UPMC ROONEY SPORTS COMPLEX

UPMC LIFE CHANGING MEDICINE

ACL-R in a Professional Chinese Basketball Player

Brittany Lynch PT, DPT, SCS, OCS

Patient Background

Demographics

- 20 year old M professional basketball player from China
- 6’11” tall, 270 pounds
- Lives in China but having surgery/rehab in Pittsburgh

Mechanism of Injury

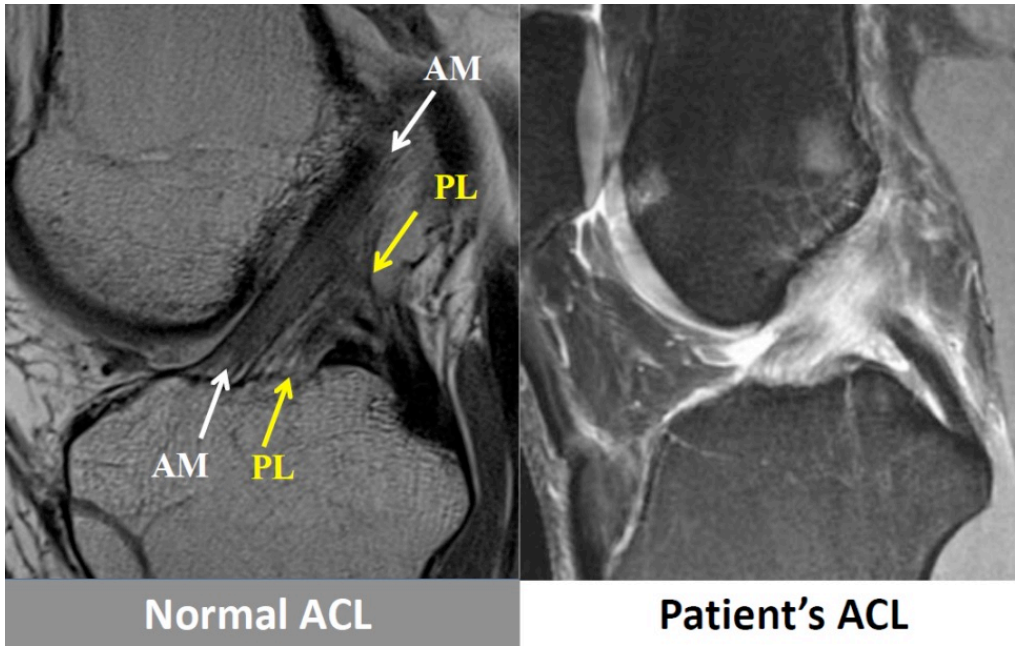
- Non contact ACL tear during play
- Concomitant pathology: grade I MCL, small LMT

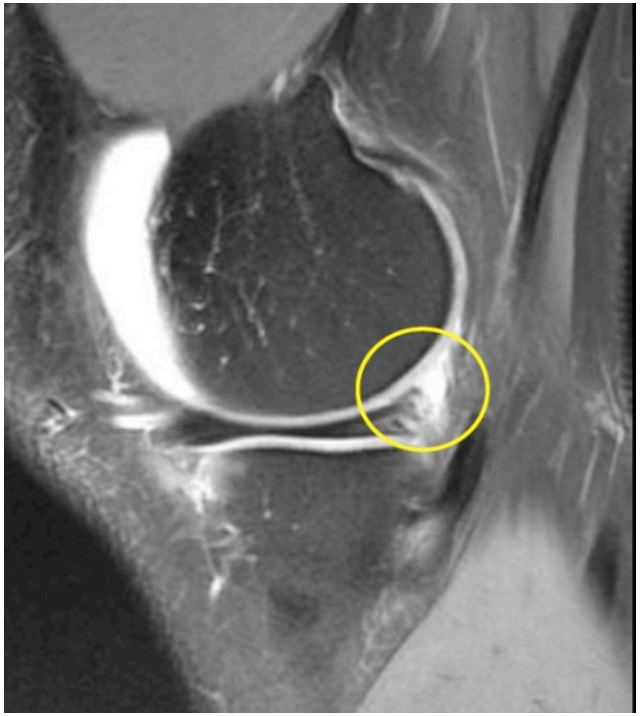
Prehab: little to none

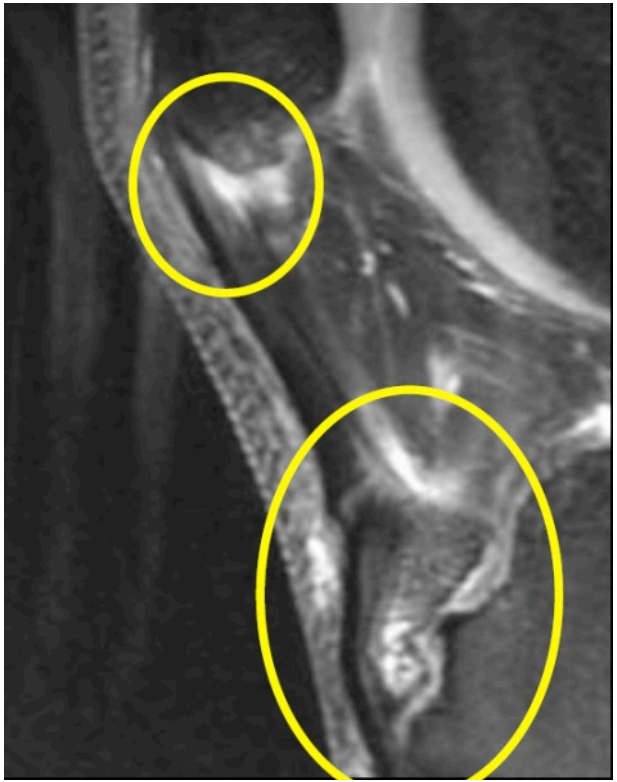
PHx: ipsilateral patellar tendinopathy and ankle sprain

DOS: 8/1/17

MRI







Surgical Management

ACL-R BPTB allograft

Decision making for allograft

- Quad: Small size and mild degeneration
- BPTB: moderate-severe patellar tendinopathy
- Hamstring: less commonly used for elite athletes, especially large athletes

Allograft

- Delayed healing compared to autograft
  - Vascularization/ligamentization
- Most time-based milestones are delayed by at least a month

Phase 1 Early Post Op Rehab

Range of motion
Isometric progressing to concentric strength
Gait
Controlling effusion
Normalizing arthrokinematics
Goal: symmetric gait, trace effusion
  0 deg lag, full extension/flexion

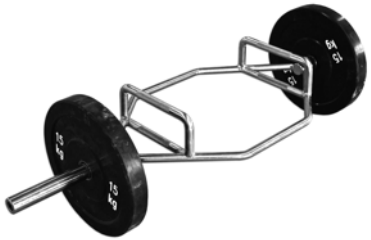
Why is Quad Strength so Important?

- Lewek et al (2002)
  - Weak (<80%) and strong (>90%)
  - No differences found in strong group and healthy controls for both walking and jogging
  - Weak and deficient subjects: decreased knee angles and moments during walking and jogging
- Ithurburn et al (2015)
  - High quad was <10% difference, low quad was >10% difference tested via isometric at 60
  - ACL-R group greater limb asymmetry during landing compared with control group in knee flexion excursion, peak trunk flexion and peak knee extension moment
  - Greater asymmetry was noted in the low quad group
- Schmitt et al (2016)
  - High quad (>90%) and low quad (<85%)
  - No difference in landing patterns between high quad and control group
  - Landing asymmetry in quadriceps deficient: limb peak knee external flexion moment, peak vGRF, limb peak loading rates
- Grindem et al (2016)
  - Quadriceps strength deficit prior to RTS was a significant predictor for knee re-injury
  - 3% reduced re-injury rate for every one percentage point increase in strength symmetry
  - 33% of those who returned with <90% quadriceps symmetry suffered re-injuries, vs 12.5% who had >90%

Phase 2

- Squatting
- Dead Lift and Hip Hinge
- Lunge
- Lateral Movements
- Eccentric Hamstring Training

- Incorporating Unilateral WB Training
- When to d/c to gym



Does Type of Strengthening Matter

Roig et al 2000 - Systematic Review

- Comparing eccentric to concentric training in muscle strength and mass gains
- Eccentric training lead to greater improvements in total and eccentric strength
- Eccentric is superior to concentric exercise in promoting strength gains but also that strength gains from eccentric were highly specific to the mode of contraction and velocity of movement
- Concentric strength training trended to have higher strength gains when measured concentrically
- Isometric strength gains: no difference in eccentric vs concentric training
- Eccentric exercise is more effective in increasing muscle girth compared to concentric

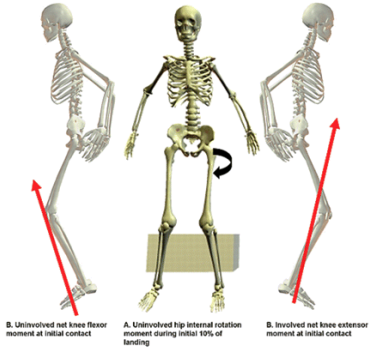
Phase 3 Rehab

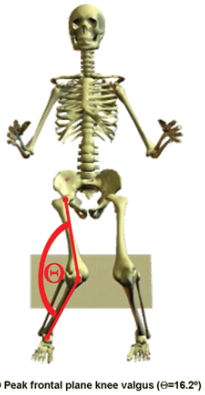
- Optimize LE muscle performance
  - Sport-Specific – Length and Strength
- Re-introduce dynamic loading in a progressive fashion
  - Running
  - Agility Training
  - Jumping/Hopping
  - Sport-specific exercise
- Incorporate Injury Prevention Techniques

Literature Review for Risk of Injury

Paterno MV, et al. Biomechanical measures during landing and postural stability predict second ACL tear after ACLR and return to sport. AJSM. 2010; 38(10):1968-1978.

- Uninvolved hip IR during the first 10% of landing DVJ
  - Sens.=0.77, Spec.=0.81
  - 8x more likely to have a 2nd ACL tear
- Increase in valgus collapse were >3x more likely to have a 2nd tear
- Side to side differences for quad activity at initial contact demonstrate a 4.1x greater chance for 2nd injury
  - "Quad dominant"
- Poor postural control were 2x as likely to have a 2nd ACL tear as controls
- Combo of the 4
  - Sens.=0.92, Spec.=0.88





Assessing Risk of Injury

Development of a Clinician-Rated Drop Vertical Jump Scale for Patients Undergoing Rehabilitation After ACLC-R: A Delphi Approach.

- Mimics rebounding, blocking in volleyball, etc.
- Observe <u>at least</u> *three* repeated DVJ's from different positions to observe movement in all planes
- Look for joint positions and possible compensatory movements (right and left)
  - i) *Knee Valgus Collapse*
  - ii) *Other Undesirable Movements*,
- If a compensatory movement is observed 1x, it should be recorded.

Valgus Collapse

- NO (none);
- SOME (slight valgus collapse ("wiggle") with correction);
- MODERATE (obvious valgus collapse with correction);
- EXTREME (obvious valgus collapse with NO correction).
- "Correction" refers to a knee valgus collapse pattern that returns to neutral alignment.

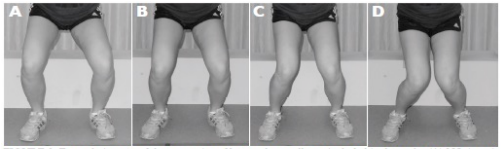


FIGURE 3. Example images of the categories of knee valgus collapse included in the scale. (A) NO (none); (B) SOME; (C) MODERATE; and (D) EXTREME knee valgus collapse

Other Undesirable Movements

- *Lateral Trunk Lean*
  - observe for patient in neutral frontal plane alignment
- *Insufficient Trunk Flexion*
  - evaluate for insufficient trunk flexion in the sagittal plane
  - also check for accompanying decreased knee/hip flexion
- *Insufficient Knee Flexion*
  - evaluate for insufficient knee flexion in the sagittal plane
  - look for flat-foot straight-leg landing; loud contact
- *Asymmetry*
  - watch for patients leaving the box with one limb prior to the other and/or landing with one limb prior to the other

What to Look for..

- Ligament Dominant
  - Knees collapse due to poor frontal/transverse plane control (i.e. dynamic valgus)
  - Feet not shoulder width apart
  - Athlete allows the knee ligaments, rather than the lower extremity musculature, to absorb a significant portion of the GRFs with sports
- Quadriceps Dominant
  - Low knee flexion angles and loud landings
  - Athletes increase their knee extensor moments over their knee flexor moments when performing sport movements
  - Hypothesized to lead to imbalances in strength and coordination between the quads and hamstrings
- Leg Dominant
  - Asymmetry in balance and control
  - Measurable muscle asymmetry
  - They lean to one side with take-off and landing
- Trunk Dominant
  - Can't control the trunk in space
  - Lateral or forward trunk lean

Prevention Strategies

Current Concepts for Injury Prevention in Athletes After Anterior Cruciate Ligament Reconstruction

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Investigation performed at The Sports Health and Performance Institute, The Ohio State

- Sports technique modification
  - Single Leg Progressions - Strength
  - Single Leg Progressions - Plyometric training
- Proprioception and neuromuscular training
  - Biomechanical Feedback
  - Balance and Proprioception Training
- Adequate hamstring/quadriceps ratios
- Trunk/core/hip control training

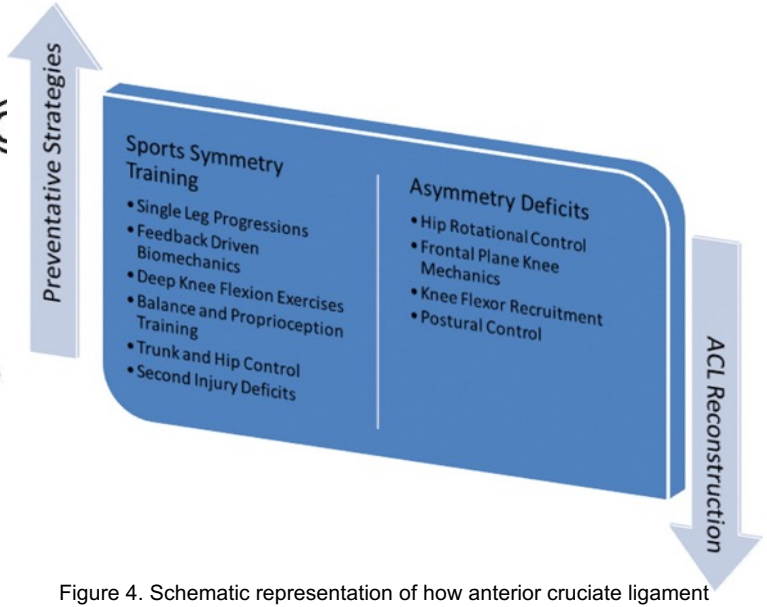

Figure 4. Schematic representation of how anterior cruciate ligament reconstruction can drive postsurgical symmetries and neuromuscular deficits. These impairments are, in turn, minimized with sports symmetry training and preventative multiplane dynamic movement tasks.

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Neuromuscular Training to Target Deficits Associated With Second Anterior Cruciate Ligament Injury

Single Leg Squat – With Shoes

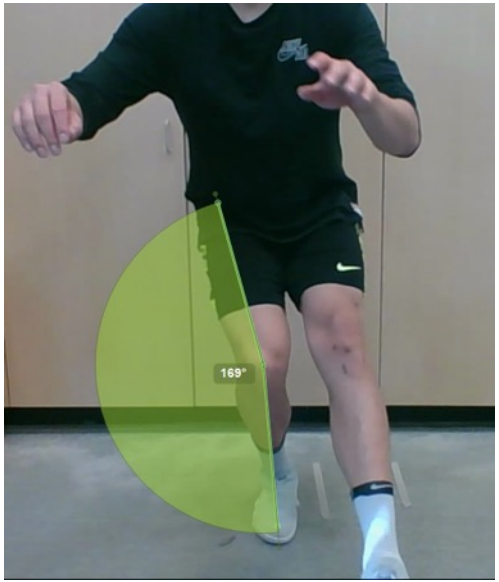
- What we need to work on
  - Hip strength to limit dynamic valgus (Glute Medius and Max)
  - Core strength to improve trunk stability (Obliques, Rectus Abdominis, Quadratus lumborum, etc.)
  - Balance and Proprioception to limit errors, decrease dynamic valgus, decrease risk of re-injury)
  - Ankle mobility to decrease forefoot over-pronation and possible influence on knee valgus
  - Motor control training- Implement verbal and tactile cueing to improve/correct dynamic functional mobility.

Single Leg Squat – No shoes

- What we need to work on
  - Hip strength to limit dynamic valgus (Glute Medius and Max)
  - Core strength to improve trunk stability (Obliques, Rectus Abdominis, Quadratus lumborum, etc.)
  - Balance and Proprioception to limit errors, decrease dynamic valgus, decrease risk of re-injury)
  - Ankle mobility to decrease forefoot over-pronation Ankle mobility to decrease forefoot over-pronation and possible influence on knee valgus
  - Motor control training- Implement verbal and tactile cueing to improve/correct dynamic functional mobility.
  - Foot intrinsic strengthening through doming and verbal cueing to place weight through big toe in order strength mid-foot and medial arch.

Dynamic Valgus – Single Leg Squat

Uninvolved



Single Leg Squat

- Normal knee abduction is 172° ± 7 °
- Uninvolved leg - minor errors with trunk stability/balance seen in video.
- Involved leg - Errors with trunk stability and balance:
  - Upper extremity compensation
  - Poor Trunk Control
  - Poor dynamic stability at foot/ankle
  - Compensation at talocural joint due to lack of dorsiflexion. Decreased tibial ER

Involved

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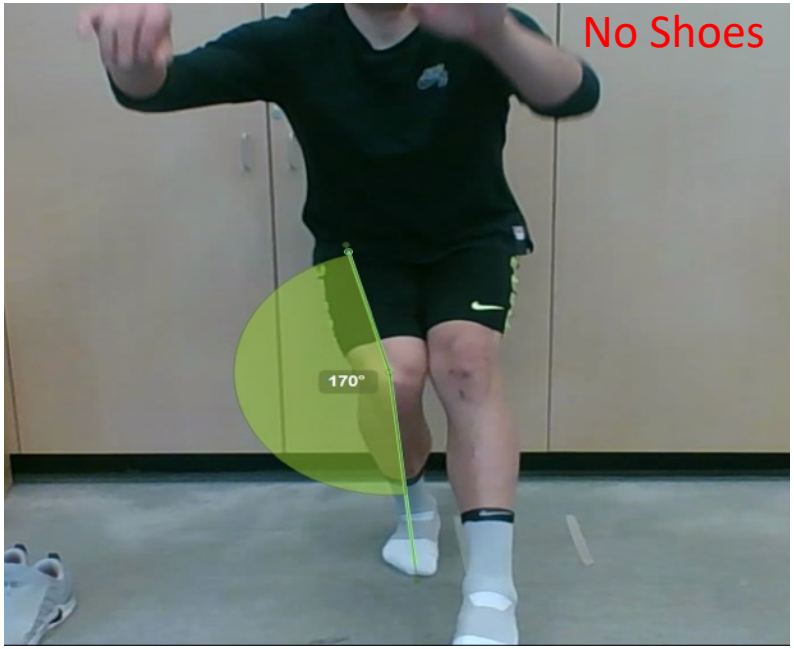
Dynamic Valgus - Uninvolved



- Uninvolved Single Leg Squat
  - Normal knee abduction with Single Leg Squat with non-stance limb extended in front is 172°
  - Considering measurement error, this angle is appropriate.
  - Minor errors with trunk stability and balance can be seen in live video.
  - Corrections in ankle mobility may assist in improvement in form

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Dynamic Valgus - Involved

- Involved Single Leg Squat
  - Normal knee abduction with Single Leg Squat with non-stance limb extended in front is 172°
  - Dynamic Valgus is demonstrated here, we would like to improve this angle to ~172°
  - Errors with trunk stability and balance:
    - upper extremity compensation
    - Poor Trunk Control
    - Poor dynamic stability at foot/ankle and midfoot

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Dynamic Loading Frontal Plane

Right LE

Left LE

Dynamic Loading Sagittal Plane

- What we need to work on
  - Decreased impact sounds (Decrease joint load, increase muscular efficiency)
  - Balance/proprioception (Decrease Femoral Internal Rotation, Tibial abduction)
  - Challenging multiple planes of movements by implementing reactive training to improve neuromuscular control, proprioception and spatial awareness.

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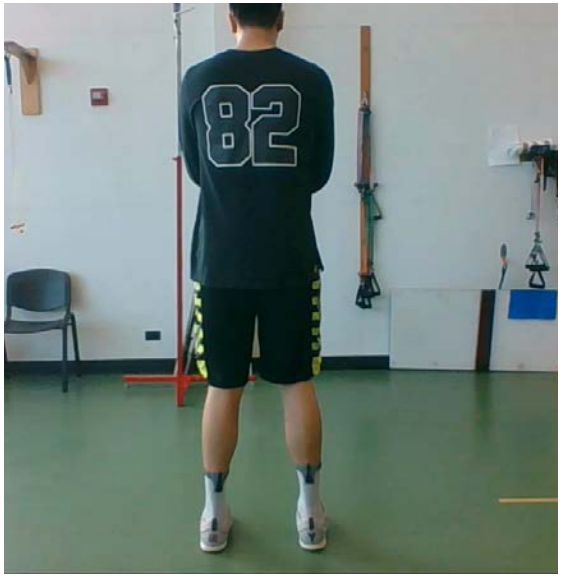
Vertical Jump

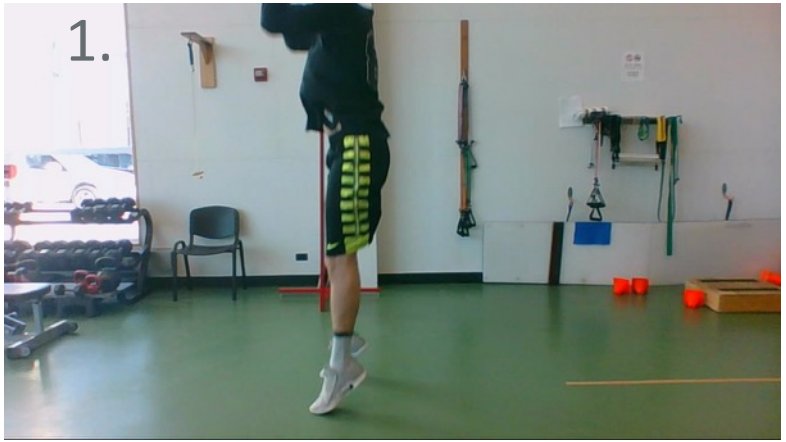
Frontal Plane



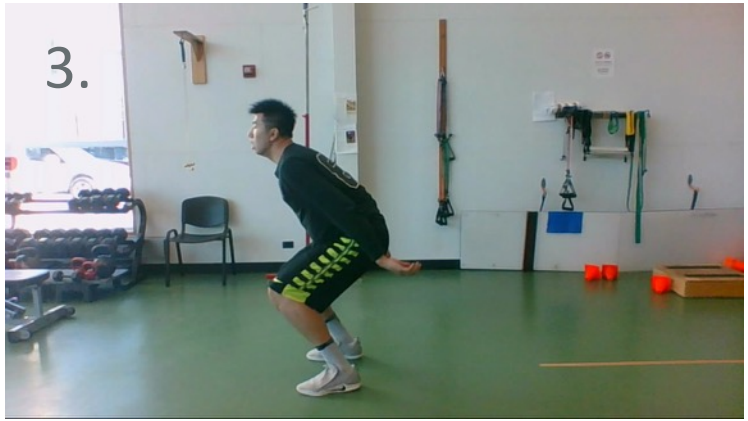
Sagittal Plane

- What we need to work on
  - Improve eccentric hip and quadriceps efficiency/control
  - Improve symmetry
  - Decreased impact sounds → Increase knee flexion upon loading in order to reduce joint impact force.
  - Decrease quadriceps dominance
  - Improve correct loading mechanic consistency and efficiency by improving overall muscular and cardiovascular endurance as well as dynamic postural re-education in a fatigued state.

Vertical Jump



- Landing on toes first, then loading LE through and extended hip and knee joint.
- Lacking efficient glute activation and hip thrust.



- Goal: Decrease quadriceps dominance through plyometric and motor control training to utilize glutes. Also instruct and work on explosive triple extension

Benefit from training → Jump higher while decreasing joint force !

Vertical Jump

- Take-off
  - Exhibiting dynamic valgus
  - Need to improve hip/core strength and motor control

- Landing
  - Asymmetric, loading RLE first, then shifts weight onto LLE
  - Dynamic valgus on LLE
  - Form consistency decreases with increased repetition which warrants continued muscular and cardiovascular endurance training and dynamic postural re-education at a fatigued state.

Broad Jump

- Impairments
  - Asymmetric landing, favoring RLE
  - Dynamic valgus on L LE
  - Poor trunk control
  - Loud impact sounds

- Benefits from training
  - Increase power
  - Improve athleticism
  - Decrease knee joint pain
  - Decrease risk of injury

- Goals
  - Improve tolerance to loading involved limb
  - Decrease dynamic valgus
  - Improve trunk strength
  - Decrease impact upon landing
  - Increase muscular and cardiovascular endurance especially with dynamic activities.

Weekly Exercise Plan

- Mondays: Running, proprioception, SL isolation exs
- Tuesday: Squat/ step-up / split Squat / isolated HS exs / High pulls
- Wednesday- Jumping/ proprioception (light load day)
- Thursday: Dead Lift, RDLs, Isolations Quad, front squats, KB swings
- Friday- Fast twitch Power Day, Running

Outcome Measures

Returned to China on 1/16/18 (5.5 months from DOS)
Strength: 1/9/18 Isometric at 60 deg flexion
Function: DL plyometrics

		AWAY 60 DEG			TOWARD 60 DEG		
# OF REPS (60 DEG): R 3 - L 3		UNINV	INV	DEFICIT	UNINV	INV	DEFICIT
		Right	Left		Right	Left	
PEAK TORQUE	FT-LBS	207.6	212.0	-2.1	129.4	130.4	-0.8
AVG PEAK TQ	FT-LBS	197.6	198.1		120.7	116.4	
AVE PKTQ/BW	%	73.2	73.4		44.7	43.1	
RELAXATION TIME	SEC	30	30		30	30	
CONTRACTION TIME	SEC	5	5		5	5	
COEFF. OF VAR.	%	8.0	6.4		7.8	11.8	
AGON/ANTAG RATIO	%	62.3			61.5		

Literature Review for Outcomes

Webster AJSM 2016
- 354 pts <20 at time of ACLR, 316 followed
  - 17.2 y.o. at ACLR (r: 11-19)
  - Graft Rupture:
    - 57 (18%) @ avg of 1.8 years (med: 1.2y)
    - 47% of tears within year 1
    - 74% of tears within year 2
    - 22.3% of males vs. 12.0% of females (P=0.02)
  - Contralateral ACL Injury:
    - 56 (17.7%) @ avg of 3.7 years (med 3.4y)
    - 14% of tears within year 1
    - No sex differences
  - 110 (35%) had either graft rupture or contralateral injury!!

Wright JBJS 2011
- 6 prospective level 1 or 2 studies with greater than 5 year follow-up of 2026 patients that underwent autograft ACL reconstruction
- Risk for graft failure – 5.8% (1.8% to 10.4%)
- Risk for subsequent contra-lateral knee injury – 11.8% (8.2% to 16.0%)

Wiggins AJSM 2016 Systematic Review
- Overall 15% (7% ipsilat, 8% contra) Re-injury in those < 25 yrs
  - 10% ipsilateral; 11% contralateral
- Re-injury for athletes that returned to sports was 20%
  - 8% ipsilateral; 12% contralateral

ACL-Revision

7/13/18: Noncontact injury (11 months PO)

2+ months worsening of patellar tendinopathy with cortisone injection 2 days prior to injury

MRI: partial ACL, MMT, LMT and worsening of patellar tendinopathy

10/23/18: **Left SB Revision ACLR with QT auto with bone block and patellar tendon debridement**

Potential cause of injury:

- Likely not allograft due to excellent graft remodeling with frequent follow up images
- Patellar tendinopathy and pain compromised RTS progression

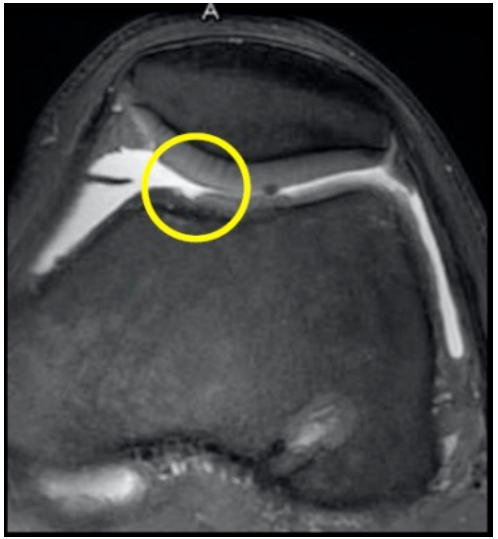
Quad Tendon Auto

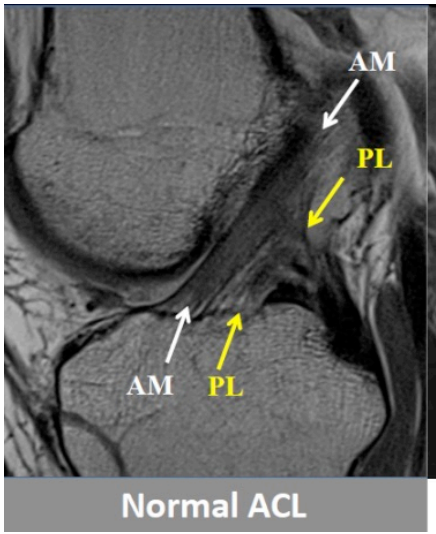
Preferred technique for attendings involved

Sheean, Musahl BJSM 2018

- Higher ultimate load/stiffness than BPTB
- Dec strain failure after cyclic loading vs BPTB
- Less anterior tibial translation than HS
- Better Lysholm and KOOS scores than HS
- Better flexor muscle strength than HS

MRI





Normal ACL

Patient's ACL

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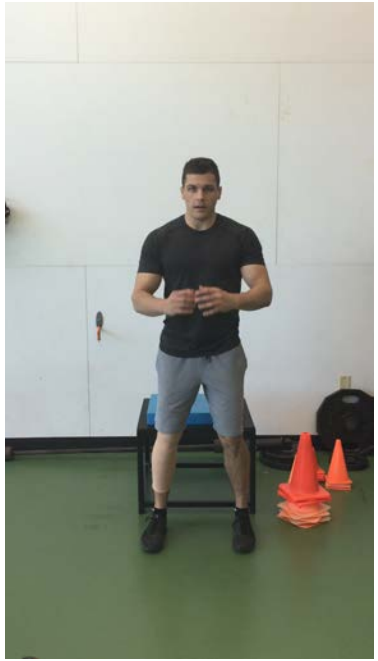
Mid to Late Rehab- Squatting



Hip Hinge

Hip Hinge Progression




Lunge Progressions




Lateral Progressions

Mid to Late Rehab- Agility

Agility

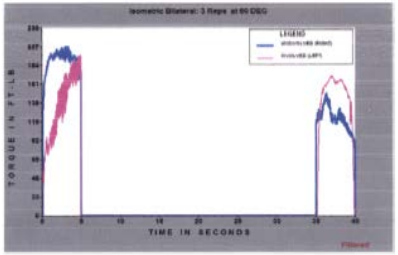
Hopping Limitations

Forcing Triple Joint Power

Strength Results

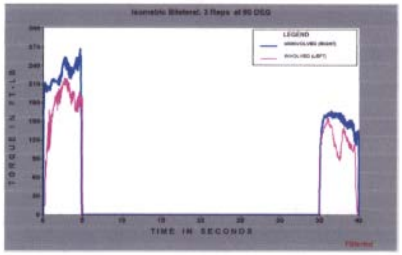
		AWAY 60 DEG			TOWARD 60 DEG		
# OF REPS (60 DEG): P 3 - C 3		TEST DATE	TEST DATE	PROG	TEST DATE	TEST DATE	PROG
		1/16/18	10/15/18		1/16/18	10/15/18	
PEAK TORQUE	FT-LBS	212.0	184.5	-13.0	130.4	158.1	21.3
AVG PEAK TQ	FT-LBS	198.1	148.3		116.4	149.3	
AVE PKTQ/BW	%	73.4	54.9		43.1	55.3	
RELAXATION TIME	SEC	30	30		30	30	
CONTRACTION TIME	SEC	5	5		5	5	
COEFF. OF VAR.	%	6.4	21.1		11.8	4.7	
AGON/ANTAG RATIO	%	61.5	85.7				

10/15/18
preop



		AWAY 60 DEG			TOWARD 60 DEG		
# OF REPS (60 DEG): R 3 - L 3		UNINV	INV	DEFICIT	UNINV	INV	DEFICIT
		Right	Left		Right	Left	
PEAK TORQUE	FT-LBS	205.5	187.6	8.7	147.7	170.4	-15.4
AVG PEAK TQ	FT-LBS	199.2	186.7		138.1	159.4	
AVE PKTQ/BW	%	69.9	65.5		48.5	55.9	
RELAXATION TIME	SEC	30	30		30	30	
CONTRACTION TIME	SEC	5	5		5	5	
COEFF. OF VAR.	%	4.5	0.7		6.1	8.2	
AGON/ANTAG RATIO	%	71.9			90.8		

1/11/19
~3 months



		AWAY 60 DEG			TOWARD 60 DEG		
# OF REPS (60 DEG): R 3 - L 3		UNINV	INV	DEFICIT	UNINV	INV	DEFICIT
		Right	Left		Right	Left	
PEAK TORQUE	FT-LBS	262.1	217.2	17.1	165.0	155.5	5.8
AVG PEAK TQ	FT-LBS	246.7	213.4		151.9	151.1	
AVE PKTQ/BW	%	86.6	74.9		53.3	53.0	
RELAXATION TIME	SEC	30	30		30	30	
CONTRACTION TIME	SEC	5	5		5	5	
COEFF. OF VAR.	%	7.6	1.4		8.2	2.4	
AGON/ANTAG RATIO	%	63.0			71.6		

3/7/19
~5 months

Long-term Outcomes

Kaur et al (2016)

- Systematic review and meta-analysis
- Strong evidence for lower peak flexion moments in ACLR compared to control and contralateral limb during walking/stair activities
- Strong to moderate evidence for lower peak adduction in ACLR compared to contralateral limb during walking stair descent
- Persisted for 6 years following surgery

Abourezk et al (2016)

- Hamstring strength asymmetry was found 3 years out from ACL-R auto hamstring
- Altered sagittal plane during gait and transverse plane during gait and jogging

Long-term Outcomes

Tengman et al (2014)

- 70 total patients, unilat ACL injury (21 with ACL-R and PT, 23 with PT alone) compared with age- and gender- matched controls
- 20 years from injury
- Knee extension peak torque, concentric and eccentric, was 10% lower for injured leg compared with non-injured leg
- No difference between uninvolved and healthy controls
- No difference between degree of OA

Development of OA

- Barenius AJSM 2014
  - Medial compartment OA inc compared to uninvolved side
  - 132 ACLR, 14 years, 57% OA

Questions