“Return to Sport after ACL Reconstruction: How Objective is the Decision?”

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Objectives
1. Review current tools used to assess readiness to return to sports after ACL reconstruction
2. Evaluate strengths and weaknesses of current return to sport criteria
3. Discuss means to improve the Return to Sport evaluation to better assess readiness to safely return to activity

CLINICAL QUESTION:
When is it safe to return to sports after ACL Reconstruction?

1. What is “safe”
2. What are the functional demands of the sport?
   • What is safe?
     Incidence of Osteoarthritis

Lohmander et al Arth and Rheum 2004
• 103 female soccer players with unilateral ACL injury
• 82% follow up 12 years after ACL injury
• Radiographic evaluation at 12 years post injury
• 51% of the involved limb had signs of OA
• 8% of the uninvolved limbs had signs of OA
• What is safe?
  Incidence of Re-injury

“Athletes with prior ACL injury are at greater risk for future ACL injury”
*Souryal et al AJSM 1988:*

Incidence of bilaterality = 4.01%

*Shelbourne et al AJSM 1996:*

1 in 26.4 went on to tear contralateral ACL

1 in 37.5 went on to re-tear involved ACL

Long-term Morbidity: Incidence of Second Injury

“*Athletes with prior ACL injury are at greater risk for future ACL injury*”

*Wright et al AJSM 2007:*

- Data from MOON Group
- 1 in 17 (6%) suffered a second ACL injury after ACLR (½ contra; ½ ipsilateral)

*Pinczewski et al AJSM 2007:*

In the 10 years following ACL reconstruction, as many as 1 in 3.7 athletes (27%) will suffer a 2\textsuperscript{nd} ACL injury.

What are the functional demands of the sport?

- Mechanical Stability
- Functional stability
- Strength
- Power
- Agility
- Endurance
- Balance/Postural Control
- Etc.
ACL Return to Sport: Systematic Review


34 articles between 1998-2003

• Current Criteria for Return to Sport

Outline of criteria reported:

• 13/34 assessed isokinetic strength
• 25/34 used jump testing
• 14/34 reported some clinical criteria (i.e. ROM, knee stability etc.)
• 4/34 had no assessment of strength or performance

Kvist J. Sports Med 2004

Current Return to Sport Measures

1. Time from surgery
2. Strength
3. Knee laxity
4. Functional Performance Testing

Post op time to Return to Sport


Return to ....

Running 4.3 months (1.5-12 months)
Jumping 6.5 months (3-12 months)
Light Sports 5 months (3-9 months)
Mod. Sports 5.8 months (4-9 months)
Stren. Sports 8.1 months (4-18 months)
Post op time to Return to Sport

*Kvist J 2004 – Systematic Review*

Strength/Muscle Performance

Assessment of Muscle Performance:

1. Manual muscle testing
2. Isokinetic Strength testing (non-WB)
3. Functional performance testing (WB)

Return to Sport: Lower Extremity Strength

...Quadriceps strength can take between 18-24 months to return to values within 10-15% of the contralateral limb...

Mattacola et al 2002
Kobayashi et al 2004

Mechanical Stability

1. Lachman exam
2. KT 1000/ KT 2000
3. Pivot Shift Exam

“What is the relationship of mechanical stability and function?”

Mechanical Stability and Function

“Pivot shift exam had significant association with satisfaction, partial giving way, full giving way, difficulty cutting, difficulty twisting, activity limitation, overall knee function, sports participation and Lysholm. (p<0.05)”
Kocher MS et al.

“Relationship Between Objective Assessment of Ligament Stability and Subjective Assessment of Symptoms and Function after ACL Reconstruction.”

AJSM 2004

Functional Performance Testing

1. Single leg hop for distance
2. Single leg triple hop
3. Single leg cross over triple hop
4. Single leg time hop
5. Single leg vertical hop
6. Shuttle runs
7. Side shuffle runs
8. Carioca Running
9. Etc. , etc., etc.

Goal: Mimic a functional activity to make correlations for readiness to return to sport.

Problems with Functional Performance Tests:

1. Low sensitivity and specificity
2. Relationship to other measures of impairment and disability (i.e. muscle performance, knee laxity, proprioception, self-reported measures of function.)

Fitzgerald GK et al

“Hop Tests as Predictors of Dynamic Knee Stability”
Current Criteria for Return to Sport

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ACL Return to Sport: What is Missing?

1. Patient reported outcomes
2. Balance and Proprioception
3. Bilateral Asymmetries
4. Others...

What are we missing: Patient reported outcomes?

1. International Knee Documentation Committee (IKDC)
2. KOOS
3. Tegner
4. Lysholm
5. Others...
What are we missing: Postural Stability?

- What are we missing: Bilateral Symmetry with Functional Tasks?
- 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.

Asymmetries with Functional Tasks.

“Limb asymmetries in landing and jumping 2 years following ACL reconstruction”

**Paterno et al CJSM 2007**

- Drop Vertical Jump
- Tuck Jump

Biomechanical Measures during Landing and Postural Stability Predict Second Anterior Cruciate Ligament Injury after ACL Reconstruction and Return to Sport

- Mark V. Paterno PT, MS, SCS, ATC
- Laura C. Schmitt PT, PhD
- Kevin R. Ford PhD
- Mitchell J. Rauh PT, PhD, MPH, FACSM
- Gregory D. Myer MS, CSCS
- Bin Huang PhD
- Timothy E. Hewett PhD, FACSM
Clinical Problem: Who is at Risk?

- Few studies have reported risk factors for a second ACL injury after ACLR
- Previously identified risk factors are un-modifiable (i.e. contact mechanism or RTS)

*Identification of modifiable risk factors of a 2<sup>nd</sup> ACL injury is necessary to effectively reduce the risk of second injury*

Purpose and Hypothesis

**Purpose:** Use a prospective, case-cohort design to identify predictors of a second ACL injury following ACLR in a young, athletic sample

**Hypothesis:** After primary ACLR, prospectively measured deficits in neuromuscular control at the hip and knee and in postural stability would predict second ACL injury with high sensitivity and specificity

- Methods: Subjects
  
  N=56 subjects (35 female, 21 Male) after ACLR and ready to pivot/cutting sports
  - 25 BTB Autograft
  - 27 HS Autograft
  - 4 Allograft

Methods

All subjects received a biomechanical screening during a drop vertical jump maneuver and an assessment of postural stability

Methods: Injury Surveillance

- Athletic Exposures and ACL injury was tracked x 12 months following RTS
- **13 subjects** (11 female; 2 male) sustained a second ACL injury
- **10** contralateral injuries; **3** ipsilateral re-tears
Statistical Analysis

- Kinematics, kinetics, power and vertical ground reaction force at the hip and knee at specific time points during the landing phase of the DVJ maneuver and postural stability were compared between groups. All moments were reported as internal moments.
- Multivariate logistic regression (all variables p<0.10) to identify most predictive model.
- Odds ratios and corresponding 95% confidence intervals of significant predictors (p<0.05) of second ACL injury were reported from the last final model.
- Receiver operating curve (ROC) was plotted, and the area under the ROC statistics was reported.

Results

- Results: Hip Rotation Net Moment Impulse (Initial 10% of stance)
- Results: 2D Frontal Plane Knee Kinematics
- Results: Sagittal Plane Moment at Initial Contact
- Results: Postural Stability
- Results: Predictive Model

Area under ROC = 0.94 (Sensitivity = 0.92, Specificity = 0.88)

Area under ROC (hip imp. only) = 0.81 (Sen=0.77, Spec = 0.81)

Discussion

Predictors of Second ACL Injury:

1. Hip rotation moment at onset of landing
2. 2D Frontal plane knee motion
3. Asymmetries in sagittal plane knee moment at initial contact
4. Deficits in postural stability
Discussion

_Proximal Neuromuscular Control of Frontal Plane Motion_

Dynamics Valgus: Combination of hip adduction, hip internal rotation, knee flexion, knee abduction and tibial rotation

_Schmitz et al JAT 2009_

_Krosshaug et al AJSM_

_Hewett et al AJSM 2005_

Discussion

_Dynamic Valgus:_

- Increased strain on ACL
  - Markolf et al JOR 1995
- Predicted ACL injury in healthy female athletes
  - Hewett et al AJSM 2005

Discussion

_Proximal Neuromuscular Control of Frontal Plane Motion_

- Hip rotation moment at initial 10% of landing was the strongest predictor of 2\textsuperscript{nd} injury
- Evidence suggests hip ER and hip extensors contribute to control of hip IR in an athletic position
  - Newmann JOSPT 2010
  - Souza and Powers AJSM 2009
Clinical Application: Targeted rehabilitation focused on hip extensor and hip ER strength and muscle activation may assist in reducing 2nd injury rates

Discussion

Asymmetries in Sagittal Plane

Knee Moment at Initial Contact

Asymmetries in neuromuscular control of the knee identified as a risk factor for ACL injury

Hewett et al 2005

Asymmetries in loading patterns seen up to 2 years after ACLR

Neitzel et al 2002

Paterno et al 2007

Discussion

Postural stability: means to assess ability to maintain center of mass within base of support

Recent evidence has linked altered core proprioception with ACL injury in healthy females

- Zazulak et al 2007

Prior evidence suggests deficits in postural stability after ACL injury and ACLR

Future Directions

• The identification of high risk variables that predict future ACL injury, at the time of patient discharge to return to sports after ACLR, is the first step

• Development and testing of more specific, efficacious interventions to target predictive impairments

• Develop and test more appropriate discharge criteria to minimize risk of future ACL injury

• Conclusion/Summary

• The incidence of second ACL injury after ACLR is high in a young, active population

• Potential risk factors have been prospectively identified in this work
• Future studies need to investigate more appropriate end stage rehabilitation and return to sport criteria to attempt to decrease the risk of future ACL injury after ACLR.

• ACL Return to Sport

“Rehabilitation after Anterior Cruciate Ligament Reconstruction: Criteria-Based Progression Through the Return-to-Sport Phase”

Myer GD, Paterno MV, Ford KR, Quatman CE, Hewett TE

JOSPT

June 2006

Return to Sport Phase

Purpose:

1. Introduce a criteria-driven progression through the return to sport phase of rehabilitation

2. Offer an example of a standardized criteria driven progression through the end stage of rehab to sports integration

3. Stimulate discussion of validation of this and future testing to give us a more objective determinant of readiness to play

Limitations

1. Future studies needed to further determine reliability, validity and long term outcome of this approach to the end stages of rehab.

2. Very equipment dependant

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.
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

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3. Future research needs to continue to explore new methods to accurately determine an athlete’s readiness to safely return to sport.

Thank You!

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