The ACL From A-Z

Zach Christopherson, DPT, SCS, COMT
Combined Sections Meeting
February 16th, 2017

Educational Session Objective
• Outline care of the ACLr from on-field evaluation to return to play

Acknowledgement
• The Sports Section
  • Erik Meira & Mike Mullaney
• Fellow Presenters
  • Dr. Dan Lorenz
  • Dr. Barton Bishop
  • Dr. McCullough
• Mentors
  • Robert Bruzga
  • Kerry Mullenix
  • Mike Essa
  • Brian Wurzinger
  • Corine Martinez
  • Duke Sports Physical Therapy

On-Field Evaluation and Management of the ACL Injury

Objectives: On-Field Management
• Discuss the Emergency Action Plan (EAP)
• Highlight on-field evaluation of an ACL injury
• Discuss when an ACL injury becomes an emergency
• Review transfer techniques
• Highlight the components of the sideline
• Discuss means of effective communication with involved parties
• Discuss facilitation of next step in medical management

Financial Disclosures

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Financial Disclosures
What is Your Environment?

The Emergency Action Plan (EAP)

- "Blueprint" for handling emergencies, outlines roles and responsibilities
- Helps protect you in case of legal action resulting from emergency
- Time out with other medical personnel prior to event to review EAP

National Athletic Trainers’ Association Position Statement: Emergency Planning in Athletics

J. C. Anderson*, Ronald W. Cowser†, Douglas M. Kleiner‡, Todd A. McLaughlin

Bring the Calm
On-Field Exam Time: Considerations

- Emergent verse non-emergent situation
- Emotional state of the athlete
- Ability to adjust environment

Consent to Treat

- In non-emergent situations, consent must be obtained.
- Verbal vs Written
  - Introduce (Name, Credentials, Ask for consent)
- Minor vs Adult (Martin 1994)
  - Part IV of the Juvenile Justice Standards Project outlines conditions under which a minor may receive medical care without parental consent
  - When the patient is a minor, the parent/guardian is the optimal consent-giver.

On-Field Evaluation: Primary Survey

- Circulation, Airway, Breathing, Consciousness, Shock
- Injured athletes who are conscious and stable do not require primary survey.
- American Psychiatric Association principles for the emergency care of emotional reactions to trauma:
  - Accept everyone’s right to personal feelings
  - Do not tell the injured person how to feel; instead show empathy not pity
  - Accept the athlete’s limitations as real
  - Accept your own limitation as a provider of first aid

On-Field Evaluation: Secondary Survey

- Subjective
  - Where does it hurt specifically?
  - Did you hear or feel a snap, crack or pop?
- Observe and palpate for deformities
  - Patellar/quad tendon
  - Patella
  - Joint line
- Incidence of dislocations (Majewski et al. 2006)
  - 3.3% of knee injuries
  - Primarily patellofemoral
  - Tibiofemoral very rare

On-Field Evaluation: Secondary Survey

- Neuro/Vascular
  - Sensation and motor control distal to site of injury
  - Pulses if suspect serious injury
  - Ankle Brachial Pressure Index of less than 0.9 (Howells et al. 2011)

Incidence of common peroneal nerve injury: 14% - 25%
Incidence of vascular injury: 7.5 - 14%
Initial Assessment: Considerations

- Severity of the injury
- Immobilization or splinting needs
- Transportation off the field to the sideline or hospital

Severity of Injury

Is this something that I need to call on?

- If not life or limb threatening, get athlete to sideline as fast as is safe.

Emergency Splinting

- Apply dressing to any open wound.
- Splint in the position in which injury is found.
- Make sure the splint immobilizes the injury and doesn’t permit movement.
- Immobilize joints above and below the site of injury.
- Serially monitor neurovascular status below site of injury

Pittsburgh Knee Decision Rule

- Test for fracture at the knee
  1. Hx of blunt trauma or fall
  2. Inability to bear weight both immediately and in ER for 4 steps
  3. < 12 yo or >50 yo
- Positive test = 1 + 2 or 3
- Positive test requires referral for x-ray

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<th>Study</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>QUADAS score</th>
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Sideline Evaluation

- Remove obstructive clothing, padding or brace
- Observe and palpate for swelling
- ROM
  - Knee flexion, extension
- Neuro/Vascular
  - Sensation: Peroneal
  - Motor: DF, Ev, PF, Inv
  - Pedal pulse

Transporting the athlete

Factors to consider
- Severity of injury
- Emotional state of athlete
- Desire of the athlete
- Distance
Sideline Evaluation

Further special tests
- Ligament testing
- Meniscus

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Sensitivity Specificity QUADAS score

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<td>Rose &amp; Gold 1996 (Anterior Drawer, Lachman’s, Pivot Shift)</td>
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<td>Wagemaker et al. 2010 (Hx; effusion, popping, giving way; Exam: anterior drawer)</td>
<td>18</td>
<td>98</td>
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<tr>
<td>3 from history + anterior drawer</td>
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Secondary Assessment: Considerations

- What communication needs to take place?
- Initial treatment/HEP
- Physician referral

Great decision next exit

Communication is Key

Coaches
Player
Other medical personnel
Other Staff
Parents

Initial Treatment and HEP

Goals:
- Protect knee
- Control pain
- Reduce swelling and excessive inflammation

PRICER
Protect
Rest
Ice
Compress
Elevate
Refer / Rehab

Summary

- Establish an EAP and review it prior to competition.
- Bring the calm, manage the environment and know your limits.
- Most ACLs are non emergent injuries, get the athlete to the side line as fast as is safe.
- Basic exam includes: observation, palpation, ROM, neurovascular and special test.
- Effective communication is KEY.
- Initial treatment = PRICER
References


Thank You!

- zachary.christopherson@duke.edu
- @zachary_ross3
- @DukeSportsPTF
ACL Reconstruction
Surgical Management Update

Kirk A. McCullough, M.D.
Kansas City Orthopaedic Institute
Leawood, KS

Disclosure

• I have no relevant disclosures related to the content of the presentation

Session Learning Objectives

• Anatomic considerations for ACLR
  – Tunnel placement
  – Graft type
  – Fixation
  – ALL (Anterolateral Ligament)
• Additional Considerations for ACLR
  – Psychological
  – Intra-articular inflammation

ACLR Considerations

Tunnel Placement

• Define the problem
  – Femoral footprint area is 3.5x size of midsubstance ACL
    • 85-200 mm² compared to 70 mm² for 10mm tunnel
  – Can’t “fill” the footprint - must be strategic
• Historically
  – Two-incision technique
    • Independent femoral and tibial tunnels
  – Transtibial technique
    • “Dependent” tibial and femoral tunnels
    • Tibial mean anatomic in native footprint
    • Femoral transverse “vertical”

ACLR Considerations

Tunnel Placement

• “Freddie Fu Effect”
  – Double-bundle technique
    • Still utilized by some when anatomy can accommodate (>18mm)
  – Subsequent research
  – **Optimal anatomic placement of tunnels emphasized**
    • Biomechanical testing
      • Graft in center of footprint more accurately restores AP and rotational stability than vertical non-anatomic grafts
        – Beaulé et al 2011
        – Kondo et al 2011
        – D’Ambrosio et al 2012
        – D’Ambrosio et al 2012
“Anatomic” AM portal technique
- Independent tunnel drilling
- Aim is for central placement of tunnels between bundles on tibia AND femur
- Concerns
  - Increased graft tension??
  - PCL impingement if TOO “low”?
- “IDEAL” Tunnel

CONCLUSIONS
• Anatomic restoration important
  - HOWEVER, questions still remain
    - How important is attempt at gaining isometry?
    - Some short-term data suggests AM portal leads to early failure
    - Some very good long-term data on transtibial
  - Reality:
    - Excessively “low” tunnel probably just as detrimental as “vertical” femoral tunnel

ACLR Considerations
Graft Type

• Autograft
  - Patellar tendon
  - Hamstring
  - Quadriceps
  - Bone
  - All soft tissue
• Allograft

Graft Options

• Autograft
  - No “clear” winner
  - Patellar BTB
  - NFL physicians survey - majority utilize patellar BTB for 1° ACL
  - No SURF at the anterior knee area
  - Hamstring
    - Early graft incorporation takes longer
    - Sharpey’s fibers begin maturation at 12 wks
  - Suspension fixation
    - “Windshield wiper” effect
    - If more than 3mm graft movement – won’t incorporate
    - Size matters = 8mm diameter or >
  - Quadriceps
    - Biomechanical/Histologic studies
      - More collagen and stronger at time of reconstruction
      - Long term data lacking compared to volume of hamstring/BTB studies

• Allograft
  - Allure is loss of donor site morbidity
  - “Blessing in disguise”
    - Graft incorporation LONGER than autograft
    - Schaffer et al 2006
    - Non-compliance early on 2/2 lack of protective pain
    - Certainly not all allograft is same
  - Preparation (cleanse/sterilization process)
    - General consensus:
      - Use in young patients <30yo discouraged 2/2 high failure rates in literature
ACLR Considerations

Fixation

• Ideal device:
  – Secure fixation (cyclic displacement, ultimate load to failure, strain, etc)
  – Allows for imaging post-op (e.g., MRI)
  – Permits revision surgery without excess tissue/bone loss
  – Low risk comorbidity
  – Versatile, reproducible, easy to use

Fixation Options

• Suspensory
  – Cortical
  – Endobutton
  – Staples
  – Screw post
  – Cancellous
    • Transfixion pins
• Interference/Aperture
  – Stainless/Steel
  – Bioabsorbable

ACLR Considerations

Fixation Options

• Potential concerns
  – Soft tissue graft + Suspensory fixation
  – Graft incorporation
  – Windshield-wiper effect
  – Hybrid construct (Suspensory Femur and 2nd generation tibial interference)
    Better than screw alone (Prodromos et al 2005)
  – Interference screws
    • Bioabsorbable tend to cause more tunnel widening compared to metal
  • KNOW your graft and KNOW your fixation

Anterolateral Ligament

• Since 2013, 105 articles published on ALL
• HOWEVER, not so “new” structure
• Dr. Paul Segond
  – 1879 – Avulsion injury off of anterolateral tibia
  • Pathognomonic for ACL tear
• Hughston et al JBUJ Am 1976
  – “The middle 1/3 of the lateral ligaments, composed of IT band and the capsular ligament deep to it, extends posteriorly as far the the fibular collateral ligament”
Important for internal rotation
  – Most significantly after 35° flex

• Cut the ALL, 1+ pivot shift
• Cut the ACL, 1+ pivot shift
• Cut BOTH, 3+ pivot shift

• Claes S et al. *J of Anatomy* 2013

**ALL Reconstruction**

**Considerations**

• 3+ pivot shift
• Hyperextension > 10° recurvatum
• Segond fracture
• Revision reconstruction
• Systemic ligamentous laxity
• Accentuated lateral femoral sulcus sign (x-ray)/large lateral bone bruise

**ACL Considerations**

**Psychological Factors**

• Frequently success in ACLR determined by objective measures
  – Laxity assessment with KT-1000
  – Functional testing score
• Yet RTP/function has remained surprisingly low
  – Ardern et al 2014 *Br J Sport Med*
    • Only 65% return to pre-injury level of sport
    • Only 55% return to competitive sports
• Return to Play after ACLR frequently affected by psychological factors
  – 20% of all pts with ACLR cite psychological factors as primary reason for not RTP
• Most established ACL rehab and return to sport criteria do NOT include assessment or recommendations for intervention

**MOON Cohort retrospective study from 2002 and 2003 collection years**

• 147 amateur football players
• 30% no RTP
  – Of these 50% cited fear of re-injury as reason

**ACL Considerations**

**Psychological**

• MOON Cohort retrospective study from 2002 and 2003 collection years
• 147 amateur football players
• 30% no RTP
  – Of these 50% cited fear of re-injury as reason

**Return to High School- and College-Level Football After Anterior Cruciate Ligament Reconstruction**

**A Multicenter Orthopaedic Outcomes Network (MOON) Cohort Study**

• 46 pts with assessment of RTP @ 6 mo and 1 yr following ACLR
• Pts divided into groups based upon return to sport status @ 1 yr
• In patients with no return to sport due to fear/lack of confidence, three main characteristics found (compared to successful RTP):
  – Quad weakness
  – Reduced knee flexion
  – Elevated pain-related fear of re-injury
• Assessment of these parameters @ 6 months may help identify pts at risk for no RTP @ 1 year

**Comparison of Physical Impairment, Functional, and Psychosocial Measures Based on Fear of Re-injury/Lack of Confidence and Return-to-Sport Status After ACL Reconstruction**

*The American Journal of Sports Medicine, Vol. 41, No. 11* 2013 The Author
ACLR Considerations

Intra-articular Inflammation

• Despite reconstruction, risk of early onset OA changes @ 5-6 years post-injury has been well established – Ferretti et al 1991; Cameron et al 1997
• Known up-regulation/release of inflammatory cytokines with intra-articular trauma from ACL injury
• Concern that prolonged inflammation and 2ndary cartilage breakdown/apoptotic pathway initiation may occur despite restoration of normal joint kinematics

A Multicenter Study of Early Anti-inflammatory Treatment in Patients With Acute Anterior Cruciate Ligament Tear

• 49 pts randomized to 4 groups
  – Kenalog @ 4 days, placebo @ 2 wks
  – Placebo @ 4 days, Kenalog @ 2 wks
  – Kenalog @ both
  – Placebo @ both
• PRO and synovial biomarkers @ 4 d, 11 d, and 5 wks
• Chondrodegenerative markers worsened over 1-5 wks
• PRO no different among groups
• Increased type II collagen breakdown in placebo compared to groups that received CSI in first several days after injury
• Further study needed
• Risk vs benefit of steroid in acutely injured knee that needs surgery – Infection risk – 2ndary steroid risk
• Potential role for PRP/BMAC injection???

Conclusions

• Continued advances, newer techniques for ACLR
• Restoration of anatomy and prevention of pathomechanics paramount
• Repair a future option?
  – Sheath/Membrane to isolate ACL from articular environment/joint fluid + Biologics
  – Time Zero stability with use of tension resistant scaffold
• Don’t overlook the “supratentorial effect” on function
  – Identification and effective communication are key

Select References

The ACL From A to Z: Early Stages of Rehab from Post Surgery to 3 Months Post Op

Barton N. Bishop, DPT, SCS, TPI CGFI-MP2, CSCS
Combined Sections Meeting – APTA
Sports Section Educational Session
February 16, 2017

Disclosures
・ Consultant/Educator:
  • Performance Health
  • Hawk Grips
  • Motion Guidance
  • Verve
  • Everseat

Objectives
・ Strategies of 0-3 months post operative rehab
・ Discuss criterion based as opposed to temporal based rehab
・ Discuss rehab modifications for graft type
・ Discuss rehab modifications for meniscus involvement

Goals
・ Eliminate swelling (at least to minimal levels)
・ Return quad control/proprioception
・ Full knee extension (equal to contralateral knee)
・ Knee flexion to 115 degrees
・ No pain (joint line and patellofemoral area)
・ Glute max and medius activation

ACL Rehabilitation
Day 1 Post Surgery → 12 Weeks Post Surgery

Weeks 0-4 Post Op*
*Criterion Based Advancement
Research Game Ready and Normatec

- Cryotherapy and compression > Cryotherapy alone
  - Compliance: Waterman 2012, Barber 2000
  - Lower narcotic/pain med use: Murgier 2014, Barber 2000
  - Increased range of motion: Barber 2000
  - Recovery? (Not ACL specific): Sands 2015

Initial Quad Exercises

- Quad Sets
- Straight Leg Raise (get to full extension first)
- Short Arc Quads
- Long Arc Quads (Knee Extensions)
- Terminal Knee Extension
- Minisquats

External Cuing
**Proprioception and ACLR**

- Pre-Post ACLR deficits in frontal and sagittal planes
- Frontal and sagittal planes on jump landing
- Knee Valgus and Hip Adduction at initial ground contact
- Knee Valgus angle and Knee Valgus Angle landing phase
- Knee extensor, hip flexor moment, and ant tib shear force in landing phase

  Goerger 2015

- Static proprioceptive differences post ACLR post return to physical activity

  Relph 2015

**External Cuing and Exercise/Movement**

- Improved firing patterns of glute max during bridging
  Kim 2016

- Improved motor pattern learning
  Wulf 2010

**Terminal Knee Extension**

**Step Up/Down**

**Squat (Contralateral Unloaded)**

**Varus/Valgus Control**
Squat Mechanics

Other Exercises – Glute Max/Med

- Weight shifts
- Single Leg Stance
- Prone Hip Extension
- Sidelying Hip Abduction
- Clams (with resistance)
- Bridging (with resistance)
- Firehydrant

(Selkowitz 2013, Bishop 2014)

Bridging

Clams

Fire Hydrant

Modifications

- For Hamstring Autograft
- For Patellar Tendon
- For Meniscus Repair
Hamstring Tendon Graft
• Avoid hamstring exercises until ~Week 2
• Avoid resisted hamstring exercises until ~Week 4-6
• Limit hamstring stretching initially
• Careful with hyperextension

Patellar Tendon/Ligament Graft
• Delay OKC resisted quad exercises for X weeks?
• Watch for anterior knee pain/adhesions (ensure flexion goals are met)
  • Anterior knee pain with extension
  • Careful with kneeling in first few weeks

ACLR with Meniscus Repair
• To weight bear or not to weight bear?
  • Better outcomes with early weight bearing with and without ACLR
  • Better outcomes with early WB and ACLR
  • Systematic Review – similar outcomes regardless of weight bearing status
  • Recommend early weight bearing locked in ext for 4-6 weeks

ACLR with Meniscus Repair
• Better outcomes with early weight bearing with and without ACLR
  • Shelbourne 1996
  • Barber 1997
  • Systematic Review – similar outcomes regardless of weight bearing status
  • VanderHave 2015

Goals
• Eliminate swelling
• Return quad control/proprioception
• Full, pain free ROM
• Normal gait pattern
• Normal ADLs
• Increase strength
• KT-2000? – 30lb Ant-Post
• Isokinetics? – 180 and 300°/s

Weeks 5-12 Post Op
Thank you CSM!

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The ACL from A to Z: Performance Enhancement in the Terminal Phases & Return to Sport
Dan Lorenz, DPT, PT, ATC/L, CSCS
Combined Sections Meeting
February 18, 2017

No Conflicts of Interest, No Disclosures

THANK YOU!!!
• The Sports Section
• Erik Meira & Mike Mullaney
• Zach Christopherson
• Dr. McCullough for taking the time to be here and share with us
• My family
• My mentors along the way

What’s the Problem?
• Strength training data is often based on one-repetition maximum (1RM)
• Manipulating of training variables is more an “art”
• No “best” way to rehabilitate/train
• The venue can be challenging
  — “Disneyland” v. a basement gym

Sooo...what’s your reality?
Let’s make sure we’re on the same page…

Definitions Ardern et al, BJSM 2016

To Make Informed RTS Decision:
Need to know sport and the level of participation that athlete aims to return to

Return to PARTICIPATION
Athlete participating in training (modified or restricted), or in sport, but at a level lower than the desired RTS

Return to SPORT
Athlete has returned to their defined sport, but is not performing at his or her desired performance level

Return to PERFORMANCE
— Athlete has returned to sport and is performing at or above his or her preinjury level
— Might have personal best or expected personal best?

Where is your athlete on this RTS continuum??

RTS Lentz et al, JOSPT

Why no RTS?
Kinesiophobia* - more present in low level athletes
Instability* - 31 patients responded they had instability (68%)
Quad PT/BW ratio* important test parameter
quads are shock absorbers
Wilk et al, JOSPT 1994 correlation b/w QPT/BW
IKDC scores (15 pts difference)*
Knee effusion (present in 9 pts)* - 21%
Pain scale difference* Tegner scale differences
**Performance/End-Stage & RTS – Why is this so dang hard?**

- Re-tear rates are extremely high!
- More based on “time” rather than specific objective criteria
- Many advocated testing measures (i.e. isokinetics) are not in most facilities
- Progressions in late-stages can be vague, more “artsy”, less specific
- Graft differences
- Based on athlete perception of “readiness”

**Return to Sport**

- **Insufficient return to sport guidelines** may underlie poor return to sport rates
- **Relevant measures** may be absent
- **Inconsistency** in measures and targets

**Return to Sport Ardern et al, BJSM 2014**

- Not everyone returns to sport after ACL
  - 81% returned to any sport
  - 65% returned to pre-injury level
  - 53% returned to competitive sport

**What’s the criteria to be in the “terminal” or performance enhancement phase?**

**Important concept...**

**We develop ATHLETICISM, NOT skill!**

“You get better at basketball by playing basketball”

**What does the patient need?**

1. Static and dynamic **stability**
2. Good/normal articular surface/meniscus
3. **Full ROM**
4. **Neuromuscular control** of the extremity
5. Hip and Foot/Ankle Control
6. **Quad strength**
7. **Limb confidence**
Preparing the Athlete for Performance Training

- Do they have appropriate...?
  - Mobility
  - Exercise technique
  - Performance Qualities
    - Strength, Power, Elastic/Reactive
    - Strength, Speed
  - Work Capacity

Why Screen or Pretest?

“A training program that focuses on the least developed factor contributing to maximal power will prompt the greatest neuromuscular adaptations and therefore result in superior performance improvements.”


What Performance Characteristics Determine Elite Performance? (Lorenz et al, Sports Health)

- In the anaerobic athlete: POWER
- In the endurance athlete: Elite test better in training variable tested, BUT running performance and economy related to ability to produce force or running velocity at VO2 Max

Athletic Performance

- The fastest and most powerful athletes in the world are those that place the greatest amount of force into the ground surface area in the shortest period of time.
- “The fastest athletes spend the least amount of time on the ground (.07-.09 sec sprinting speed)”
- “Main determinant of achieving maximum sprint speed was reducing the contact time during the stance phase” Mann 1998

Athletic Performance

- “Because of the narrow constraints on the minimum swing times and maximum contacts lengths that runners can use, speed is conferred predominately by an enhanced ability to generate and transmit muscular force to the ground.” Weyand J Appl Physiol 2000

Strength is the foundation for athletic performance...so if it is lacking in that limb...
Quadzilla!!!!!

  - 96 subjects, isometric quad strength at 90° flexion after primary ACLR
  - Quad strength normalized to body mass strong predictor of self-reported function

Eccentric Strength after ACL

- Studies have shown increased quad strength, quad mass, and subjective outcomes in subjects who utilized eccentric training during rehabilitation
  - Gerber et al, JOSPT 2006
  - Gerber et al, JBJS 2007
  - Gerber et al, PT Journal 2009

Eccentric Quad

Eccentric Strength

- Strength increased with higher load/intensity
- Eccentric strength critical for change of direction performance
  - Spiteri et al, J Strength Cond Res 2014
- Force-Velocity Curve
  - Greatest tension at high deceleration
  - Needed for deceleration/cutting

Eccentric Training

- Eccentric Training: Increases agonist volitional drive
  - Fast motor unit recruitment
  - Muscle CSA
  - Number of sarcomeres in series
    - Increases shortening velocity
  - Type IIX composition
    - Most force!!
  - Tendon Stiffness

“Eccentrics improve strength, power, speed, SSC performance better than concentric training or other traditional modalities”
Single Leg Exercise  Neitzel et al, Clin Biomech 2002

- 24 patients per post-op group
- Measured WB on involved limb
- 6-12 weeks: “Unconsciously unload”
- 6-7 months: “Unconsciously unload”
- 12-14 months: “Do not unload”

**Benefit of early single-leg exercise!!

“Unconsciously Unloading”

- Recent studies have shown that even a year after ACL reconstruction, subjects continue to unload their involved limb during jumping tasks
  - Chmielewski et al, JOSPT 2011
  - Paterno et al, JOSPT 2011

Try this...

Open Chain Knee Extension

For many years, OKC =

Renewed Interest in OKC ex’s...

- Fukuda et al, AJSM 2014
  - RCT, Level 1 study
  - HS grafts
  - Early OKC – 4th P/O week, 90-45°
  - Late OKC – 12th P/O week, 0-90°
  - Early no different than late in terms of laxity
  - Faster recovery of quad strength in early
    - Better strength at 19- and 25-week and 17-month assessment
Similar results in other studies...

- Perry et al, KSSTA 2005
- Tagesson et al, AJSM 2008
- Glass et al, NAISPT 2010

But...careful when we start full arc!!
Greater laxity when started at 4 weeks compared to 12 weeks
Heijne & Werner, KSSTA 2007

Rate of Force Development in the ACL Reconstructed Knee

- 6 Months Post-op ACL Reconstruction
- MVIC – 97% preinjury value
  - RFD to 30% Max MVIC – 80% preinjury value
  - RFD to 50% Max MVIC – 77% preinjury value
  - RFD to 90% Max MVIC – 63% preinjury value
- The mean RFD values attained or exceed 90% preinjury values only at 12 months post-op

Why does this matter after ACL?

- Xergia et al, JOSPT 2013
  - 6-9 months s/p ACL reconstruction, subjects demonstrated kinematic differences w/ the involved side during functional hop testing
    - Landing and propelling with less ankle DF and less knee flexion
      - TRIPLE FLEXION!!!

  We have to do more to attenuate GRF’s through “triple flexion” and improve knee extensor strength

So they can...TRIPLE EXTEND!

KB Swings w/ a “Triple Extension Twist”
Facilitate Weight Shifting
Why should we facilitate *Triple Extension* earlier?

- Numerous studies have shown deficits in neuromuscular coordination following injury or surgery
  - Delahunt et al, *J Orthop Rel Res* 2012
  - Myers et al, *Man Ther* 2006
  - Nyland et al, *Knee* 2014

Explosive Strength/Power

- Power = Force X Velocity
- Optimal load for power is 30-45% of 1RM
- *Increase force production into the ground*
- “Triple Extension” required for sprinting
  - Ankle PF
  - Knee Extension **Achieved w/ Olympic lifting**
  - Hip Extension

Unilateral strength/power

- Lockie et al, *JSCR* 2014
  - Single leg horizontal and lateral jump power corresponded to multidirectional speed

Single Leg CMJ

- Benjanuvatra et al, *JSCR* 2013
  - Single leg CMJ should be used when assessing limb asymmetries

There’s something to this...

  - 45% of patients had poor performance on single leg squat test at 6 months s/p ACL reconstruction
  - Also showed poor hip abduction strength, decreased single leg hop distance, decreased IKDC scores, increased age

Plyometrics

- “Ply” = measure, “Metric” = increase
- Stretch-Shortening Cycle
  - Foundation of plyometrics
  - Deceleration followed by rapid acceleration
Guidelines

- Depth jumps (>18 inches) should not be performed by athletes >220 lbs
- Should not be performed on consecutive days for one muscle group
- Should not be performed when an athlete is fatigued
- Footwear and surface should have good shock absorbing capabilities
- Warm-up should be performed before program

Plyometric Recommendations – Soccer Athletes

- Systematic review of soccer players up to 17 y.o
- Program design recommendations:
  - 2x/week for 8-10 weeks
  - 72 hours between sessions
  - Foot contacts 50-60 per session, no more than 8-120
  - 3-4 exercises, 2-4 sets, for 6-15 reps
  - Supervision is key!

Progression of Plyometrics

- **Step 1:**
  - Jump TO box
  - Works on technique
  - 2 leg to 2 leg
  - 2 Leg to one leg
  - One leg to other leg (Bound)
  - Same leg to same leg

- **Step 2:**
  - Jump FROM box
  - Teaches muscle to override GTO

- **Step 3:**
  - Reactive

**Explosive Strength**

- Jumps TO Box
- Countermovement Jumps
- Lunge jumps
- Jump Squats
- "Scissors"/Split Jumps
- Stadium Steps
- Running Uphill

**Jumps TO**

**Bound TO**
**Starting Strength**

**Single Leg Vertical**

**Elastic/Reactive Strength**

- Leg **stiffness** is the ability of the leg musculature to resist lengthening when subjected to a given force. McMahonet et al. SCJ 2012
  - Need baseline strength to maximize elastic components
- Achieved with **plyometric training**
- Jumps FROM Box
  - **Stretch Shortening Cycle**
    - Eccentric phase
    - Amortization phase
    - Concentric phase

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**REMEMBER!!!!**

- **RUNNING** is the most basic plyometric activity we do!!
- Athletes should show proficiency with jumps TO box then jumps on land PRIOR TO starting a return to running program
Reactive

When can/should we start training agility?

Agility

- Change of direction in response to a sport-specific situation or stimulus
  - Physical component
    - Increase force production into the ground
  - Cognitive/"Technical" component
    - Ability to react
    - Ability to execute according to stimuli

"Precursor" to Agility Training

Therefore...

- Should demonstrate ability to shift weight fully to involved limb
- Have demonstrated good technique and willingness to load limb with forward/backward movement
- Should have demonstrated appropriate strength

Cognitive Component

- Have athlete react to stimulus
  - Clap to change direction
  - "Mirror" drills
  - "Chaos" drills
  - Roll/throw balls into agility drill, forcing athlete to react
Agility Training

• **Acceleration**
  - “Overspeed”
  - Power/explosiveness – Increase force production into the ground
  - Running uphill, resisted running

• **Deceleration**
  - Eccentric strength
  - Heavy step downs, eccentric-emphasized leg press, eccentric “drops”, jumps FROM box
  - Reactive strength
  - Plyometrics

Keys to Agility Training

• Identify elite athletes in the sport and how they move
• Practice agility in **game situations w/ time constraints**
• Match energy requirements to sport
• Focus on **lateral movements w/ plyometrics** for COD
• Include perception and decision making into tasks

Six Critical Factors for Proper Change of Direction

• Lower COM before the turn
• Move COM in direction the athlete is going
• Arms and legs close to body when turning
• COM ahead of take-off foot
• Full extension of driving leg
  - Triple Extension
• Intense driving action of the arms

What about **Blood Flow Restriction**?

• Ohta et al, Acta Orthopaedica 2003
  - 44 subjects, first 16 weeks after ACL. BFR group started week 2, 180 mmHg
  - 1-2x/day, 20 reps, 6 days a week
  - Outcomes: Biodex at 60 and 180°/sec, isometric strength, muscle girth, KT2000 for laxity
  - No difference in laxity
  - Significant differences noted in girth, knee ext and flex strength in BFR group

Exciting times w/ BFR...

• Given incidence of knee OA after ACL reconstruction (Barenius et al, AJSM 2014), might BFR training help mitigate those effects?
• Can train MORE OFTEN w/ LESS loading!
Performance Tests

- 10 yd dash
  - Acceleration
- 40 yd dash
- Pro Agility
- ACL Hop Tests
  - Single leg hop v. Triple Hop
  - 6 M timed hop

Jump/Hop Testing

- Vertical Jump
- Double Leg Broad Jump
  - Males 100% of ht, Females 90%
- Single leg hop for distance
  - Males 90% of ht, Females 80%
- Triple Hop for Distance
- Medial/Lateral or “Crossover” Hop
- 6 M Timed Hop
- “Hop and Stop” - Juris et al, JOSPT 1997

Unpublished data on hop tests and ACL...

Are we overestimating LSI and hop tests??

- Wellsandt et al, unpub data, submitted for publication
  - 70 athletes performed 4 hop tests & quad strength 6 mos after ACLR and compared to uninjured limb testing before surgery
  - Compared involved to uninvolved prior to surgery
  - Only 28% met uninvolved scores pre-ACLR, while 57% passed 90% at 6 mos
  - 60% of patients who achieved 90% LSI 6 mos p/o did not achieve 90% for all tests prior

Single Leg Vertical Jump

- Myer et al, AIJSM 2012
  - 33 subjects w/ unilateral ACL performed single leg vertical jump for 10 secs and measured VGRF
  - Significant differences in force generation and force absorption, even 11 mos after reconstruction
  - Conclusion: Single limb power should be assessed prior to release
- Swearingen et al, Phys Ther Sport 2011
  - Single leg hop for distance and for time = strong correlation
  - Single leg vertical jump and single leg hops don't measure same functional components and should be tested separately

Lower Extremity Functional Testing

- LEFT (Lower Extremity Functional Test)
  - Reliable measure of LE function
    - Tabor et al, J Sport Rehab 2002
    - Comparable reliability w/ other LE tests
      - Negrete et al, J Sport Rehab 2002
      - Norms
        - Males 90-125 seconds
        - Females 120-150 seconds

  - Sprint-Front
  - Sprint - Retro Run
  - Side Shuffles – Both Ways
  - Cariocas – Both Ways
  - Figure 8’s – Both Ways
  - 45° Angle Cuts – Both Ways
  - 90° Angle Cuts – Both Way
  - Cross-Over Steps – Both Ways
  - Sprint - Front
  - Sprint – Retro Run

“Hop and Stop” - Juris et al, JOSPT 1997

- Force absorption might be better indicator of function than force production for determination of functional capacity
- “Hop Test”
- “Stop Test”
- Stop:Hop Ratio for symmetry
Hop & Stop

Modified T-Agility Test

- Traditional T test + cuts/shuffles to one side
  - Objective, quantitative, reliable functional assessment
  - ICC = 0.825
  - Recommend < 10% difference

Endurance Tests

- Square hop test Caffrey et al, JOSPT 2009
  - Moderate to high reliability for measure of functional endurance.
  - As many times as possible in 30 seconds
  - Really, a strength-endurance test

What about FATIGUE?

- Functional Agility Short-term Fatigue Protocol (FAST-FP)
  - Step downs 20 secs off 30 cm box, 220 bpm
  - 1RM of "L Drill"
  - 5 consecutive countermovement jumps
  - Run back/forth on agility ladder
  - No rest, complete 4 sets
  - Complete 5 run-stop jump tasks post

RTP – Criteria to lower risk??

- Kyritsis et al, BJSM 2016
  - Meeting these 6 criteria…
    - <10% quad strength deficit
    - >90% symmetry in single, triple, and crossover hop
    - On-field rehab program complete
    - Running T-test <11 secs

  LEADS to 4X LOWER injury risk!!

Reduce risk by 84%???

- Grindem et al, BJSM 2016
  - Those who returned to level I sports had 4.32x higher re-injury rate than those who don’t
  - Re-injury rate reduced by 51% for each month RTS was delayed until 9 months
  - 38% who failed criteria re-tore
  - For every month after 6 mos, risk reduces by 24%!!!
Outcomes

• Marx et al, JBJS 2001
  – Lysholm, Cincinnati Knee Score, AAOS Sports Knee Rating Scale, and ADL scale of Knee Outcome Survey all valid and reliable for clinical research ICC= 0.88-0.95
• Higgins et al, J Bone Spine 2007
  – IKDC valid and reliable measure for knee outcomes
• Salavati et al, Osteoarthritis Cartil 2011
  – Knee Injury Osteoarthritis Outcome Score (KOOS) is valid and reliable after ACL reconstruction
• Blonna et al, Knee Surg Sports Traumatol Arthrosc 2011
  – Subjective Patient Outcomes on Return to Sports (SPORTS) score valid and reliable for sports activity ICC= 0.967

THANK YOU!!!!

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