“Rehabilitation after ACL Reconstruction: From the OR to the Playing Field”

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Objectives

1) Review the biomechanical and neuromuscular risk factors to consider in ACL reconstruction rehabilitation

2) Outline unique factors to consider in the rehabilitation of the athlete with ACL Injury

3) Outline critical issues with conservative management of ACL injuries in female athletes

4) Review our current rehabilitation program for ACL reconstruction from early management to return to play

Mechanisms of ACL Injuries

72%-80% of ACL injuries are non-contact

- Noyes et al 1983
- Boden et al 2000
- Mechanisms of ACL Injuries

Greatest load on ACL with combination of anterior shear, internal rotation force and varus or valgus moments

Markolf et al 1995

Beynnon et al 1995
Mechanisms of ACL Injuries

“At-risk” positions:

1. Landing from a jump
   Hewett et al 1996
   Ferretti et al 1992

2. Sidestepping/cutting maneuvers
   Lloyd 2001

Risk Factors: Biomechanical/Neuromuscular

Lloyd DG. JOSPT (2001)

• Examined kinematics and kinetics during running, sidestep cutting and cross over cutting
• Found increased internal rotation and varus/valgus moments with sidestep cutting maneuvers
• These forces were increased with unanticipated movements

Risk Factors: Biomechanical/Neuromuscular

Malinzak et al. Clinical Biomechanics (2001)

• Comparison of kinematic and EMG data in men and women with running and cutting
• Results: Women have …
  – Decreased knee flexion angles
  – Increased knee valgus
  – Greater quad activation
  – Lower hamstring activation

... in each of these athletic tasks
**Proprioception:**

Assessment

- Active and Passive Repositioning
- Threshold to detection of passive movement
- Muscle Activation/Latency of Reflex
- Postural Balance/Stabilometry

Risk Factors: Biomechanical/Neuromuscular

**Proprioceptive deficits with ACL-Deficiency:**

- Barrack, 1989
- Friden, 1990
- Barrett, 1991
- Mizuta, 1992
- Beard, 1993
- Wojtys, 1994
- Roberts, 1999
- Risk Factors: Biomechanical/Neuromuscular

**Proprioceptive deficits with ACL-Reconstruction:**

- Reconstructed knees equal to controls
  - Co 1993
  - Harrison 1994
  - MacDonald 1996
- Reconstructed knees improved vs. ACL deficient knees
  - Barrett 1992
- Reconstructed knees have proprioceptive deficit vs. noninvolved leg
Risk Factors: Biomechanical/Neuromuscular

Hewett TE, Paterno MV, Myer GD. CORR (2002)

1. Postural balance is significantly effected by ACL injury
2. Postural balance deficits persisted following ACL reconstruction up to 9 months post-op
3. The contralateral limb is a poor control in the assessment of postural balance in patients with ACL injury

Risk Factors: Biomechanical/Neuromuscular

Hewett TE, Paterno MV, Myer GD. CORR (2002)

1. Female controls demonstrate superior postural balance compared to their male counterparts
2. Female patients with ACL injury demonstrated more significant changes in their postural control as compared to male with a similar injury.
3. Females took longer post-op to regain postural control following ACL reconstruction than males with ACL reconstruction

Risk Factors:

*How do we address them in rehabilitation?*

Risk Factors: Biomechanical/Neuromuscular

Hewett TE, Paterno MV, Myer GD. CORR (2002)

“Dynamic Neuromuscular Imbalances”
1. Ligament Dominance
2. Quadriceps Dominance
3. Dominant Leg Dominance

**Goal: Regain Balance!**

Ligament Dominance

Lack of dynamic muscular control in the mediolateral direction resulting in increased valgus stress on the ligaments

- Mission: Attain balance!!

**Ligament Dominance:**

1. Control knee valgus
2. Train muscle co-activation
3. Control knee extension
4. Train hip and trunk musculature to enhance knee stability

Lloyd. *JOSPT*, 2001

“enhanced hamstring and quadriceps co-activation appears to be the activation pattern that people use to lower ligament load.”

“hamstring and quad co-contraction contribute approximately 80% of the varus/valgus support of the knee.”

Train Muscle Co-contraction

Control Knee Extension

Full knee extension = increased vulnerability

Lloyd (2001)

Train Hip and Trunk Musculature

1. Train hip strength through correct form with CKC activities
2. Free weight/Body weight strengthening
3. Balance and Proprioception activities
4. Core Stability Exercises

Quad Dominance

Preferential activation of knee extensors over knee flexors in athletic maneuvers


• Malinzak et al (2001)
• Huston and Wojtys (1996)
• Mission: Attain balance!!

Quadriiceps Dominance:

1. Normalize hamstring to quad ratio
2. Enhance muscular endurance:
   • Focus on endurance training
   • Train to maintain neuromuscular control when fatigued
   • Train the Hamstrings
   • T-band hip extension
   • Leg Curls
   • Stool/Cart Pulls
   • Leg press
   • Wall sits
   • Swiss Ball curls
• Assisted Russian hamstrings
• Asymmetry with Squatting

Neitzel et al Clinical Biomechanics 2002:

**Objective:** To determine if patients are able to demonstrate equal loading response, bilaterally with a parallel squat exercise during the first 15 months following ACL reconstruction

**Results:** Following ACL reconstruction, subjects load their uninvolved lower extremity until 12-15 months post-op.

Leg Asymmetries

Hewett et al AJSM 2005

“Biomechanical Measures of Neuromuscular Control and Valgus Loading of the Knee Predict Anterior Cruciate Ligament Injury Risk in Female Athletes: A Prospective Study”

**Objective:** Prospectively identify neuromuscular factors that are predictors of ACL injury in female athletes

**Results:** 4 of the 9 variables in the predictive model are side to side differences in NM control and valgus loading

Special Considerations for the Female Athlete


1. Dynamic control of valgus moment
2. Train muscle co-activation
3. Muscle training for faster reaction times
4. Learn to control hip and pelvis
5. Hip joint and trunk stabilization to enhance knee stability
6. Train athlete to control knee hyperextension
7. Enhance neuromuscular control of the lower extremity
8. Train to enhance muscular endurance

ACL Rehab: Conservative Management

Why Consider Conservative Management?
Mechanical Stability vs. Functional Stability

ACL Rehab: Conservative Management

Noyes’ Rule of Thirds
“Copers vs. Non-Copers” Snyder-Mackler et al

- ACL Rehab: Conservative Management

Assess Risk:
- Potential giving way
- Further meniscal damage
- Potential chondral damage
- Potential for long term arthritic changes with repeated giving way and instability

*Communication with all involved parties is critical!!*

- ACL Rehab: Conservative Management

Rehabilitation Considerations:
1. Maximize a balance of strength
2. Focus on balance and proprioception – Pertubation Training
3. Focus on mechanics/technique
4. Sports Specific
5. Consider bracing
Non-Operative Management

“A 10-year prospective trial of a patient management algorithm and screening examination for highly active individuals with anterior cruciate ligament injury.”

*Hurd et al, AJSM 2008*

- Non-Operative Management

*Hurd et al, AJSM 2008*

- 345 of 832 ACL injuries qualified for screening
- 146 were classified as potential non-copers
- 63 of 88 potential non copers were able to return to sports prior to surgery
- Rehab: ACL Reconstruction

History of Rehabilitation:

1. Immediate Motion
2. “Accelerated Rehabilitation”
3. Where are we today?

*Always:*

1. *Know your MD’s surgical protocol*
2. *Communicate with your MD’s*

Rehab: ACL Reconstruction

Acute Phase (0-2 Weeks)

- No brace or immobilization
- ROM (0-90 degrees)
- WBAT with 2 crutches
- Modalities: NMES for Muscle re-ed
- Ice/Cryo for pain/effusion
Rehab: ACL Reconstruction

Acute Phase (0-2 weeks) Exercise Initiation:

- LE stretching
- Initiate quad control
- Patellar Mobilization
- Gait re-training
- Initiate balance and proprioception activities

Rehab: ACL Reconstruction

Sub-Acute Phase (2-6 weeks)

- ROM (0-135 degrees)
- Progress off Crutches when criteria met
- Continued use of Modalities as needed
- Initiate LE conditioning activities

Rehab: ACL Reconstruction

Sub-Acute Phase: Progression of Exercises

- CKC Activities: Progress with WB status
- Isotonics:
  - Leg press (70-10 degrees)
  - Leg curls (0-90 degrees)
  - Leg extension (90-30 degrees)
  - 4-way hip
- Progression of Balance and Proprioception
Criteria to Progress to Phase III:

1. Good quad control
2. ROM = WNL
3. Good patellar mobility
4. KT-1000 unchanged
5. Minimal effusion
6. No patellofemoral pain

Rehab: ACL Reconstruction

Neuromuscular Development Phase (6-12 Wks):

1. Progression of current program to maximize strength and endurance
2. Focus on development of good technique/form
3. Advance current balance/proprioception activities with the increase in speed, removal of visual input, alter direction of movement, etc.
4. Initiate light plyometric program

“Transition to Function” Phase (12-16 wks):

1. Progress strength program
2. Continue plyometric program beyond technique phase
3. Initiate straight line running program

“Return to Play” Phase:

1. Initiation of pivoting and cutting drills
2. Sports specific training
3. Continuation of strength development

Goal: Return to activity safely and efficiently
Criteria to progress to “Return to Play”

**Goal:** Return to activity safely and efficiently

**Summary**

1. Rehabilitation should focus on controlling the abnormal biomechanics and maximizing neuromuscular control of the lower extremity
2. Rehabilitation should focus on rehabbing injured knee and preventing future injury
3. Return to sport decision should be based on objective criteria
4. **CHANGE THE OUTCOME!**

“Return to Sport after ACL Reconstruction”

**Return to Sport: The Next Frontier...**

1. Future research needs to continue to investigate other factors that are effected by ACLR and determine their potential connection to a poor outcome.
2. Determine what cluster of variables in fact predict a poor outcome or a successful outcome
3. Modify current return to sports criteria to better align with these variables
4. Modify the end stages of rehabilitation to provide the patient with a better opportunity to successfully meet these criteria.

**Summary**

1. Current methods to evaluate readiness to return to sport include subjective reports of function, in addition to assessments of laxity, muscle performance and functional performance testing
2. Critical variables in determining safe ability to return to sport may not be adequately assessed in current return to sport evaluations
3. Future research needs to continue to explore new methods to accurately determine an athlete’s readiness to safely return to sport.
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