How to Effectively Use Isometric Strength Testing post ACL Reconstruction

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Post ACLR:

- 81% return to any level of sport
- 65% return to preinjury level of sport
- 55% return to competitive sports

Up to 23-30% of young athletes will suffer a 2nd ACL rupture within the first few years after surgery

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Return to sport decision making is **complex** and **multifactorial**

- Decisions must be **individualized** based on contextual factors
- Consider psychological readiness, physical readiness, work-load management, and biological healing time

Given the poor outcomes, how we program and make decisions regarding rehab completion and RTS readiness is critical!!

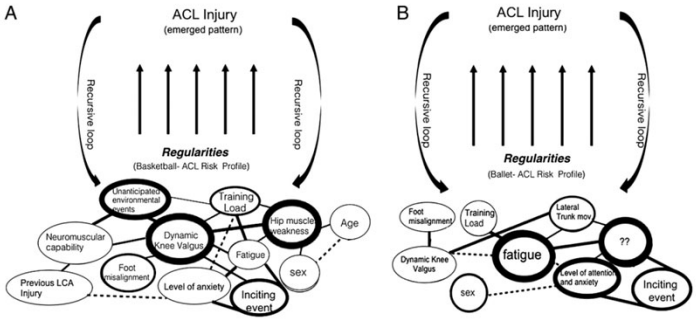

Figure 2 (A) Web of determinants for an ACL injury in basketball athletes and (B) web of determinants for an ACL injury in ballet dancer.

Bittencourt NFN, *et al. Br J Sports Med* 2016;**0**:1–7. doi:10.1136/bjsports-2015-095850

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Zooming in

Define:

- Strength is dependent on context
- Strength is the ability to exert force on an external object

F = mass * Acceleration

Force is key whether discussing an elite athlete wanting to return to highest level or a geriatric patient working to reduce fall risk

Knee extensor force

- Torque = Force* moment arm * sin(theta)

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Of note, **60-85% of**
quad symmetry and
bodyweight values b

Quadriceps strength
I sport was a signific
reinjury, with **3 % re**
every one percentag
symmetry

REDUCE REINJURY RISK AFTER
MENT RECONSTRUCTION:
STUDY

Mackler, PT, ScD, SCS, ATC, FAPTA[2], Håvard
MD, PhD[3,4], and May Arna Risberg, PT, PhD[1,4]

to enhance safe return to sports
ent reconstruction

affagnini[3] · Romain Seil[4] ·

s Patient Function More Than Single
Stage ACL Rehabilitation

ooke Farmer, MS, ATC[1], Dimitrios Katsavelis, PhD[2],
, Chris Wichman, PhD[1], Terry L. Grindstaff, PhD, PT, ATC[3]

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How to Test Isometric Knee Extensor Force

Biodex or Cybex

Dynamometer

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Hand Held Dynamometers


Prices range from $220-1500.
HHD's are more affordable than isokinetic testing.
You cannot afford not to test!

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Inline dynamometry provides reliable measurements of quadriceps strength in healthy and ACL-reconstructed individuals and is a valid substitute for isometric electromechanical dynamometry following ACL reconstruction

Richard Norris [a,b,*], Scot Morrison [c,d], Alan Price [a], Sian Pulford [e], Erik Meira [f], Seth O'Neill [g], Huw Williams [e], Thomas W. Maddox [b,h], Paul Carter [a], Rachel A. Oldershaw [b,i]

VALIDITY OF HAND-HELD DYNAMOMETRY IN MEASURING QUADRICEPS STRENGTH AND RATE OF TORQUE DEVELOPMENT

Joseph Lesnak, PT, DPT,[1] Dillon Anderson, SPT,[1] Brooke Farmer, MS, ATC,[1] Dimitrios Katsavelis, PhD,[2] and Terry L. Grindstaff, PT, PhD, ATC[1]

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What are we assessing with Isometric testing?

Quadriceps Steadiness

Limb Symmetry Index

Torque to Body Weight Ratio

Rate of Torque Development

Refer to baseline isometric testing if you have it

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Week	Criteria	Progression
6	Quad MVIC LSI > 60%	Modify programming based on results Monitor for AMI
9	Quad MVIC LSI > 70%	
12	Quad MVIC LSI > 75%	Jumping Running
16	Quad MVIC LSI > 80%	Start on Field Training – Speed and COD
24 (6M)	Quad MVIC LSI > 85%	Start noncontact practice
36 (9M)	Quad MVIC LSI > 90%	Start contact practice Progress to full return to sport

Adapted from Univ of Delaware ACLR protocol

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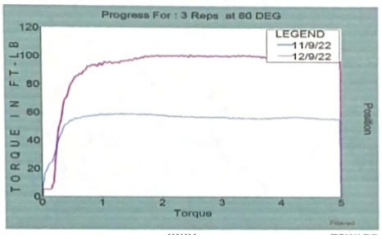
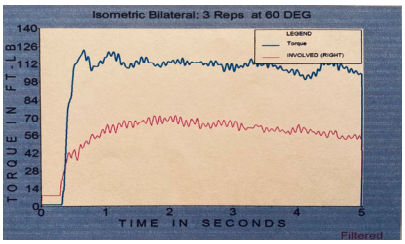
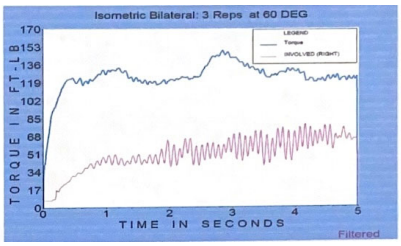
Quad/Torque Steadiness







Good quad steadiness:
- Good response to Strengthening

Fair quad steadiness:
- Fair response to strengthening
- Utilize NMES, interventions to mitigate AMI

Poor quad steadiness:
- Anticipate slower rate of quad strength recovery
- NMES, joint cooling, BFR, eccentric exercises, cross exercise, fatigue antagonists (hamstrings)

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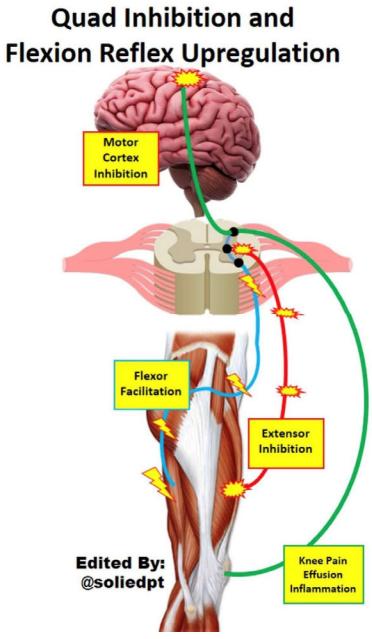

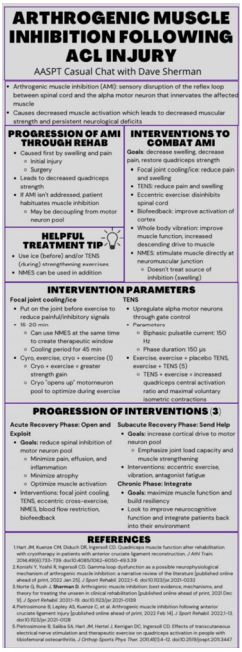
ARTHROGENIC MUSCLE INHIBITION FOLLOWING ACL INJURY

AASPT Casual Chat with Dave Sherman

- Arthrogenic muscle inhibition (AMI): sensory disruption of the reflex loop between spinal cord and the alpha motor neuron that innervates the affected muscle
- Causes decreased muscle activation which leads to decreased muscular strength and persistent neurological deficits

PROGRESSION OF AMI THROUGH REHAB
- Caused first by swelling and pain
  - Initial injury
  - Surgery
- Leads to decreased quadriceps strength
- If AMI isn't addressed, patient habituates muscle inhibition
  - May be decoupling from motor neuron pool

INTERVENTIONS TO COMBAT AMI

Goals: decrease swelling, decrease pain, restore quadriceps strength
- Focal joint cooling/ice: reduce pain and swelling
- TENS: reduce pain and swelling
- Eccentric exercise: disinhibits spinal cord
- Biofeedback: improve activation of cortex
- Whole body vibration: improve muscle function, increased descending drive to muscle
- NMES: stimulate muscle directly at neuromuscular junction
  - Doesn't treat source of inhibition (swelling)

HELPFUL TREATMENT TIP
- Use ice (before) and/or TENS (during) strengthening exercises
- NMES can be used in addition

INTERVENTION PARAMETERS

Focal joint cooling/ice
- Put on the joint before exercise to reduce painful/inhibitory signals
- 15- 20 min
  - Can use NMES at the same time to create therapeutic window
  - Cooling period for 45 min
- Cyro, exercise, cryo + exercise (!)
  - Cryo + exercise = greater strength gain
  - Cryo "opens up" motorneuron pool to optimize during exercise

TENS
- Upregulate alpha motor neurons through gate control
- Parameters
  - Biphasic pulsatile current: 150 Hz
  - Phase duration: 150 µs
- Exercise, exercise + placebo TENS, exercise + TENS (5)
  - TENS + exercise = increased quadriceps central activation ratio and maximal voluntary isometric contractions

PROGRESSION OF INTERVENTIONS (3)

Acute Recovery Phase: Open and Exploit
- Goals: reduce spinal inhibition of motor neuron pool
  - Minimize pain, effusion, and inflammation
  - Minimize atrophy
  - Optimize muscle activation
- Interventions: focal joint cooling, TENS, eccentric cross-exercise, NMES, blood flow restriction, biofeedback

Subacute Recovery Phase: Send Help
- Goals: increase cortical drive to motor neuron pool
  - Emphasize joint load capacity and muscle strengthening
- Interventions: eccentric exercise, vibration, antagonist fatigue

Chronic Phase: Integrate
- Goals: maximize muscle function and build resiliency
- Look to improve neurocognitive function and integrate patients back into their environment

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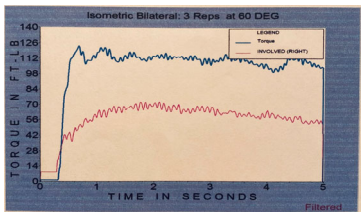
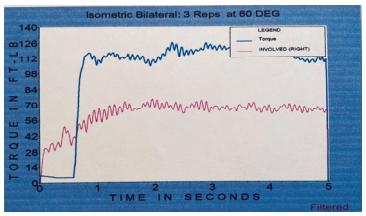
Case Suspecting AMI



Right Quad LSI: 58%
Peak torque:
- R: 70.4 ft/lbs
- L: 121.4 ft/lbs

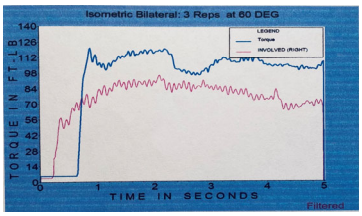
TQ/BW:
- R: 48.1%
- L: 96.7%



Right Quad LSI: 58.7%
Peak torque:
- R: 72.8 ft/lbs
- L: 124.2 ft/lbs

TQ/BW:
- R: 53%
- L: 95%

*Adjusted program
- AMI interventions



Right Quad LSI: 79.3%
Peak torque:
- R: 95.1 ft/lbs
- L: 119.9 ft/lbs

TQ/BW:
- R: 69.4%
- L: 96%

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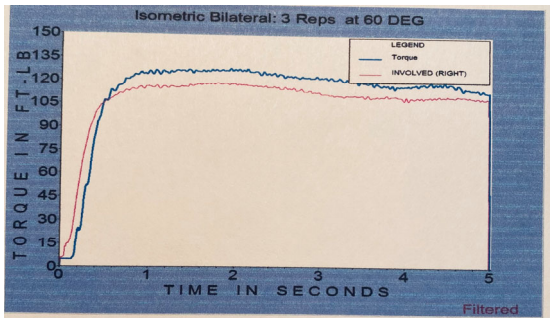
Peak Maximal Force - LSI

Limb Symmetry Index (LSI)
- Expresses the magnitude of difference in torque between limbs
- LSI = involved/uninvolved converted to a percentage
- Clinical threshold for RTS is an LSI > or = to 90%
  - (Sinacore 2017, Grindem 2020, Grindem 2016, Kyritsis 2016)

Limitations
- May overestimate function
- Specifically if uninvolved limb has a history of previous injury or develops weakness due to misuse (Wellsandt 2017)



LSI: 93%

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Torque to Bodyweight

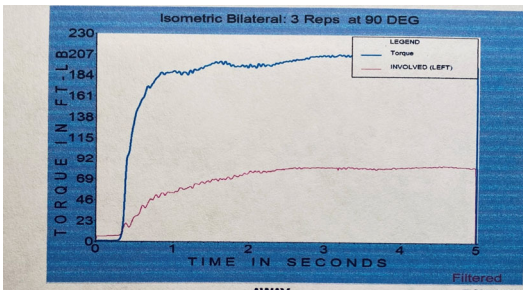
Correlation between quadriceps torque-to-bodyweight ratio and function

- Clinical thresholds for isometric quad strength
  - 3.0 Nm/kg = 100% torque to bodyweight (1 ftlb/lb)
  - (Kuenze C 2015, Pietrosimone B 2016)

70 subjects tested prior to ACLR

- At 6 months post op:
  - 57% had >90% LSI compared to uninvolved
  - Only 29% met > 90% LSI comparing involved to Pre-op data of uninvolved (Wellsandt E 2017)

Refer to baseline testing if you have it
At a minimum, aim for > 100% TQ/BW



		AWAY 90 DEG			TOWARD 90 DEG	
F REPS (90 DEG): R 3 - L 3		UNINV	INV	DEFICIT	UNINV	INV
		Right	Left		Right	Left
PEAK TORQUE	FT-LBS	207.8	85.1	59.1	0.0	0.0
AVG PEAK TQ	FT-LBS	206.5	74.5		0.0	0.0
AVE PKTQ/BW	%	138.6	50.0		0.0	0.0

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Rate of Torque Development

Rate of torque is the instantaneous change in force

- The slope of the line

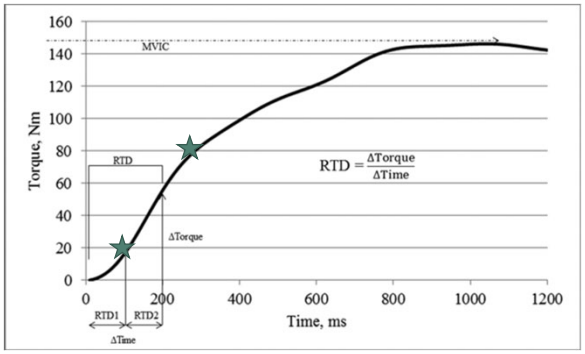
RFD is vital due to time constraints in most tasks

- Slow SSC >0.250 (change of direction)
- Fast SSC < 0.250 (ground contact time)
  - Elite sprinter < 0.100
  - Elite marathoner < 0.200

Difficult to measure in the clinic

- Slope between 20% and 80% peak torque

Illustrate how fast they can access peak torque



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Quad Performance

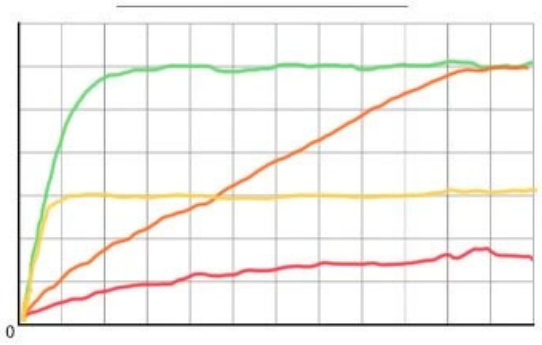
Green:
High Peak Maximal Force with High Rate of Force

Orange:
High Peak Maximal Force with low rate of force

Yellow:
Low peak maximal force with High Rate of Force

Red:
Low peak maximal force with low rate of force

*standardize Peak force/torque to bodyweight



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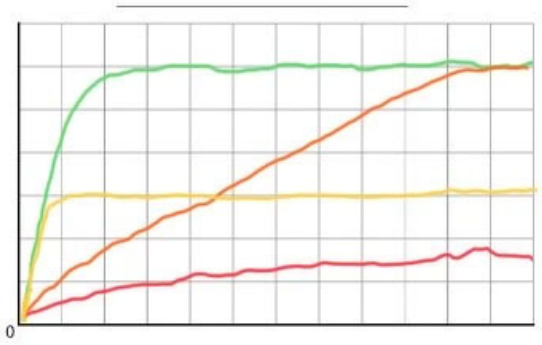
Quad Performance

Insufficient peak maximal force (yellow) and a sufficient peak maximal force that can't be accessed quickly (orange) due to time constraints are both an issue!

Need to work on both with the last one, prioritize peak



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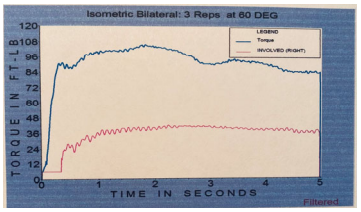
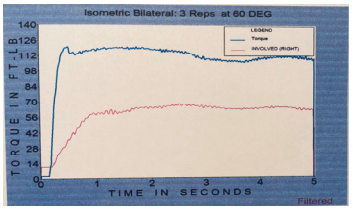
Progressive Overload Focus



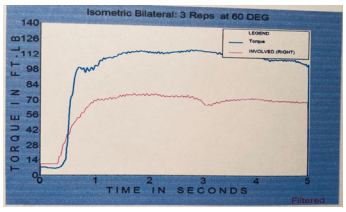
Right Quad LSI: 39.6%
Peak torque:
- R: 41.8 ft/lbs
- L: 105.6 ft/lbs

TQ/BW:
- R: 35.65%
- L: 92.6%



Right Quad LSI: 56.6%
Peak torque:
- R: 67.6 ft/lbs
- L: 119.5 ft/lbs

TQ/BW:
- R: 59.1%
- L: 106.2%



Right Quad LSI: 64.7%
Peak torque:
- R: 77 ft/lbs
- L: 118.9 ft/lbs

TQ/BW:
- R: 67%
- L: 104.8%

Progressed to jogging and non-counter reactive strength drills

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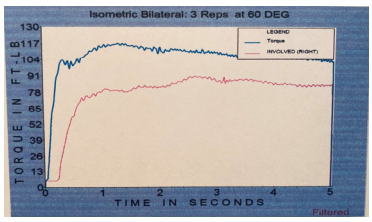
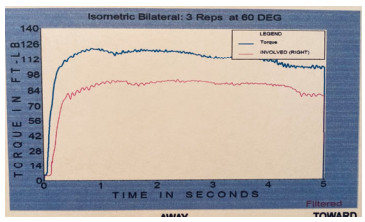
Progressive Overload Focus



Right Quad LSI: 77.6%
Peak torque:
- R: 90.8 ft/lbs
- L: 117 ft/lbs

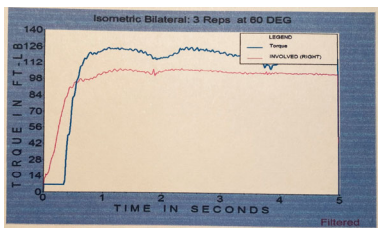
TQ/BW:
- R: 81%
- L: 104.9%



Right Quad LSI: 76.5%
Peak torque:
- R: 93.2 ft/lbs
- L: 121.8 ft/lbs

TQ/BW:
- R: 78%
- L: 102.6%

*Adjusted program



Right Quad LSI: 84.9%
Peak torque:
- R: 107.4 ft/lbs
- L: 126.5 ft/lbs

TQ/BW:
- R: 91.4%
- L: 115%

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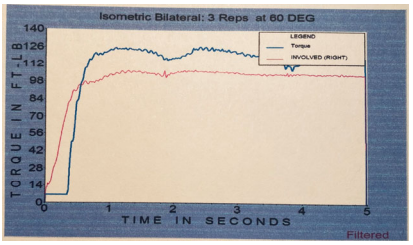
Power Focus

Late phase:
- Focus shifted to explosive power, reactive/elastic strength
- Emphasis on restoring "Rate" (RTD) along with Peak LSI

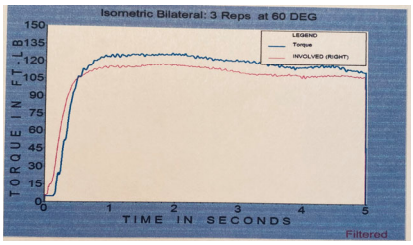
Right Quad LSI: 84.9%
Peak torque:
- R: 107.4 ft/lbs
- L: 126.5 ft/lbs

TQ/BW:
- R: 91.4%
- L: 115%



Right Quad LSI: 92.9%
Peak torque:
- R: 118.8 ft/lbs
- L: 127.9 ft/lbs

TQ/BW:
- R: 101.5%
- L: 116.1%



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Take Home Points…

Assess Don't Guess

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