):

- No complaints with functional or exercise tasks.
- Reports confidence with all running and jumping tasks.

Progression Note:

- If comorbidities create unattainable goals for discharge, discuss this with the treating physician group.



Phase 6: Return to Activity/Sport Participation Testing wks 24+

Goals:

- Identify those patients ready to return to non-contact sport participation and slow integration into competitive sport at 9 – 12 months^{2,6} depending on return to activity testing³⁷

Graft Healing Considerations for RTS:

- Graft rupture occurs in 6%-12% of cases⁸
- Some HS autograft ACL patients are not to normal levels of strength compared to control groups at 24 weeks¹³
- Delayed in the onset of the vascularization period in HS autograft and allografts compared to autografts with bony attachments may necessitate prolonged RTS training in HS and allografts^{13, 17, 43}
- BPTB Grafts begin vascularization period at 1 month and can continue to be seen on MRI until month 16-18, then the graft will look similar to a native ACL, HS autografts show slower maturation at month 6 but ultimately return to a native ACL around the same time as BPTB grafts⁸
- Graft maturation research supports return to sport closer to 9 months for decreased re-injury rates^{2, 6}. Similar studies suggest up to 2 years due to continued remodeling of graft tissue^{6, 8}. It is important to note that these studies do not look at strength/function and return to sport readiness when assessing re-injury rates.

Return to Sport Disclaimer:

- Pain free running in a predictable and controlled environment is not the same as returning to sport. Proficiency in Phase 5, meeting all RTS criteria and slow deliberate integration into athletic competition (non-contact to contact progressions) and improving confidence in those environments are critical to help reduce the risk of re-injury.
- Meeting goals of LSI, functional performance on hop tests, subjective readiness and movement quality may not be enough to eliminate sufficient risk of re-tear based on patient specific non-modifiable risk factors. If the patient also has low performing return to sport testing and unaddressed modifiable risk factors for ACL tears there is a higher need for a risk benefit analysis and discussion for returning to sport before 12 months.

The Premiere Athletic & Sport Screening (PASS) Program

Criteria for Return to Recreational Activity:

General Ortho Patient:

- Patient meets all return to running criteria in previous phase.
- Max single leg press LSI $\geq 90\%$ ^{6, 10, 11, 19}

Recreational Athlete Sequence (includes above):

- Max Isometric Quad and HS LSI = 90-100%,^{5, 6} and/or EPIC $\geq 90\%$ ³⁵ OKC at 60° of knee flexion.
- Single leg hop test for distance: Females $\geq 70\%$ of patient height
Males $\geq 80\%$ of patient height^{5,6} and Both sexes LSI $\geq 90\%$, and/or EPIC $\geq 90\%$ ³⁵
- Timed single leg squat test: LSI = 90-100% and/or EPIC $\geq 90\%$ ³⁵ at 60° of knee flexion.

Competitive Athlete (includes above):

- All testing performed with the patient in a bilaterally fatigued state⁶
 - Patient to run or bike 15 minutes at a level 8 on the Modified Borg Rate of Perceived Exertion scale immediately prior to testing
- Max single leg press LSI = 95-100%^{6, 10, 11, 19} and/or EPIC $\geq 90\%$ ³⁵
- Max Isometric Quad and HS LSI = 95-100%^{5, 6} and/or EPIC $\geq 90\%$ ³⁵ OKC at 60° of knee flexion
- Single Leg hop test for distance: Males 90% patient height / Females 80%. Both sexes LSI $\geq 95\%$ ^{5,6} and/or EPIC $\geq 90\%$ ³⁵
- Side Hop test: LSI $\geq 90\%$,³⁶ and/or EPIC $\geq 90\%$ ³⁵
- Crossover hop test for distance^{30, 31} $\geq 90\%$ of normative data & 95% LSI,^{5,6} and/or EPIC $\geq 90\%$ ³⁵
 - College Age +: \geq Males 197in / Females 157.5in
 - High School Age: \geq Males 185in / Females 134in
- Meets normative Agility T-Test: ≤ 11 seconds Males, ≤ 13 seconds Females^{30, 32}



Return to Activity Test Descriptions:

Stork Balance Test²⁵: (See Appendix A for diagram)

- Hands on hips. NWB foot: medial distal femur or medial proximal tibia.
- Timer starts when the patient lifts heel of the stance foot off the ground.
- Timer stops if/when the patient removes hands from hips, NWB foot from medial stance leg or the heel comes in contact with the ground.

Timed Single Leg Squat Test: (See Appendix B for diagram)

- Mark heel line 6 inches forward of seated surface. Sit on edge of seat, heels on heel line, adjust knee to 60° flexion by adjusting seat height.
- Patient performs single leg squats from 0° extension to tapping surface.
- Count the number of completed squats in 2 minutes per leg.

Single Leg Hop Test for Distance⁶: (See Appendix C for diagram)

- Measure patient's standing height in cm for pass/fail.
- Hands on hips to prevent arm swing momentum during jump.
 - Arms can release for landing assistance after leaving ground.
- 4 progressive warm up jumps ≈ 25%, 50%, 75% and 100% intensity.
- Patient must "stick" the landing ≠ significant knee valgus (concentric or eccentric).
- Use the best of 3 maximum effort jump tests.
- Distance is measured from toe at start line to the landed heel.

Single Leg Timed Side Hop Test³⁶: (See Appendix D for diagram)

- Set up: 2 parallel lines on floor, with outer edges of lines 40cm apart.
- Start position: standing on single test leg with hands on hips.
- Action: Patient hops from outside of one line to outside of the other.
- Record the total number of completed foot strikes in 30 seconds.
 - Completed foot strikes = foot lands completely outside the line, without touching the line, while maintaining hand position.

Crossover Hop Test^{30, 31}: (See Appendix E for diagram)

- Patient starts on one leg with center line just lateral to stance leg.
- Patient is instructed to maximally hop forwards 3 times on the same. stance leg, alternately crossing a ≈15cm wide line.
- Distance is measured from toe of start line to heel of 3rd landed hop.

Agility T-Test³⁰: (See Appendix F for diagram)

- 1.) Sprint forward, touch the cone with left hand.
- 2.) Side shuffle right (without crossing feet) and touch cone with right hand.
- 3.) Side shuffle left to furthest cone to touch with left hand.
- 4.) Side shuffle to center cone to touch with right hand.
- 5.) Back pedal sprint to starting line.

Abbreviation List:

AAROM: Active assisted range of motion	MCL: Medial collateral ligament
ABD: Abduction	MD: Medical doctor
AD: Assistive device	NWB: Non weight bearing
ADL: Activity of daily Living	OKC: Open kinetic chain
AROM: Active range of motion	PA: Physician assistant
BFR: Blood Flow Restriction	PCL: Posterior cruciate ligament
BPTB: Bone patellar tendon bone	PE: Pulmonary embolism
BW: Body Weight	PLC: Posterior lateral corner
CKC: Closed kinetic chain	PROM: Passive range of motion
DVT: Deep vein thrombosis	QT: Quad Tendon
ER: External rotation	ROM: Range of motion
EXT: Extension	RP: Resting position
FWB: Full weight bearing	RROM: Resisted range of motion
GHJ: Gleno-humeral joint	RTS: Return to sport/activity
HEP: Home exercise program	SLR: Straight leg raise
HS: Hamstring	UE: Upper extremity
IR: Internal rotation	TKE: Terminal knee extension
LCL: Lateral collateral ligament	WB: Weight bearing
LE: Lower extremity	WBAT: Weight bearing as tolerated
MA: Medical assistant	#: Pounds
	≠: Absent/Without
	≈: Approximately

EPIC: Estimated pre-injury capacity (*Average score of the involved leg divided by the average score of the uninvolved leg pre-op test scores then multiply by 100 to get the % of the involved leg's performance compared to the uninvolved leg's performance for that specific test*)

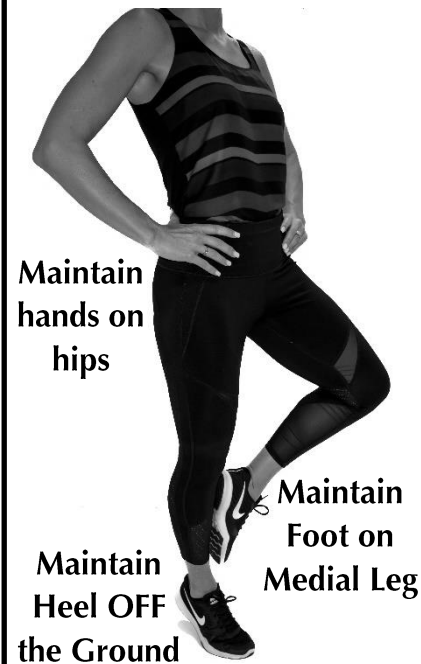
LSI: Limb Symmetry Index = (*Average score of the involved leg divided by the average score of the uninvolved leg for a specific test*)



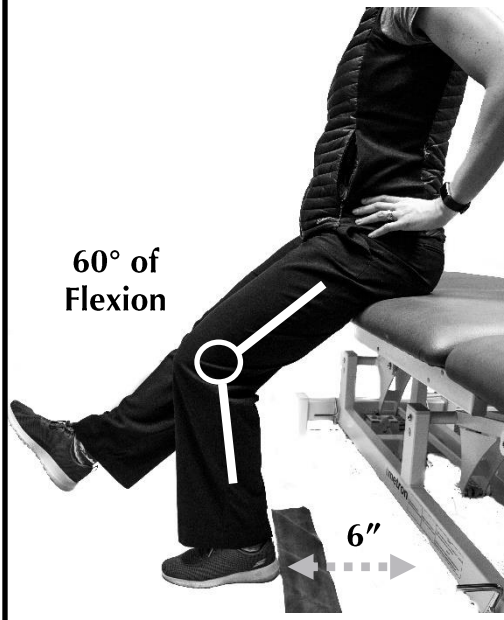
Quick Reference Activity Timeline:

Activity	Activity Restrictions
Knee ROM	<ul style="list-style-type: none"> • $0^{\circ} \approx 110^{\circ}$ until week 3 • Return to symmetrical ROM \approx week 5-6
CKC Squats	<ul style="list-style-type: none"> • Limit to 90° until week 3
RROM OKC knee Flexion	<ul style="list-style-type: none"> • HS graft: week 8
RROM OKC Knee EXT	<ul style="list-style-type: none"> • BPTB/QT graft: 90°-45° week 2-6 • HS graft/Allograft: 90°-45° week 4-6
Plyometrics	<ul style="list-style-type: none"> • BPTB/QT Double Leg: week 6 • BPTB/QT \downarrow BW Single Leg: Week 8 • BPTB/QT Full BW Single Leg: \approx week 12 • HS graft Double Leg: week 10 • HS graft \downarrow BW Single Leg: week 12 • HS graft Full BW Single leg: \approx week 16
Running	<ul style="list-style-type: none"> • BPTB/QT \approx week 12 having met return to run criteria • HS Graft \approx week 16 having met return to run criteria
CKC Pivot/Twisting	<ul style="list-style-type: none"> • Avoid until Week 12+
Return to Sport Cleared by MD	<ul style="list-style-type: none"> • Having met all return to activity testing criteria related to level of desired intensity on page 5

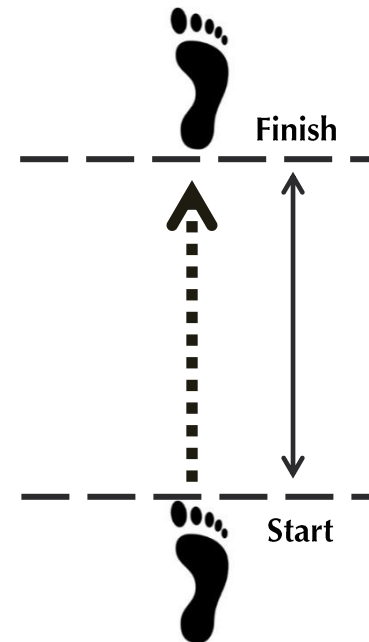
Appendix A: The Stork Test



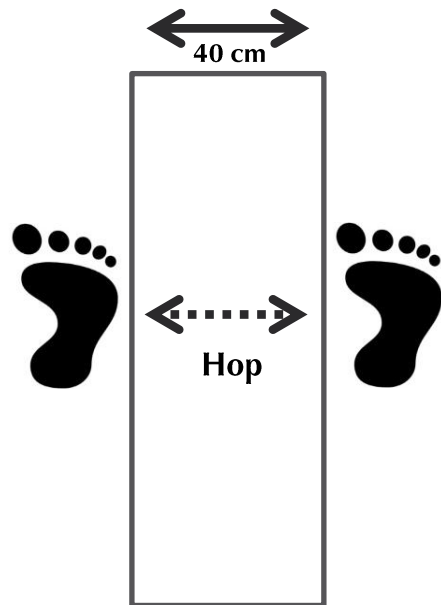
Appendix B: Timed Single Leg Squat Test



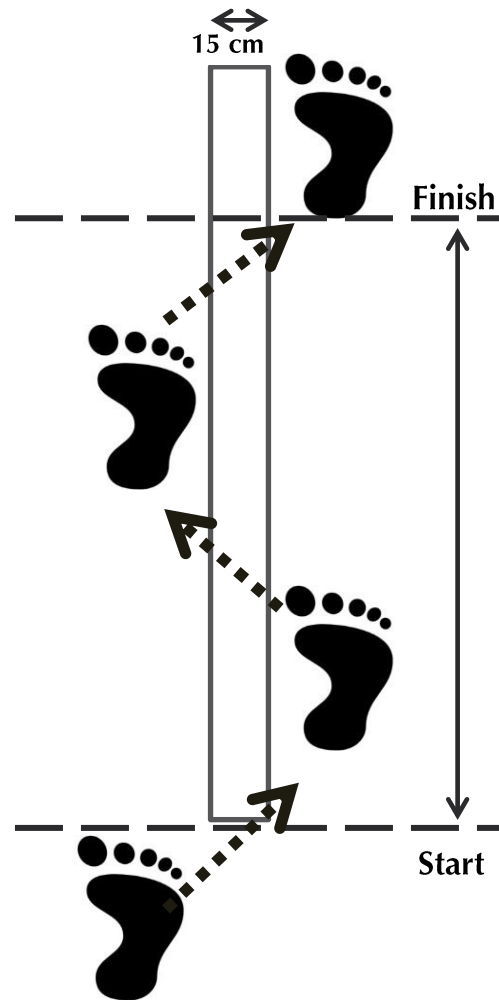
Appendix C: Single Leg Hop Test



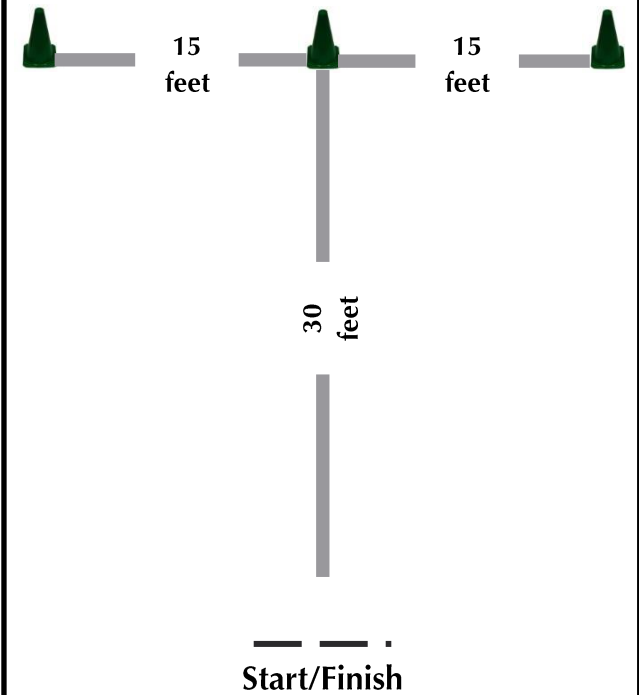
Appendix D: Single Leg Timed Side Hop Test



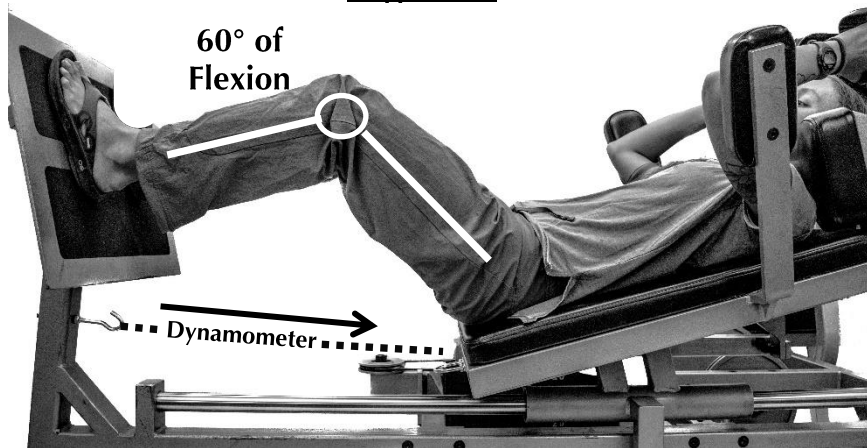
Appendix E: Crossover Hop Test



Appendix F: Agility T-Test

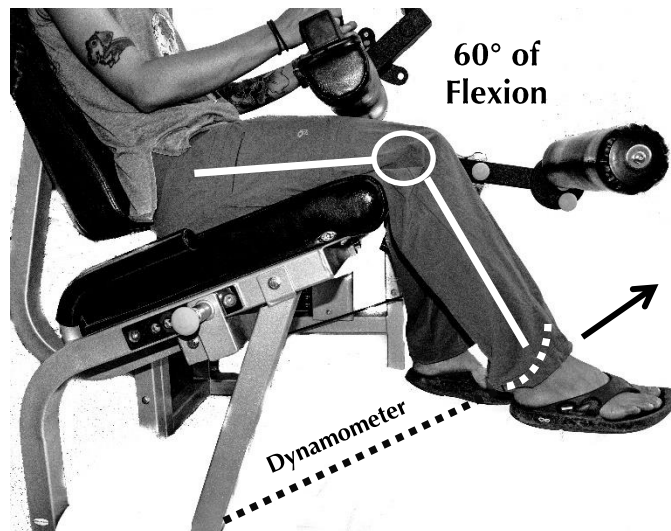


Appendix G: Isometric Single Leg Leg Press



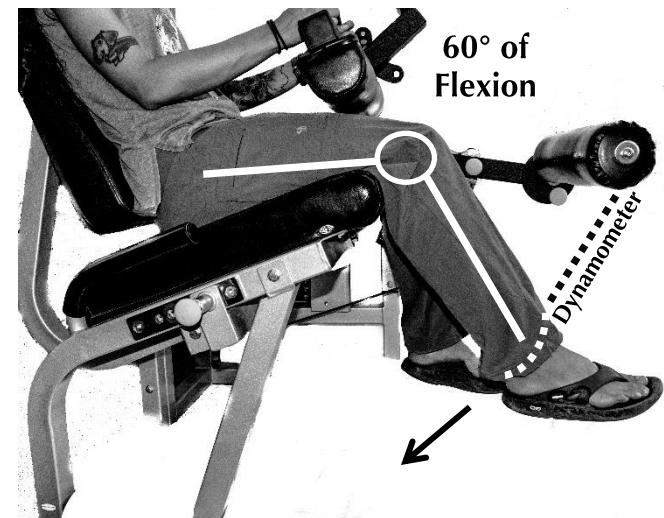
- Adjust foot and leg press position so that the knee is in 60 degrees of knee flexion when there is no slack in the dynamometer attachment.
- Perform maximal effort isometric tests per leg.
- $\text{Involved} \div \text{uninvolved} \times 100 = \text{LSI}$

Appendix H: Isometric Single Leg Quadriceps Test



- Adjust seat position and dynamometer length so that there is no slack in the dynamometer attachment when the knee is in 60° knee flexion.
- Perform maximal effort isometric tests per leg.
- $\text{Involved} \div \text{uninvolved} \times 100 = \text{LSI}$

Appendix I: Isometric Single Leg Hamstring Test



- Adjust seat position and dynamometer length so that there is no slack in the dynamometer attachment when the knee is in 60° knee flexion.
- Perform maximal effort isometric tests per leg.
- $\text{Involved} \div \text{uninvolved} \times 100 = \text{LSI}$



Appendix J: ACL-RSI

ACL-RSI

Name _____ Date _____

Instructions: Place a mark on the line, which best describes you in relation to the descriptors for surgical expectation.

1. Are you confident that you can perform at your previous level of sport participation?

Not at all
confident

Fully
confident

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0	1	2	3	4	5	6	7	8	9	10

2. Do you think you are likely to re-injury your knee by participating in your sport?

Extremely
likely

Not likely
at all

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0	1	2	3	4	5	6	7	8	9	10

3. Are you nervous about playing your sport?

Extremely
nervous

Not nervous
at all

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0	1	2	3	4	5	6	7	8	9	10

4. Are you confident that your knee will not give way by playing your sport?

Not at all
confident

Fully
confident

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0	1	2	3	4	5	6	7	8	9	10

5. Are you confident that you could play your sport without concern for your knee?

Not at all
confident

Fully
confident

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0	1	2	3	4	5	6	7	8	9	10

6. Do you find it frustrating to have to consider your knee with respect to your sport?

Extremely
frustrating

Not at all
frustrating

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0	1	2	3	4	5	6	7	8	9	10



7. Are you fearful of re-injuring your knee by playing your sport?

Extremely
fearful

No fear
at all

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0	1	2	3	4	5	6	7	8	9	10

8. Are you confident about your knee holding up under pressure?

Not at all
confident

Fully
confident

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0	1	2	3	4	5	6	7	8	9	10

9. Are you afraid of accidentally injuring your knee by playing your sport?

Extremely
afraid

Not at
all afraid

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0	1	2	3	4	5	6	7	8	9	10

10. Do thoughts of having to go through surgery and rehabilitation prevent you from playing your sport?

All of
the time

None of
the time

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0	1	2	3	4	5	6	7	8	9	10

11. Are you confident about your ability to perform well at your sport?

Not at all
confident

Fully
confident

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0	1	2	3	4	5	6	7	8	9	10

12. Do you feel relaxed about playing your sport?

Not at all
relaxed

Fully
relaxed

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
0	1	2	3	4	5	6	7	8	9	10



Calculated Score: _____ / 120 = _____ %

Appendix K: Pre-Operative Blood Flow Restriction Preconditioning

Apply this preconditioning strategy with discretion if limitations in insurance visits or self-pay will impact follow up care accessibility after surgery:

- **Goal:** provide 5 exercise days in the final 8 days before surgery, with the last pre surgical training session in the 24-48 hours before surgery⁴²
- **Preconditioning BFR protocol⁴²**
 - o Establish LAQ on knee extension machine 40 repetition max at 1st training session without BFR
 - o Tourniquet in this study set to 150mmHg during BFR for all participants (using individualizing occlusion pressures based on % of total arterial occlusion between 60-80% has important implications for safety⁴⁰)
 - o Initial warm up on knee extension machine 10-15 reps at 1lb
 - o Patient will perform 6 sets of OKC knee extension to volitional failure at 56 BPM via metronome with one beat for concentric and one beat for eccentric phase of muscle contraction. Weight was set at a patient's individual 40 repetition max from 1st session without BFR⁴
 - o Inflate tourniquet to desired pressure, rest at initial occlusion for 30 seconds before beginning training series
 - o Training Series:
 - Perform 1st set to volitional failure
 - After the 1st set rest for 45 seconds set without reperfusion
 - After the 2nd set deflate tourniquet for reperfusion for 90 seconds
 - After the 3rd set rest for 45 seconds set without reperfusion
 - After the 4th set deflate tourniquet for reperfusion for 90 seconds
 - After the 5th set rest for 45 seconds set without reperfusion
 - Deflate tourniquet after final 6th set

References

1. Anderson, M.J et al. A Systematic Summary of Systematic Reviews on the topic of the Anterior Cruciate Ligament. *The Orthopaedic Journal of Sports Medicine*. 2016. Mar 15;4(3):2325967116634074. doi: 10.1177/2325967116634074. eCollection 2016 Mar.
2. Ardern, C.L et al. 2018 International Olympic Committee consensus statement on prevention, diagnosis and management of pediatric anterior cruciate ligament injuries. *Knee Surg Sports Traumatol Arthrosc*. 2018 Apr;26(4):989-1010. doi: 10.1007/s00167-018-4865-y. Epub 2018 Feb 17.
3. Ardern, C.L et al. Psychological Responses Matter in Returning to Preinjury Level of Sport After Anterior Cruciate Ligament Reconstructive Surgery. *Am J Sports Med*. 2013 41: 1549. Doi: 10.1177/0363546513489284. Epub 2013 Jun 3.
4. Czappon, S et al. Variables Associated with Return to Sport Following Anterior Cruciate Ligament Reconstruction: A Systematic Review. *Br J Sports Med*. 2014 Mar;48(5):356-64. doi: 10.1136/bjsports-2012-091786. Epub 2013 Oct 11.
5. Davies G.J et al. ACL Return to Sport Guidelines and Criteria. *Curr Rev Musculoskelet Med*. 2017 July 10:307-314. Doi 10.1007/s12178-017-0920-9.
6. Davies G.J et al. Individualizing the Return to Sports After Anterior Cruciate Ligament Reconstruction. *Operative Techniques in Orthopaedics*. 2017 Mar 27:1 70-78.
7. Everhart, J.S et al. Psychological predictors of anterior cruciate ligament reconstruction outcomes: a systematic review. *Knee Surg Sports Traumatol Arthrosc*. 2015 Mar;23(3):752-62. doi: 10.1007/s00167-013-2699-1. Epub 2013 Oct 15.



8. Grassi, A et al. Magnetic resonance imaging after anterior cruciate ligament reconstruction: a practical guide. *World J Orthop.* 2016 Oct 18;7(10):638-649. eCollection 2016 Oct 18.
9. Grinsven, SV et al. Evidence-based rehabilitation following anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc.* 2010 Aug;18(8):1128-44. doi: 10.1007/s00167-009-1027-2. Epub 2010 Jan 13.
10. Gunderson Health System. ACL Reconstruction Rehabilitation Program. March 2010. <http://www.gundersenhealth.org/app/files/public/1464/Sports-Medicine-Protocol-ACL-Reconstruction.pdf>
11. Janssen, R.P et al. ACL reconstruction with hamstring tendon autograft and accelerated brace-free rehabilitation: a systematic review of clinical outcomes. *BMJ Open Sport Exerc Med.* 2018 Apr 9;4(1):e000301. doi: 10.1136/bmjsem-2017-000301. eCollection 2018.
12. Kay, J et al. Over 90 % of children and adolescents return to sport after anterior cruciate ligament reconstruction: a systematic review and meta-analysis. *Knee Surg Sports Traumatol Arthrosc.* 2018 Apr;26(4):1019-1036. doi: 10.1007/s00167-018-4830-9. Epub 2018 Jan 13.
13. Krafft F.C et al. How does functionality proceed in ACL reconstructed subjects? Proceeding of functional performance from pre- to six months post-ACL reconstruction. *PLoS One.* 2017 May 31;12(5):e0178430. doi: 10.1371/journal.pone.0178430. eCollection 2017.
14. Kruse L.M et al. Rehabilitation after anterior cruciate ligament reconstruction: A systematic review. *J Bone Joint Surg Am.* 2012 Oct 3;94(19):1737-48. doi: 10.2106/JBJS.K.01246.
15. Lai, C.C et al. Eighty-three per cent of elite athletes return to preinjury sport after anterior cruciate ligament reconstruction: a systematic review with meta-analysis of return to sport rates, graft rupture rates and performance outcomes. *Br J Sports Med.* 2018 Jan;52(2):128-138. doi: 10.1136/bjsports-2016-096836. Epub 2017 Feb 21.
16. Li, H et al. MRI-based ACL graft maturity does not predict clinical and functional outcomes during the first year after ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc.* 2017 Oct;25(10):3171-3178. doi: 10.1007/s00167-016-4252-5. Epub 2016 Aug 2.
17. Ma, Y et al. Graft maturity of the reconstructed anterior cruciate ligament 6 months postoperatively: a magnetic resonance imaging evaluation of quadriceps tendon with bone block and hamstring tendon autografts. *Knee Surg Sports Traumatol Arthrosc.* 2015 Mar;23(3):661-8. doi: 10.1007/s00167-014-3302-0. Epub 2014 Sep 16.
18. Makhni, E et al. Quality and Variability of Online Available Physical Therapy Protocols From Academic Orthopaedic Surgery Programs for Anterior Cruciate Ligament Reconstruction. *Arthroscopy.* 2016 Aug;32(8):1612-21. doi: 10.1016/j.arthro.2016.01.033. Epub 2016 Mar 28.
19. Melick, N.V et al. Evidence based clinical practice update: practice guidelines for anterior cruciate ligament rehabilitation based on a systematic review and multidisciplinary consensus. *Br J Sports Med.* 2016; 50: 1506-1515. Doi: 10.1136/bjsports-2015-095898.
20. Mohtadi, N et al. Return to Sport-Specific Performance After Primary Anterior Cruciate Ligament Reconstruction: A Systematic Review. *Am J Sports Med.* 2018 Nov;46(13):3307-3316. doi: 10.1177/0363546517732541. Epub 2017 Oct 13.
21. Rabuck, S et al. Anterior Cruciate Liament Healing and Advances in Imaging. *Clin Sports Med.* 2013 Jan;32(1):13-20. doi: 10.1016/j.csm.2012.08.003. Epub 2012 Oct 4.
22. Rambaud, A et al. Criteria for return to running after anterior cruciate ligament reconstruction: a scoping review. *Br J Sports Med.* 2018 Nov;52(22):1437-1444. doi: 10.1136/bjsports-2017-098602. Epub 2018 May 2.
23. Rodriguez-Merchan, C. Evidence-Based ACL Reconstruction. *Arch Bone Jt Surg.* 2015 Jan;3(1):9-12. Epub 2015 Jan 15.
24. Saka, T. Principles of postoperative anterior cruciate ligament rehabilitation. *World J Orthop.* 2014 Sep 18;5(4):450-9. doi: 10.5312/wjo.v5.i4.450. eCollection 2014 Sep 18.
25. Schell, J et al. *Physical Fitness Assessment in Exercise and Sports Science.* 1994 2nd Ed, Leelar Biomedisience Services, Matraville, NSW. p. 327
26. Schuette, H et al. Bone-Patellar Tendon-Bone Versus Hamstring Tendon Autografts for Primary Anterior Cruciate Ligament Reconstruction: A Systematic Review of Overlapping Meta-analyses. *Orthop J Sports Med.* 2017 Nov 7;5(11):2325967117736484. doi: 10.1177/2325967117736484. eCollection 2017 Nov.



27. Wright, R et al. Anterior Cruciate Ligament Reconstruction Rehabilitation: MOON Guidelines. *Sports Health*. 2015 May;7(3):239-43. doi: 10.1177/1941738113517855.
28. FIFA 11+. http://www.yrsa.ca/pdf/Fifa11/11plus_workbook_e.pdf Accessed 01/03/2019.
29. Fort-Vanmeerhaeghe, A et al. Intra- and Inter-Rater Reliability of the Modified Tuck Jump Assessment. *Journal of sports science and medicine*. 2017 Mar 1;16(1):117-124. eCollection 2017 Mar.
30. Munro, A et al. Between-Session Reliability of Four Hop Tests and the Agility T-Test. *Journal of strength and conditioning research*. May 2011; 25, (5): 1470-1477.
31. Myers, B.A et al. Normative data for hop tests in high school and collegiate basketball and soccer players. *The International Journal of Sports Physical Therapy*. 2014 October; 9(5): 596-603.
32. Gabbett, T. et al. Physiological and anthropometric characteristics of Australian junior national, state, and novice volleyball players. *Journal of strength and conditioning research*. 2007, 21(3), 902-908.
33. Fort-Vanmeerhaeghe, A. et al. Sex maturation differences in performance of functional jumping and landing deficits in youth athletes. *Journal of Sports Rehabilitation*. 2018 July 24.doi: <https://doi.org/10.1123/jsr.2017-0292>.
34. Wilk, K. et al. Rehabilitation principles of the anterior cruciate ligament reconstructed knee twelve steps for successful progression and return to play. *Clin Sports Med*. 36 (2017) 189-232.
35. Wellsandt, E. et al. Limb symmetry indexes can overestimate knee function after ACL injury. *J Orthop Sports Phys Ther*. 2017 May; 334-338. Doi: 10.2519/jospt.2017.7285.
36. Gustavsson, A. et al. A test battery for evaluating hop performance in patients with an ACL injury and patients who have undergone ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2006; 14: 778-788. DOI 10.1007/s00167-006-0045-6.
37. Kyritsis, P et al. Likelihood of ACL graft rupture: not meeting six clinical discharge criteria before return to sport is associated with a four times greater risk of rupture. *Br J Sports Med*. 2016; 50: 946-951. DOI 10.1136/bjsports-2015-095908.
38. Liotta, F. Expert Opinion and Consultation.
39. Charles, D. et al. A systematic review of the effects of blood flow restriction training on quadriceps muscle atrophy and circumference post ACL reconstruction. *The international Journal of Sports Physical Therapy*. December 2020: V15; 6. 882-891.
40. Lu, Y. Et al. Perioperative Blood Flow Restriction Rehabilitation in Patients Undergoing ACL Reconstruction: A Systematic Review. *The Orthopaedic Journal of Sports Medicine*. 2020: 8(3).
41. Bobes Alvarez, C. et al. Comparison of Blood Flow Restriction Training Versus Non-Occlusive Training in Patients with Anterior Cruciate Ligament Reconstruction or Knee Osteoarthritis: A Systematic Review. *Journal of Clinical Medicine*. 2021: 10; 68.
42. Zargi, T. et al. Short-Term Preconditioning with Blood Flow Restricted Exercise Preserves Quadriceps Muscle Endurance in Patients After Anterior Cruciate Ligament Reconstruction. *Frontiers in Physiology*. August 2018: 9; 1150.
43. Escamilla, R. et al. Anterior Cruciate Ligament Strain and Tensile Forces for Weight-Bearing and Non-Weight-Bearing Exercises: A Guide to Exercise Selection. *J Orthop Sports Phys Ther*. 2012 March: 42; 3. 208-220.

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