Return to play after ACLR: When and What Tests to Do... Safe or Sorry?

Where are we in 2016?

Functional Assessment

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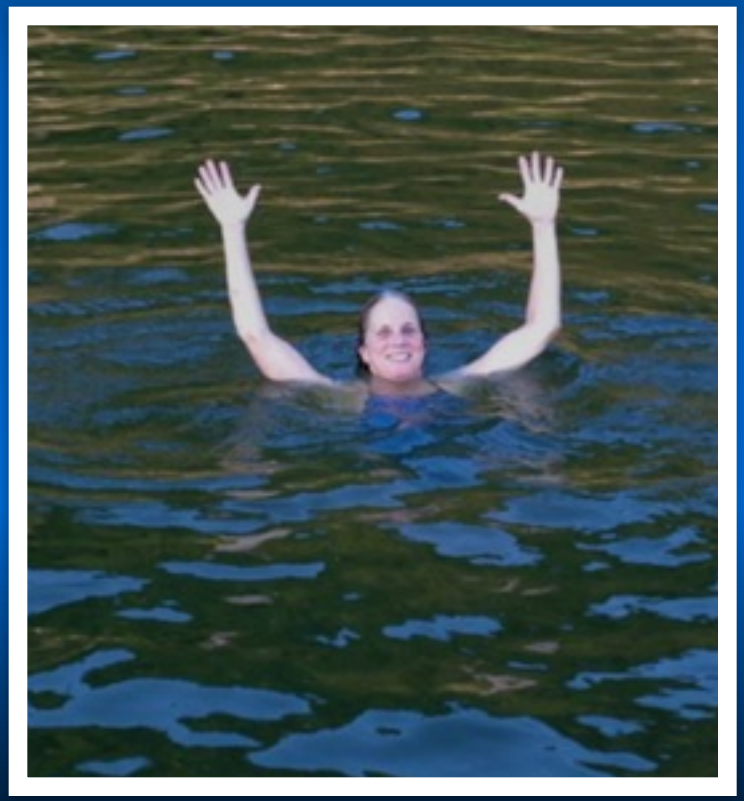
Disclaimer Slide

I, Mary Lloyd Ireland, MD, nor any family member(s), have any disclosures.



Objectives

- Understand the tests in functional assessment done prior to RTP after ACLR
- Communicate with rehab team to develop RTP protocols
- Evidence based functional assessment tests should be developed
- Ask Questions!

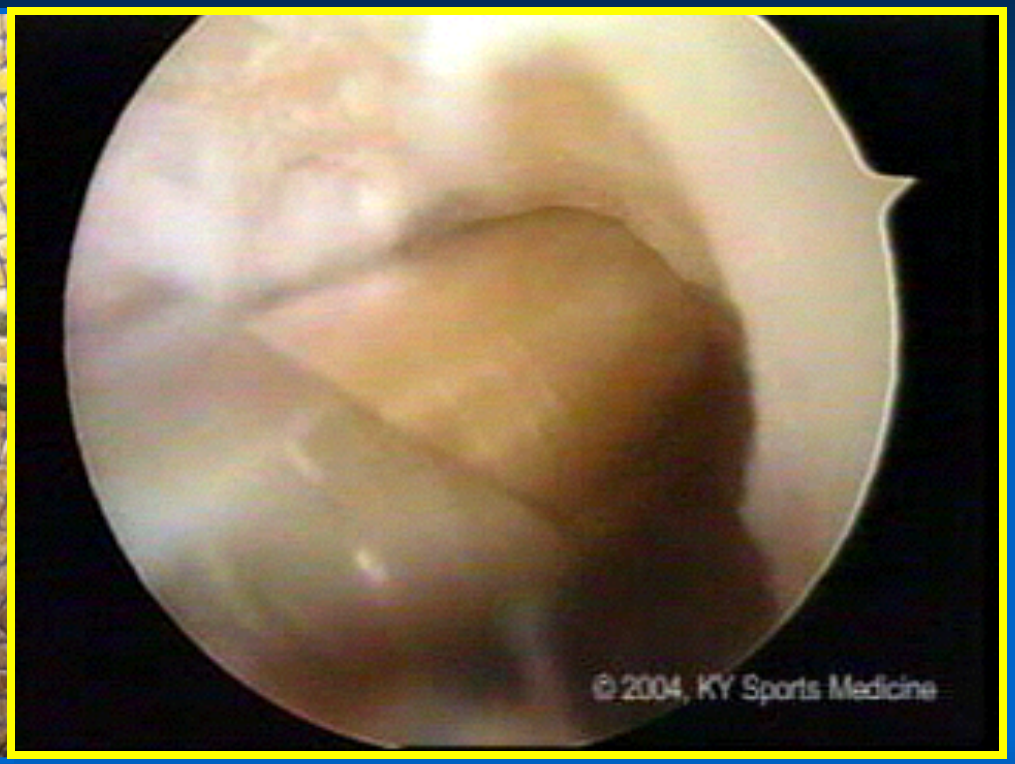
Menu

Introduction
Functional Assessment
Sex Differences
Prevention
Conclusions

What are we afraid of?

- Retear
- Athlete not performing well
- Surgeon looks bad
- Injure something else
- Develop OA
- Going to Get It Anyway
- Angry athlete parent coach

Orthopaedic Surgeons Can Stabilize the Knee, but not restore it to pre injury state.



Timing of Return to Play?

Rethink Biologic Healing

Variable due to Multiple Factors……

Development of Osteoarthritis

Swedish ACL Registry

- 84 female soccer players ACL injuries
- 12 year follow up.
- 42% Symptomatic Knee OA
- 75% Symptoms affected QOL
- No difference if underwent ACLR compared to those who had not

Lohmander LS, Ostenberg A, Englund M, Roos H. High prevalence of knee osteoarthritis, pain, and functional limitations in female soccer players twelve years after anterior cruciate ligament injury. *Arthritis Rheum* 2004;50:3145-3152.

Significant findings:

- **Non op more likely develop meniscus tear OA and undergo TKA compared to early ACLR**
- **Delayed more likely develop meniscus tear and OA compared to early ACLR**

	Meniscus Tear		Osteoarthritis		TKA	
	HR	CI	HR	CI	HR	CI
Non Op	5.4	3.8-7.6	6.0	4.3-8.4	16.7	5.0-55.2
Early ACLR						
Delayed ACLR	3.9	2.2-6.9	6.2	3.4-11.4		

HR = Hazard Ratio
CI = Confidence Index 95%

Is Anterior Cruciate Ligament Reconstruction Effective in Preventing Secondary Meniscal Tears and Osteoarthritis? Sanders, T L. et al., *Am J Sports Med* published online March 8, 2016

Purpose: Evaluate protective benefit of ACLR and evaluate factors predictive of long term sequelae

Mean FU 13.7 Years
Range 2 month – 25 years
964 Patients new onset ACL tears vs. sex match cohort without ACL tears

- **364 Non Op**
- **509 Early ACLR**
- **91 Delayed**

Level of evidence 3

Is Anterior Cruciate Ligament Reconstruction Effective in Preventing Secondary Meniscal Tears and Osteoarthritis? Sanders, T L. et al., *Am J Sports Med* published online March 8, 2016

Results

Age greater than 21 years Time of Injury Articular cartilage damage medial lateral meniscal tears predicted OA after ACLR

Is Anterior Cruciate Ligament Reconstruction Effective in Preventing Secondary Meniscal Tears and Osteoarthritis? Sanders, T L. et al., *Am J Sports Med* published online March 8, 2016

Conclusions

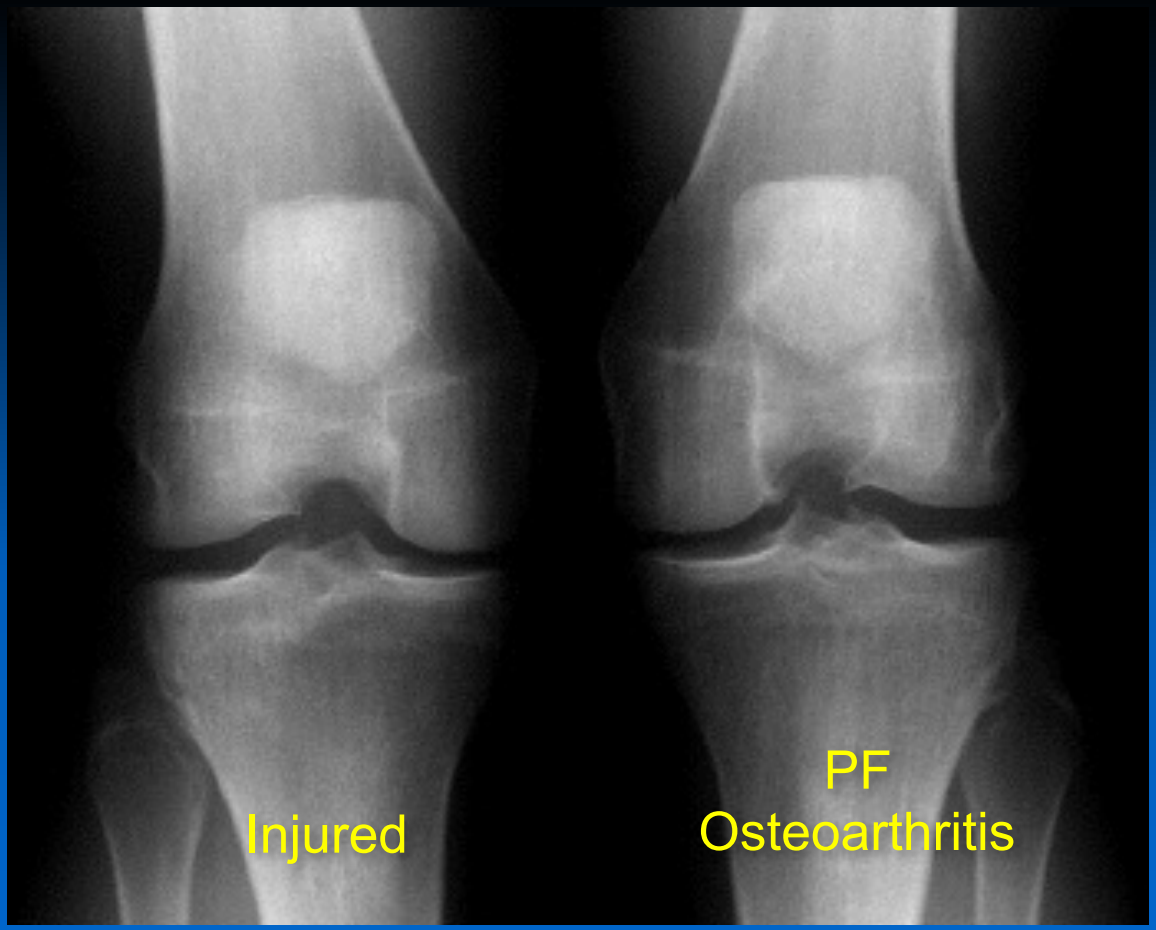
- Patients undergoing ACLR significant lower risk of meniscus tear symptomatic OA and TKA compared to non OP
- Early ACLR significantly reduces risk of subsequent meniscus tear and OA compared to delayed ACLR

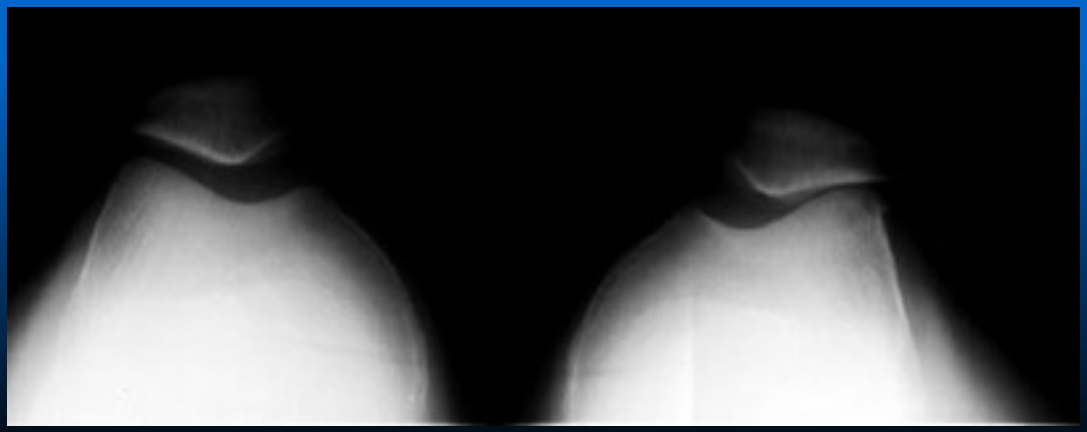
Is Anterior Cruciate Ligament Reconstruction Effective in Preventing Secondary Meniscal Tears and Osteoarthritis? Sanders, T L. et al., *Am J Sports Med* published online March 8, 2016

36YO Female

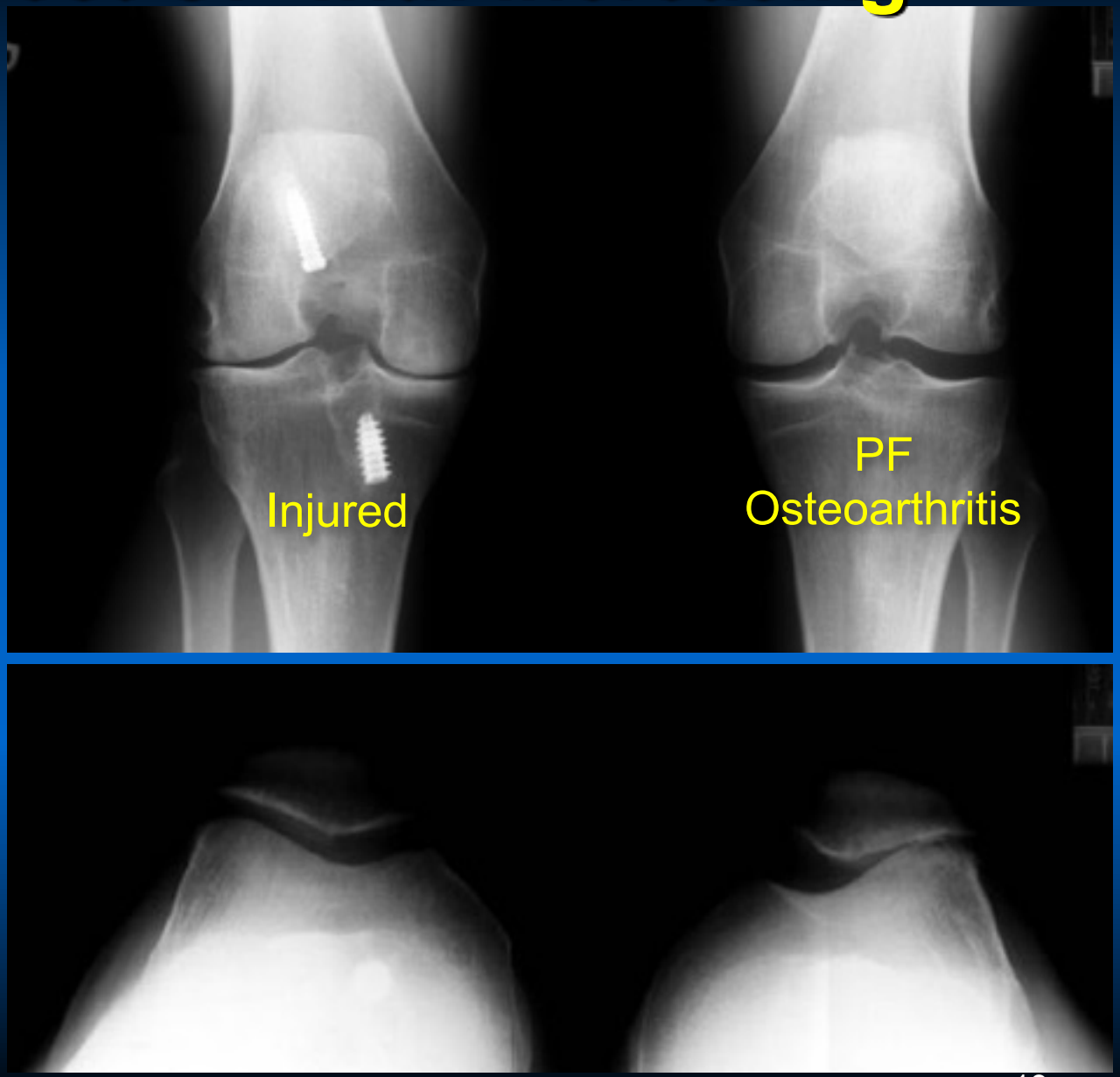
Professional basketball athlete

Allograft ACL reconstruction





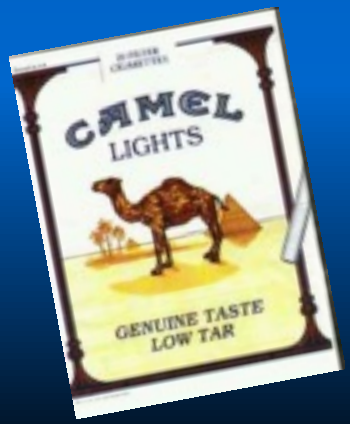
3.5 years Post OP with increasing knee pain.



Knee “pack-years” as in smoking: Additive effects of years of participation in basketball. . .

- Pack-years of smoking on **lungs**
- Pack-years of activity on **knees**

? Too many pack years of basketball ?



Goal ACL return to play after ACLR

- KNOW YOUR RETURN TO PLAY TEAM.
- Understand the tests that assess strength and movement patterns after ACLR
- Show you the tests performed in functional assessments to determine readiness to RTP.
- Understand what these tests are measuring.
- Review mechanisms of injury and how this relates to safe return to play and prevention programs
- Questions and Discussion

Successful ACLR:

Short term: safer not faster return to play
Long term: prevention of osteoarthritis

- Average return to play 6 months
- Varies with each individual patient age and sport
- Many factors the athlete must overcome prior to return:
- Fear of reinjury
- Reestablishing strength balance hip and knee control

Appropriate Use Criteria Adopted by AAOS October 2015

AAOS Now

NOVEMBER 2015

The Official Member Newsmagazine of the AAOS

aaosnow.org

Two New ACL AUC, Checklists Now Available

Full scope of prevention and management of ACL injury covered

TERRY STANTON

Both prevention and treatment of anterior cruciate ligament (ACL) injuries can be confusing given the diversity of injured patients—from skeletally immature youth to older adults, low- and high-risk athletes playing a variety of sports, and patients with and without arthritis," acknowledged **Robert H. Quinn, MD**, Appropriate Use Criteria (AUC) Section Leader on the AAOS Committee on Evidence-Based Quality and Value.

In light of that diversity, the AAOS is making available a new suite of online resources to guide orthopaedic surgeons in the management of these injuries as well as in counseling patients about

> SEE ACL AUC ON PAGE 39

The two new AUC include prevention programs geared to athletes and are accompanied by checklists for Postoperative Rehabilitation and Return to Play.

COURTESY OF ISTOCK

AAOS
AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

AMERICAN ASSOCIATION OF ORTHOPAEDIC SURGEONS

FEATURES

6 **OTA Annual Meeting**

Coverage begins with reports on the use of topical vancomycin, early weight bearing after intramedullary fixation, and vitamin D in trauma patients.

ACL Reconstruction Surgery

-Patient Return to Play Checklist-

Clip this checklist to the patient chart and upon completion, insert in file.

Patient's Name: _____

Medical Record Number: _____

Date of Birth: _____/_____/_____

(Apply patient sticker over header if available)

Date of Surgery:_____/_____/_____

Post-operative anterior cruciate return-to-play protocol:

☐ Patient's graft incorporation and graft strength has been considered

☐ Patient's functional range of motion is restored

☐ Patient has a stable knee with no pivot

☐ Functional return of patient's core, hip, quadriceps and hamstring strength has occurred, as determined by clinician discretion (can be measured by a variety of methods)

☐ Patient's functional balance restored

☐ Patient attests or surgeon observes functional skills are performed adequately

☐ Patient is confident that they are ready to return to sport of interest

☐ Patient has been advised to participate in an ongoing ACL-prevention/ movement-retraining program

Clinician Signature: _____

Date/Time: _____

AAOS

Quality and Variability of Physical Therapy Protocols for ACL Reconstruction
IN THE US THERE ARE NO
NO STANDARDIZED OR EVIDENCE BASED PROTOCOLS

- 155 Academic Orthopaedic Programs
- 33 Online post ACLR Protocols
- Substantial variability in types of exercises time to RTP
- Protocols not supported evidence based practices
- By Standardizing protocols might lead to improved outcomes

E. Makhni MD MBA, E. Crump MD, M. Steinhaus MD, N. Verma MD, C. Ahmad MD, B. Cole MD MBA, B. Bach Jr. MD
Rush Medical Center, Chicago IL - Presented at AAOS March 2016

Functional Assessment Tests

- Basic vs. Advanced
  - Strength – leg press
  - Balance
  - Timed agilities
  - Sport-specific dry-land testing to show athlete level of readiness to return to field of competition

What are the tests done to determine readiness for return to play?

Functional Assessment Level 1

- Gait assessment
- Single leg step and hold ×10
- Y Balance
- Strength testing
- Knee extension isometric 90°
- Hip abduction and seated external rotation
- One leg at bridges to fatigue
- Plank

Grading scale

- 3 = normal
- 2 = minimal deviation
- 1 = moderate deviation
- 0 = marked deviation
- Assessment
- Passes all phases, did not pass all phases because of the following deficiencies
- Pain
- Decreased eccentric knee control, neuromuscular strength, proximal strength

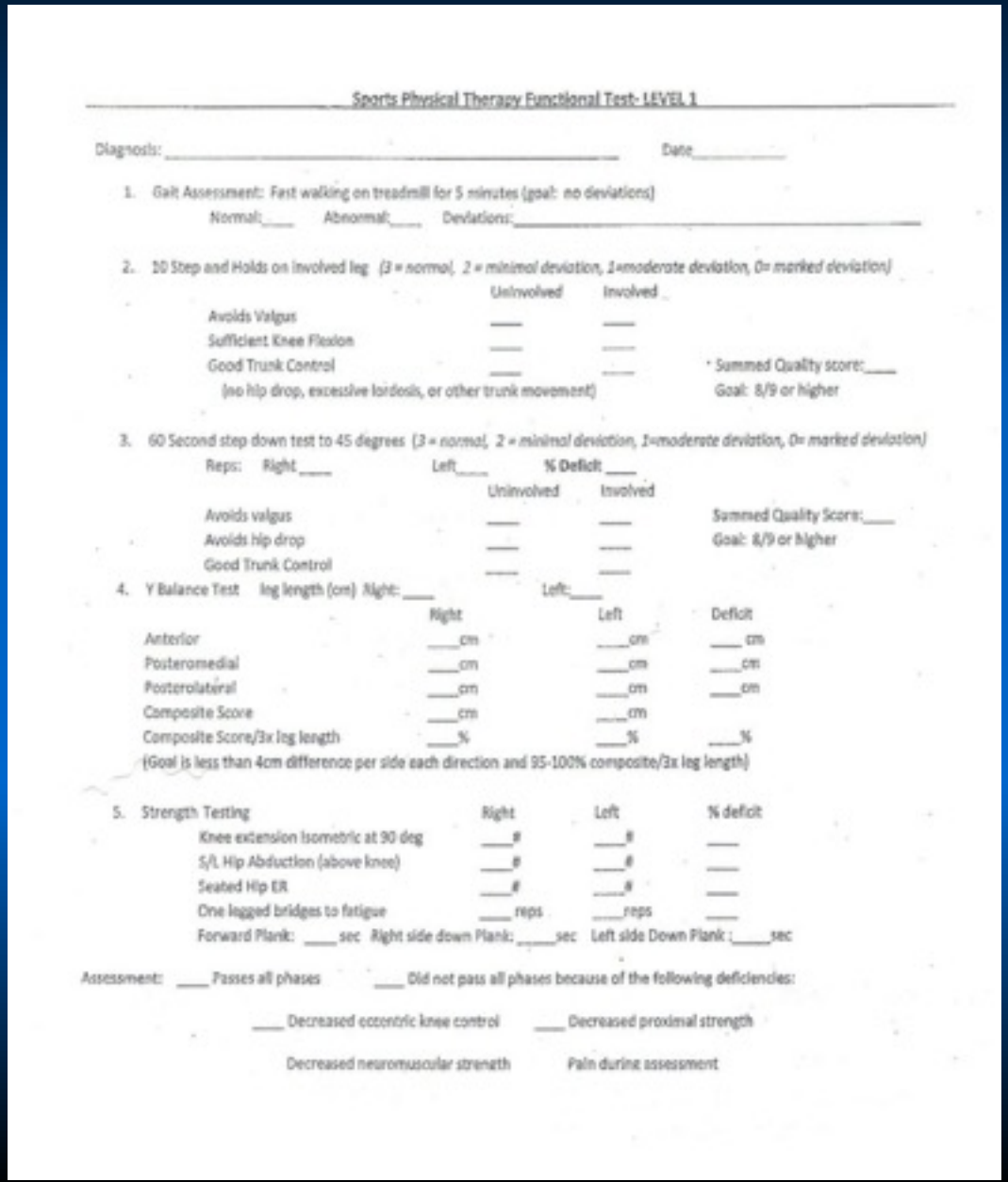
Functional Assessment Level 2: Return to play

- Hop testing in inches
- Vertical hop
- Single-leg broad jump
- Timed 6 m hop
- Single-leg triple jump
- Single-leg crossover jump
- Hop testing quality assessment
- Good trunk control sufficient knee flexion avoid valgus

Level to clearance for sports

- Drop-off box to squat jump plyometric repeat 3-5 times graded on 0-3
- Symmetrical landing on both feet
- Symmetrical hip and knee flexion
- Landing is soft
- Avoid valgus
- Landing is balanced

Functional Assessment Level 1



Sports Physical Therapy Functional Test- LEVEL 1

Diagnosis: _____ Date_____

1. Gait Assessment: Fast walking on treadmill for 5 minutes (goal: no deviations)
   Normal:____ Abnormal:____ Deviations:_____

2. 10 Step and Holds on involved leg *(3 = normal, 2 = minimal deviation, 1=moderate deviation, 0= marked deviation)*

	Uninvolved	Involved	
Avoids Valgus	____	____	
Sufficient Knee Flexion	____	____	
Good Trunk Control	____	____	* Summed Quality score:____
(no hip drop, excessive lordosis, or other trunk movement)			Goal: 8/9 or higher

3. 60 Second step down test to 45 degrees *(3 = normal, 2 = minimal deviation, 1=moderate deviation, 0= marked deviation)*
   Reps: Right ____ Left____ **% Deficit** ____

	Uninvolved	Involved	
Avoids valgus	____	____	Summed Quality Score:____
Avoids hip drop	____	____	Goal: 8/9 or higher
Good Trunk Control	____	____	

4. Y Balance Test leg length (cm) Right:____ Left:____

	Right	Left	Deficit
Anterior	____cm	____cm	____ cm
Posteromedial	____cm	____cm	____cm
Posterolateral	____cm	____cm	____cm
Composite Score	____cm	____cm	
Composite Score/3x leg length	____%	____%	____%

(Goal is less than 4cm difference per side each direction and 95-100% composite/3x leg length)

5. Strength Testing

	Right	Left	% deficit
Knee extension Isometric at 90 deg	____#	____#	____
S/L Hip Abduction (above knee)	____#	____#	____
Seated Hip ER	____#	____#	____
One legged bridges to fatigue	____ reps	____reps	____

Forward Plank: ____ sec Right side down Plank: ____sec Left side Down Plank :____sec

Assessment: ____ Passes all phases ____ Did not pass all phases because of the following deficiencies:

____ Decreased eccentric knee control ____ Decreased proximal strength

Decreased neuromuscular strength Pain during assessment

Functional Assessment Level 2

Level 2 Functional Test (Clearance for Sporting Activities)

Name:_____ Date:_____ Surgery:_____

Leg Length (cm): R:_____ L:_____ BW:_____

1. Hop Testing (in inches)

Vertical Hop Test (inches)	1	2	3	%deficit max
Uninvolved				
Involved				
Single leg broad jump (in m)				
Uninvolved				
Involved				
Timed 6m hop (in sec)				
Uninvolved				
Involved				
Single leg Triple Jump (in m)				
Uninvolved				
Involved				
Single leg Crossover jump (in m)				
Uninvolved				
Involved				

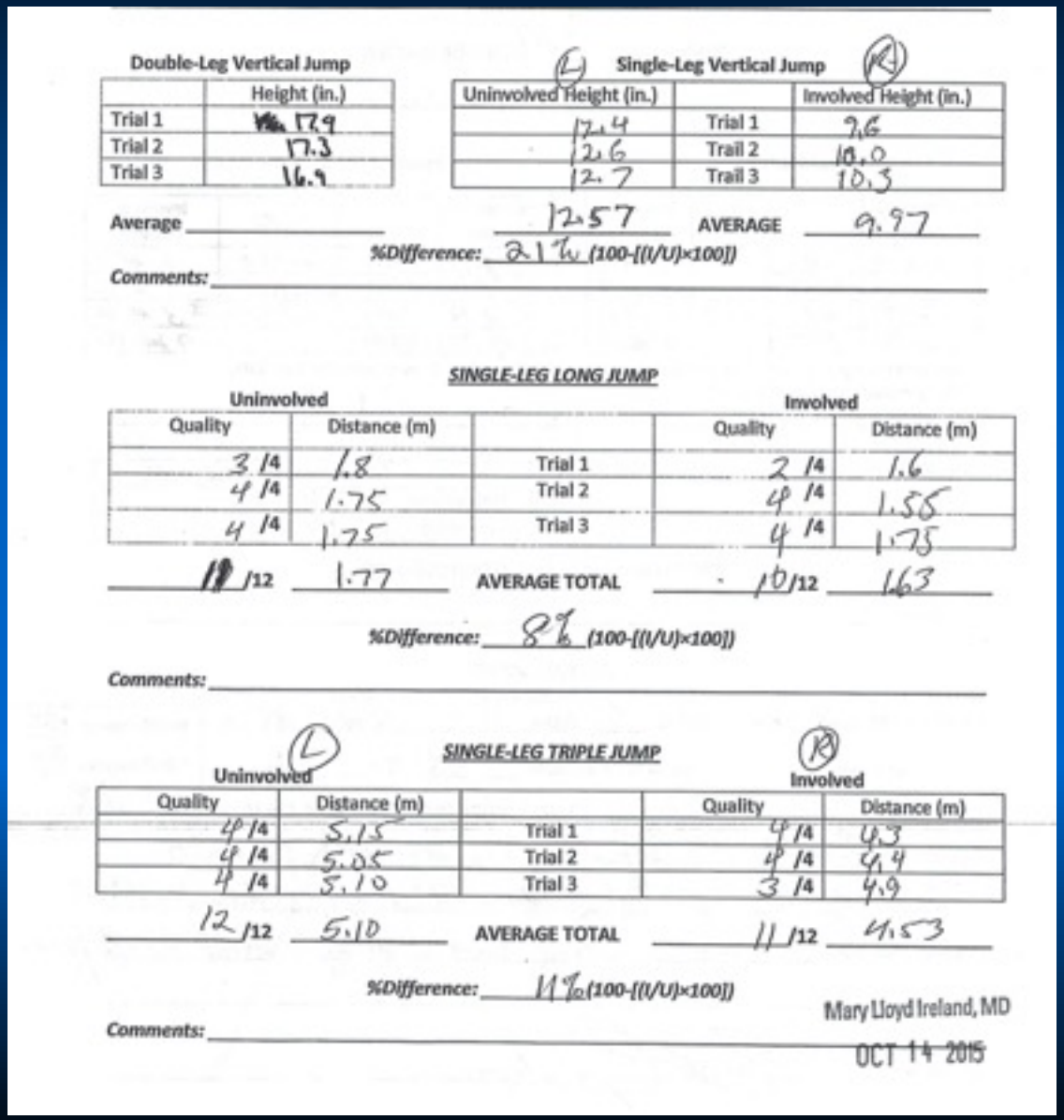
2. Hop Testing Quality Assessment *(3 = normal, 2 = minimal deviation, 1=moderate deviation, 0= marked deviation)*

	Uninvolved	Involved
Good trunk control		
Sufficient knee flexion		
Avoids valgus		
Total Score (Goal is > or = 8/9)		

3. Drop off box to squat jump plyometric performance (Repeat 3-5 times)
(3 = normal, 2 = minimal deviation, 1=moderate deviation, 0= marked deviation)

_____ Feet symmetric and hit together
_____ Symmetric and sufficient knee flexion
_____ Landing is soft
_____ **Total Score (Goal is > or = 14/15)**
_____ Avoid valgus
_____ Landing is balanced

Advanced Functional Assessment



Double-Leg Vertical Jump

	Height (in.)
Trial 1	17.9
Trial 2	17.3
Trial 3	16.9

Average 17.37

Single-Leg Vertical Jump

Uninvolved Height (in.) (L)		Involved Height (in.) (R)
17.4	Trial 1	9.6
12.6	Trail 2	10.0
12.7	Trail 3	10.3

AVERAGE 9.97

%Difference: 21% (100-[(I/U)×100])

Comments:

SINGLE-LEG LONG JUMP

Uninvolved Quality	Uninvolved Distance (m)		Involved Quality	Involved Distance (m)
3 /4	1.8	Trial 1	2 /4	1.6
4 /4	1.75	Trial 2	4 /4	1.55
4 /4	1.75	Trial 3	4 /4	1.75
11 /12	1.77	AVERAGE TOTAL	10 /12	1.63

%Difference: 8% (100-[(I/U)×100])

Comments:

SINGLE-LEG TRIPLE JUMP

Uninvolved (L) Quality	Uninvolved (L) Distance (m)		Involved (R) Quality	Involved (R) Distance (m)
4 /4	5.15	Trial 1	4 /4	4.3
4 /4	5.05	Trial 2	4 /4	4.4
4 /4	5.10	Trial 3	3 /4	4.9
12 /12	5.10	AVERAGE TOTAL	11 /12	4.53

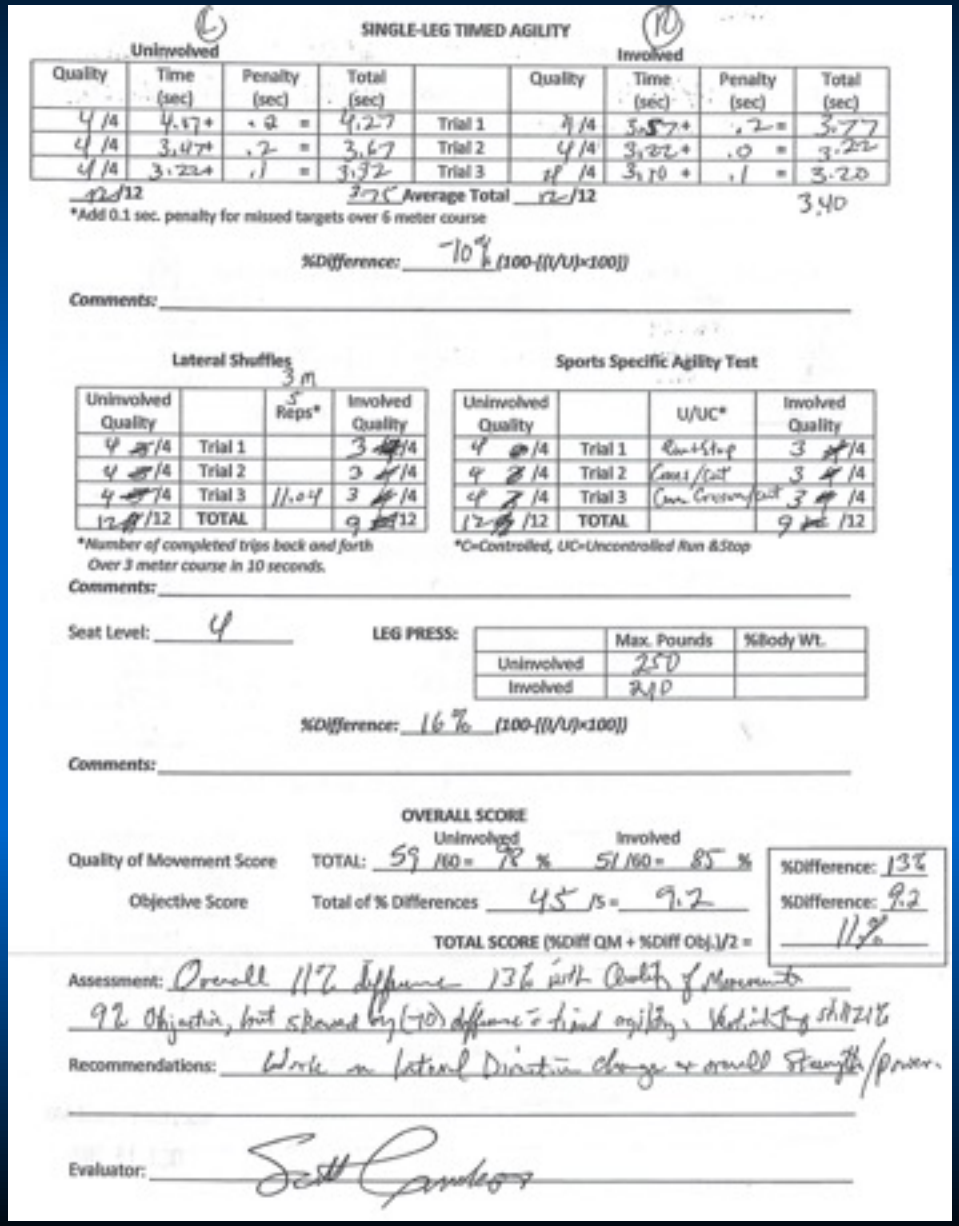
%Difference: 11% (100-[(I/U)×100])

Comments:

Mary Lloyd Ireland, MD

OCT 14 2015

Advanced Functional Assessment



SINGLE-LEG TIMED AGILITY

Uninvolved (L) Quality	Time (sec)	Penalty (sec)	Total (sec)		Involved (R) Quality	Time (sec)	Penalty (sec)	Total (sec)
4 /4	4.17 +	.2 =	4.27	Trial 1	4 /4	3.57 +	.2 =	3.77
4 /4	3.47 +	.2 =	3.67	Trial 2	4 /4	3.22 +	.0 =	3.22
4 /4	3.22 +	.1 =	3.32	Trial 3	4 /4	3.10 +	.1 =	3.20
12 /12			3.75	Average Total	12 /12			3.40

*Add 0.1 sec. penalty for missed targets over 6 meter course

%Difference: -10% *(100-[(I/U)×100])*

Comments:

Lateral Shuffles

Uninvolved Quality		3 m Reps*	Involved Quality
4 /4	Trial 1		3 /4
4 /4	Trial 2		3 /4
4 /4	Trial 3	11.04	3 /4
12 /12	TOTAL		9 /12

**Number of completed trips back and forth Over 3 meter course in 10 seconds.*

Sports Specific Agility Test

Uninvolved Quality		U/UC*	Involved Quality
4 /4	Trial 1	Run+Stop	3 /4
4 /4	Trial 2	Cross/Cut	3 /4
4 /4	Trial 3	Cross Crossover/Cut	3 /4
12 /12	TOTAL		9 /12

**C=Controlled, UC=Uncontrolled Run &Stop*

Comments:

Seat Level: 4

LEG PRESS:

	Max. Pounds	%Body Wt.
Uninvolved	250	
Involved	210	

%Difference: 16% *(100-[(I/U)×100])*

Comments:

OVERALL SCORE

		Uninvolved	Involved
Quality of Movement Score	TOTAL:	59 /60 = 98 %	51 /60 = 85 %
Objective Score	Total of % Differences	45 /5 = 9.2	

%Difference: 13%
%Difference: 9.2
TOTAL SCORE (%Diff QM + %Diff Obj.)/2 = 11%

Assessment: Overall 11% difference 13% with Quality of Movements
9% Objective, but skewed by (-10) difference in timed agility. Vertical Jump still 21%

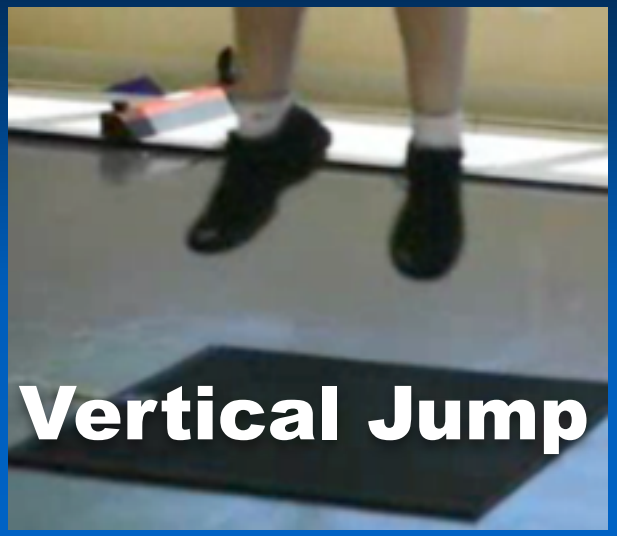
Recommendations: Work on lateral Direction change + overall Strength/power.

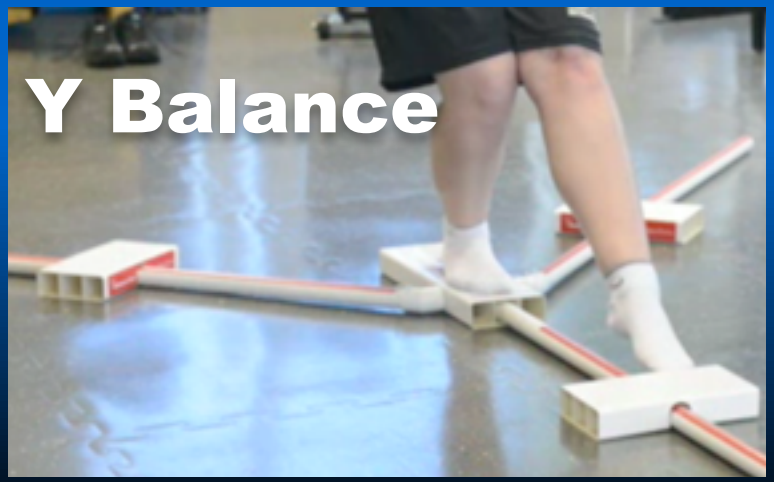
Evaluator: Scott Cambeg

Functional Assessment

Functional Assessment

Best test(s) to do to predict RTP Safely?





K. Donald Shelbourne MD
Response RTP after ACLR

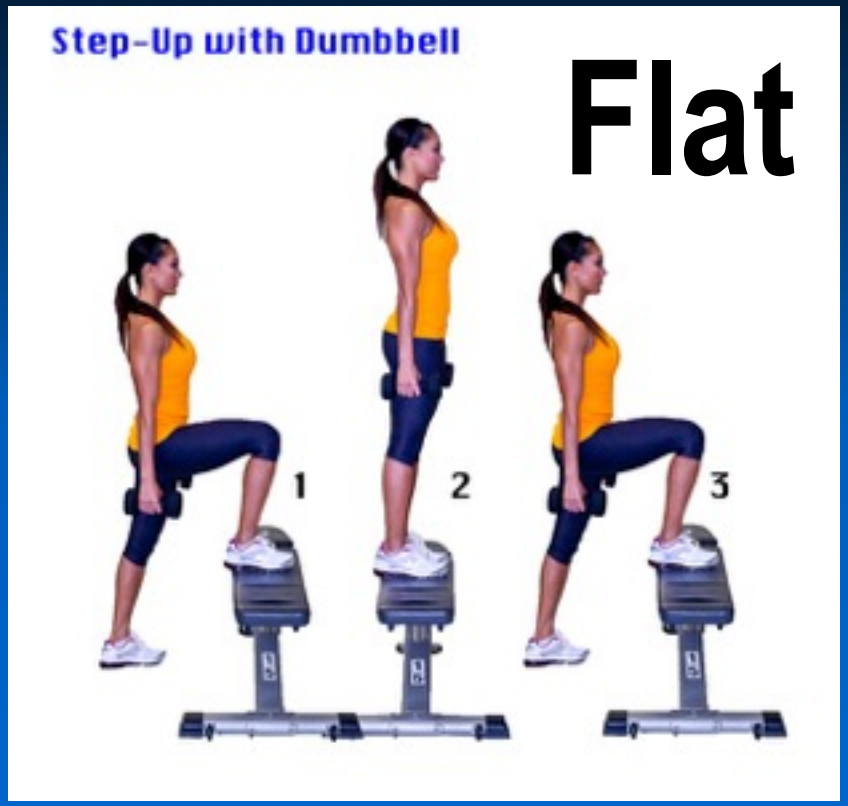
- Learn from your own results
- You can't make decisions based off others data
- 34 years dedicated to my data collection

- Goal ACLR patient
- Restore the knee to normal
  - Stable
  - Full ROM
  - KT OK

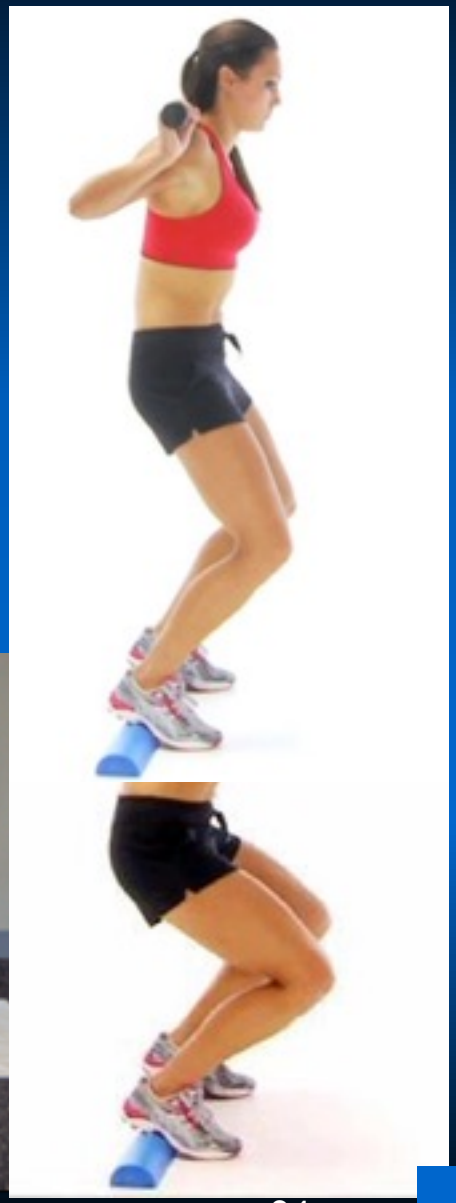
How to best get Quadriceps Back ….

- Eccentric
- Open Chain
- Safe variations of Eccentric Quad
  - Total Gym with bands early
  - Later Higher Weights

Eccentric Quad – Safe Or Sorry?



Wedge



Eccentric Quad – Safe Or Sorry?

Bands

Weight

Use of ALTER G when to start post ACLR

Fear of Reinjury?

Kineosiophobia Scales

Simple Single-Leg Squat

Give clinicians information on neuromuscular control

Plank Test

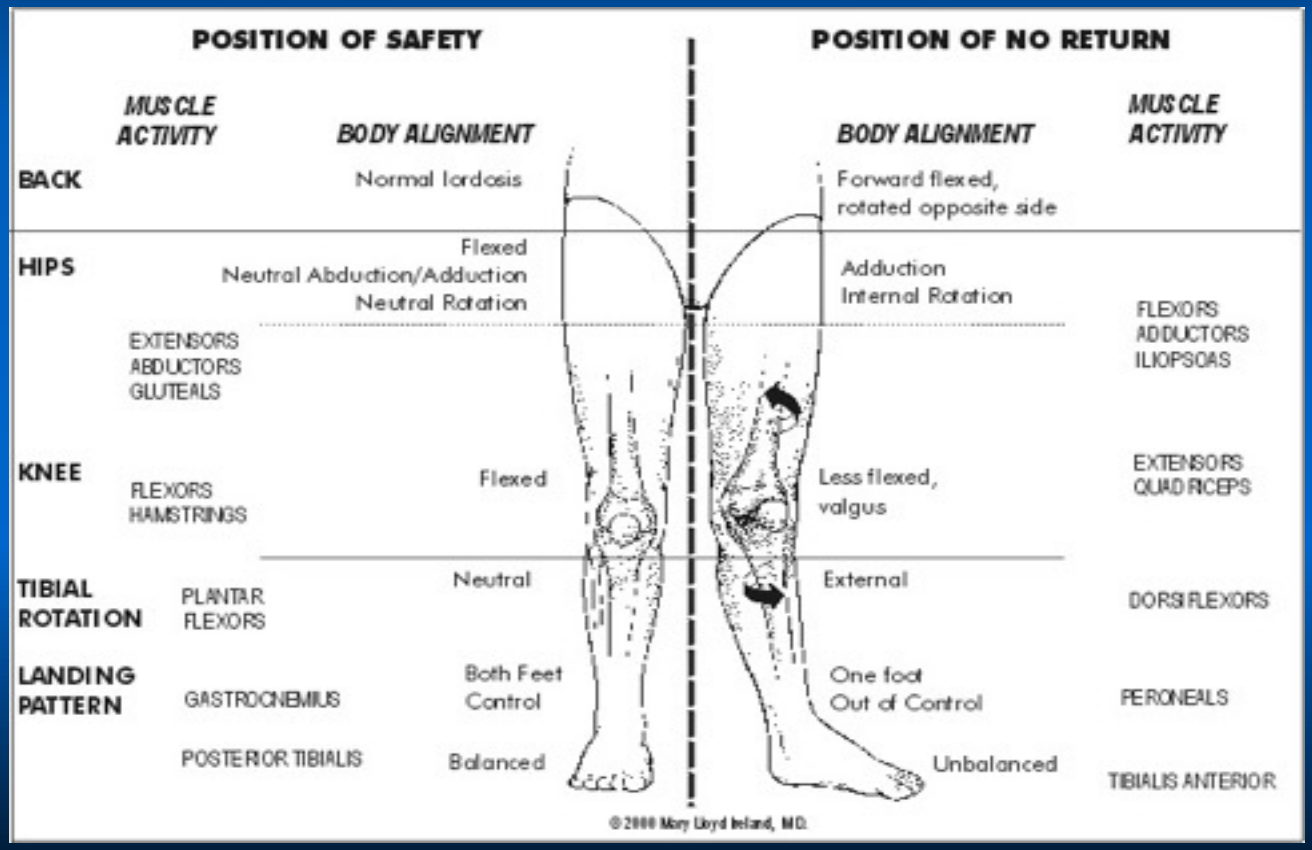
- Measures lumbar and pelvic control in side or sagittal plane
- Can see excessive lumbar lordosis

Observe in Fatigue and Non-fatigue states

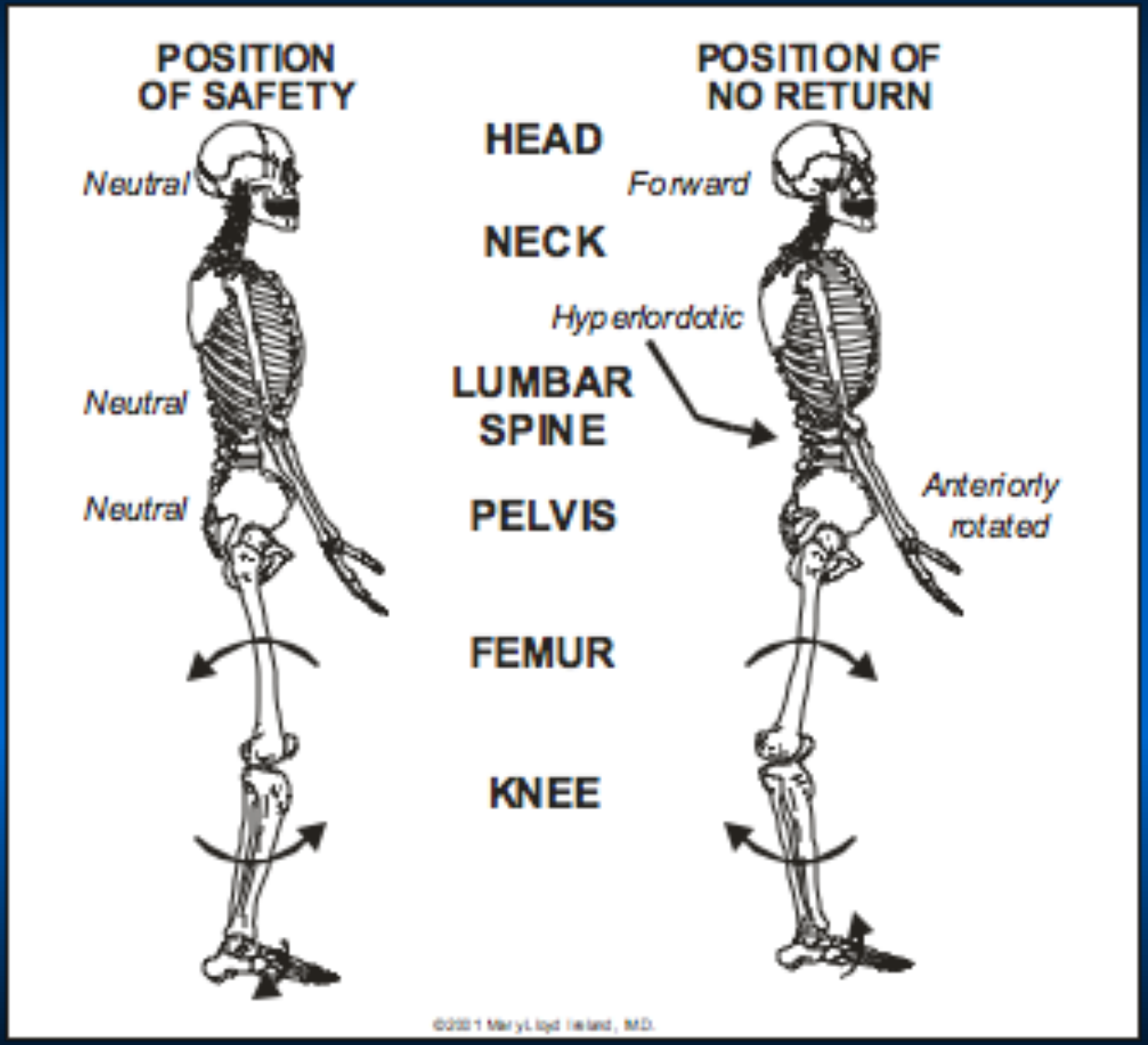
Ireland ML, Durbin T, Bolgla Lori.
Gender Differences in Core Strength and Lower Extremity Function During Single Leg Squat.
In: ACL Injuries in the Female Athlete:
Causes, Impacts, and Conditioning Programs
Noyes FR, Barber-Westin SD Eds, Springer-Verlag,

What I Have Observed

- Mechanism of Injury
  - High risk vs. low risk landing position



Alignment Proximal control / Core stability



What we test:

- **Trunk control:** through side plank, plank test
- **Knee control:** Repeated step downs- assess frontal and Sagittal plane control
- **Knee strength:** Isometric quadriceps strength test
- Through these functional tests we aim to better quantify, qualitative assessments of neuromuscular control that we feel may predispose someone to a subsequent injury.

Brian Noehren PT, Ph.D., FACSM

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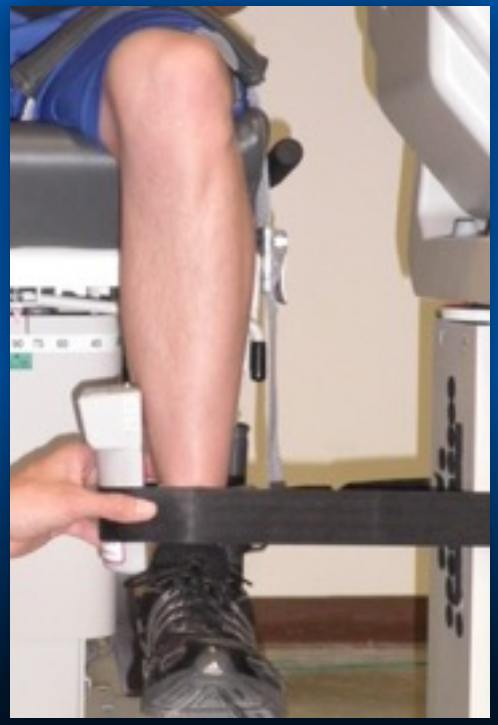
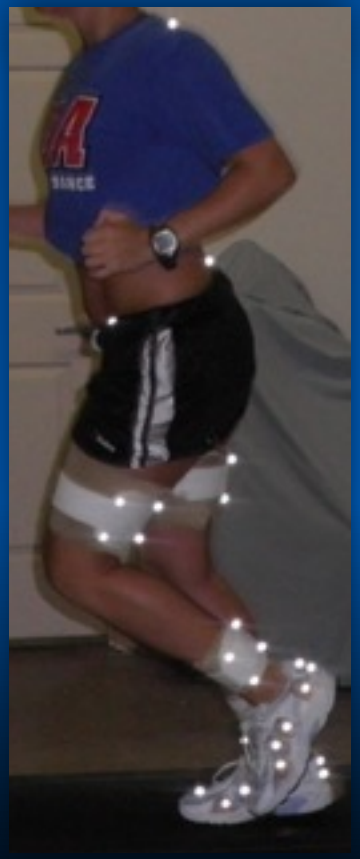
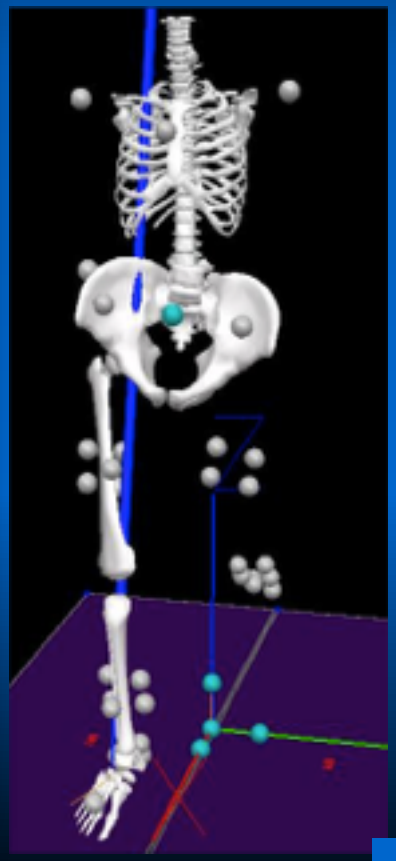






Single Leg Mini Squat

How Many Step Downs in 60 sec?

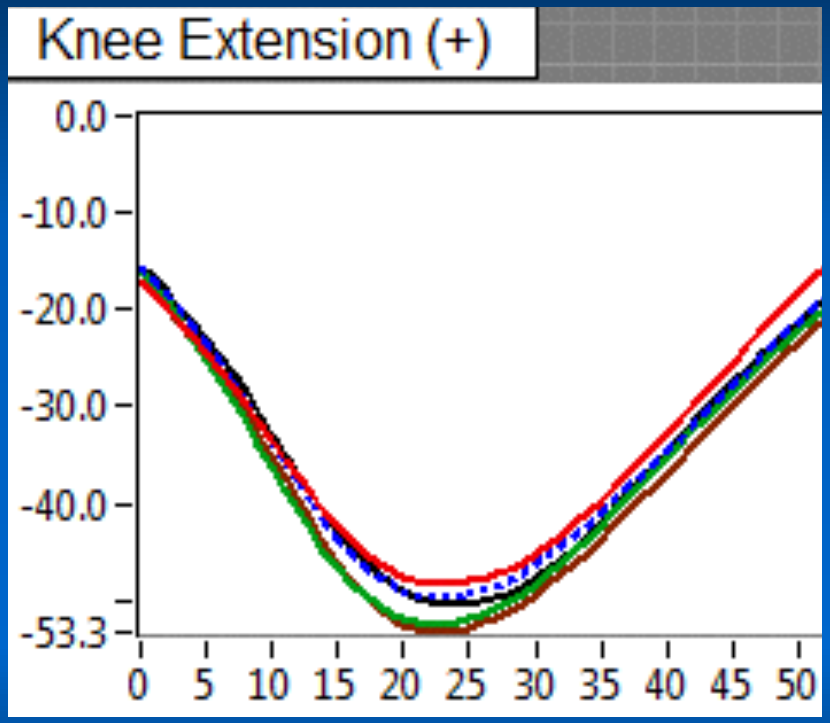
ACLR Side	31.8	
		p=.008
“Normal Side”	36	
		p=.026
Normal Control	40	

Noehren B. et al work in progress

10 Months R ACLR

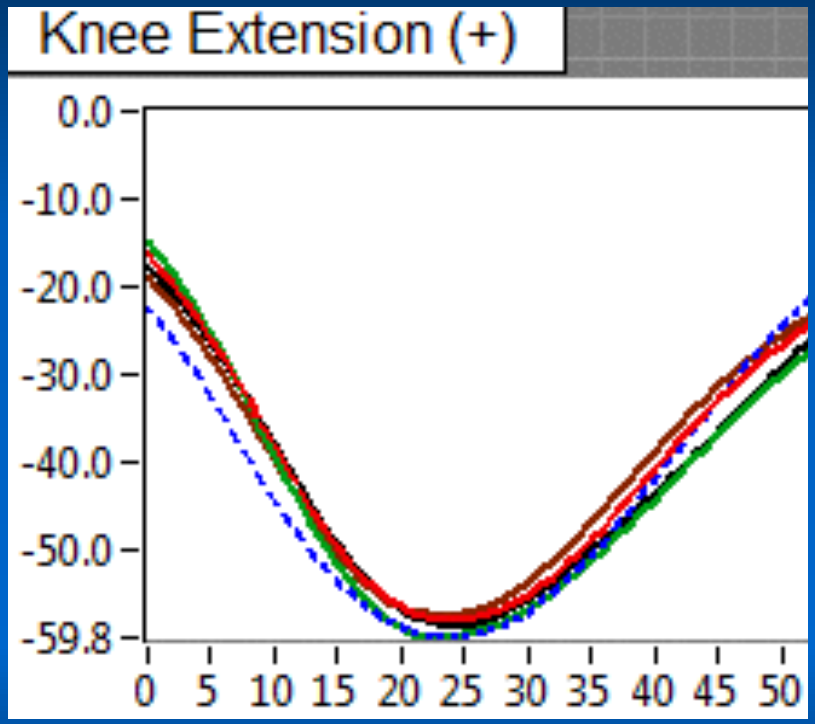
10 Months Right ACLR Full Sports

Right



Average 50 degrees

Left

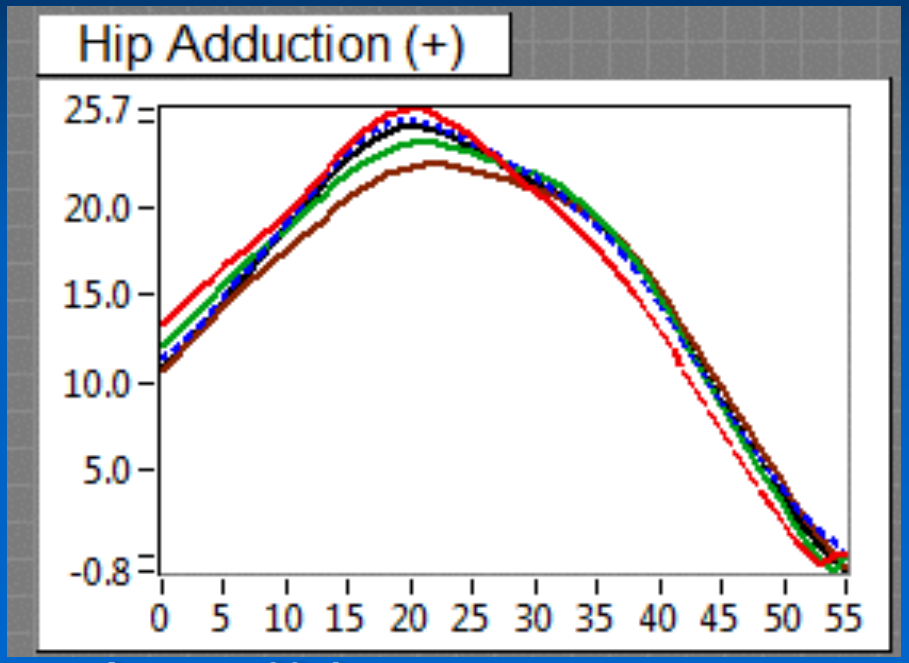


Average 58 degrees

Normal: 45 degrees

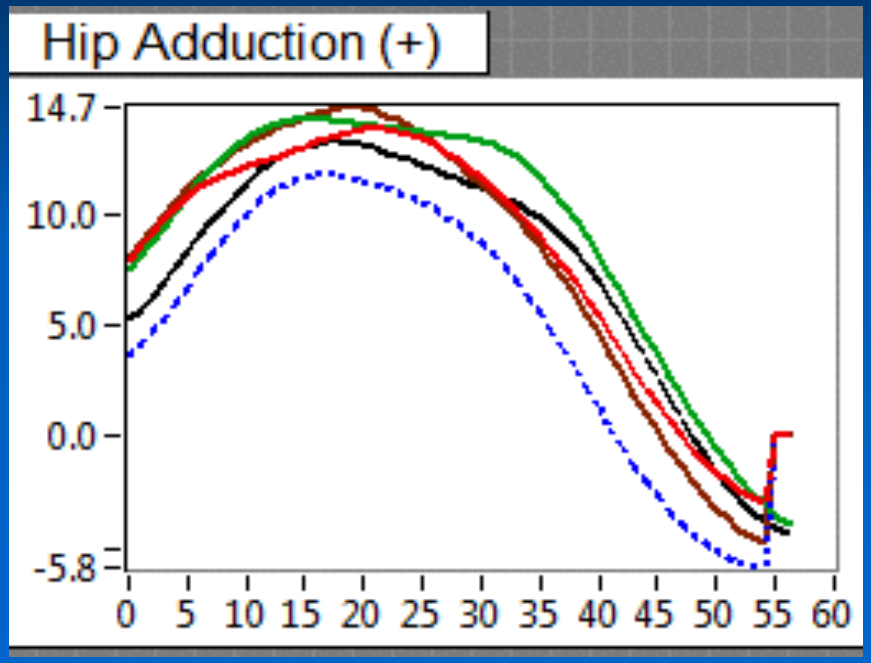
10 Months Right ACLR Full Sports

Right



Average 23 degrees

Left



Average 12 degrees

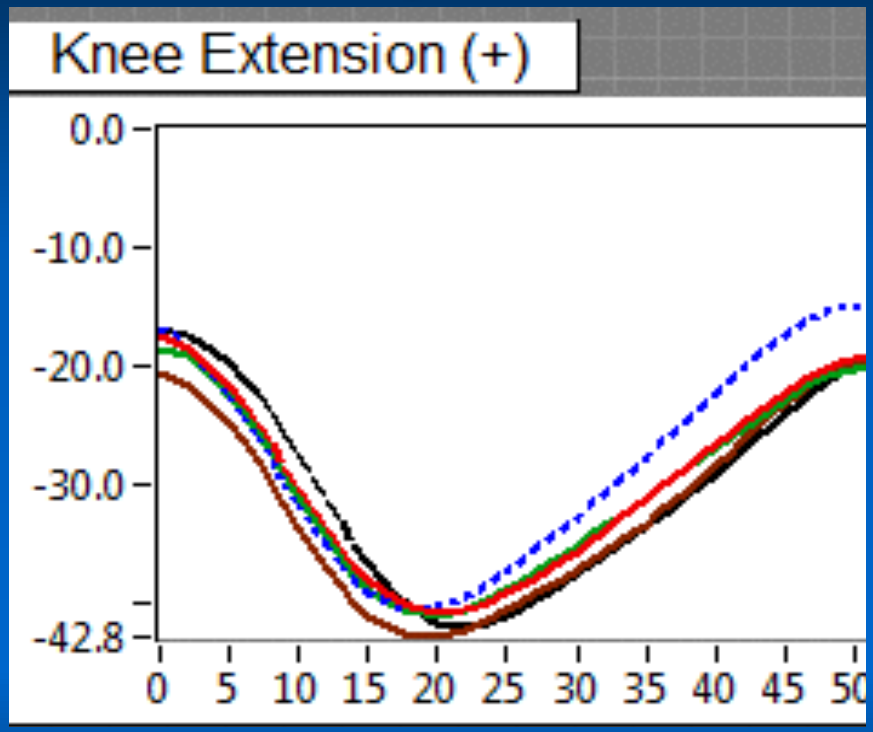
Normal: 16 degrees

7 Months Right ACLR Full Soccer

- Forward Trunk &Pelvic Tilt ,Trendelenberg

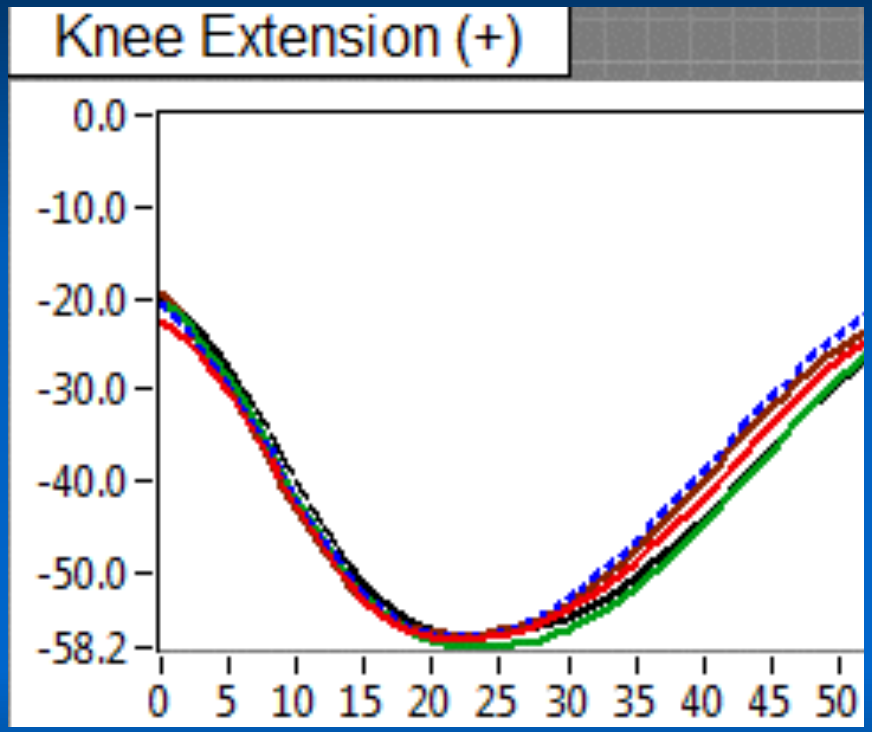
7 Months Post OP Playing Soccer
Abnormal Gait and Knee ROM

Right



Average 40 degrees

Left

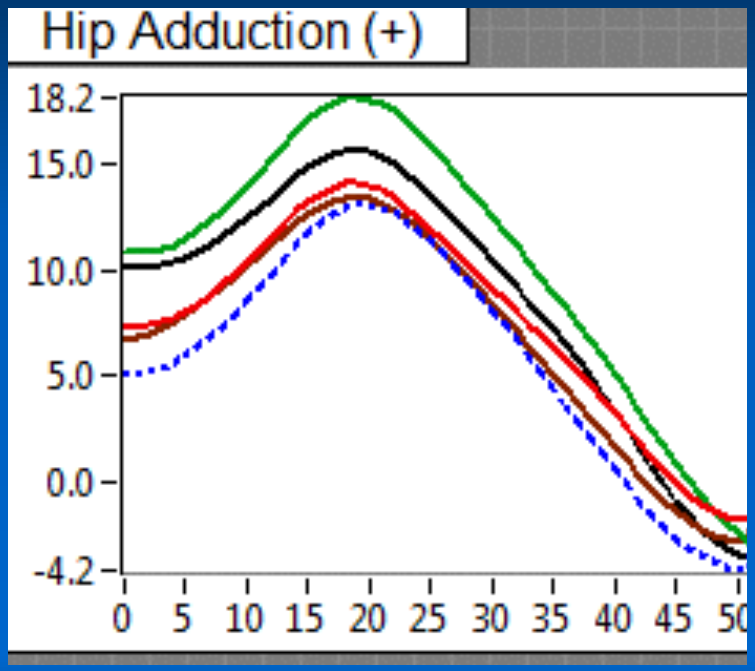


Average 58 degrees

Normal: 45 degrees

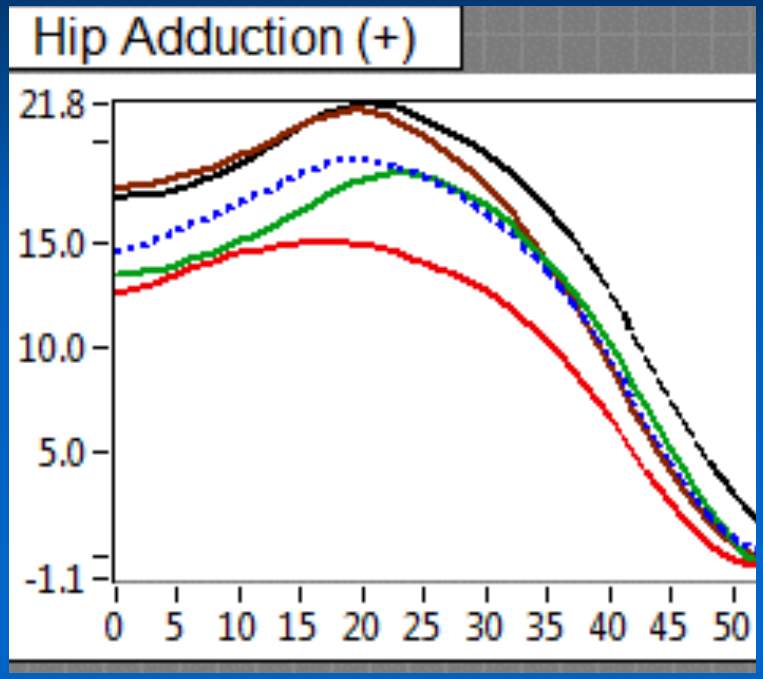
7 Months Right ACLR Playing Soccer

Right



Average 15 degrees

Left



Average 18 degrees

Normal: 16 degrees
LESS by 3 degrees

Gait Analysis, Balance, and Strength

What do we compare?

Normal vs Post ACLR vs Uninjured Leg

What are the objective measurements of?

Hip, Trunk, Balance, Gait

What do the functional tests we do really tell us?

Tell the Patient if they are ready or not.

What are the Best Tests to Do?

Trunk Control R ACLR

Trunk Control Test Errors:

p = 0.001

ACL = 7.1 Control = 3.4 ACL Opposite = 5.8

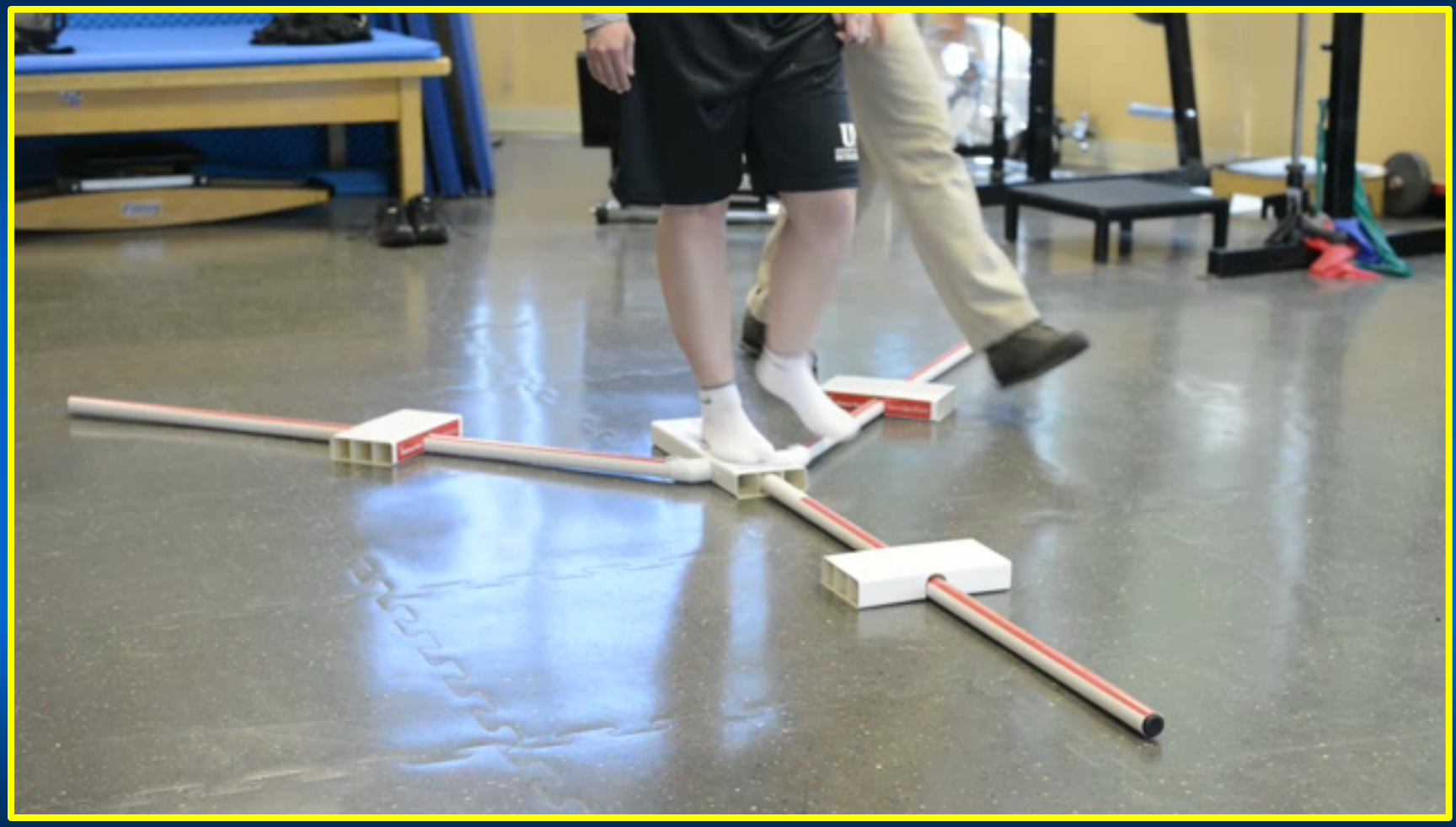
Intervention Approach

- Emphasize hip abduction and external rotation
- Proper body position
  - Back, hip and knees
- Integration of core musculature to functional activities

Functional Tests: Triple Jump

Functional Tests: TRX

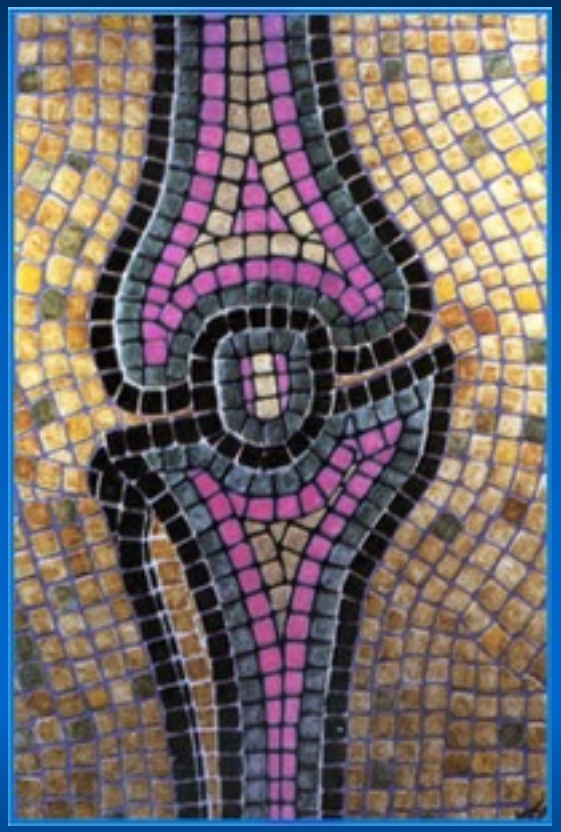
Functional Tests: Y Balance



Functional Tests: Vertical Jump

Single Leg Balance Catch

Sex and Sports:
Caring for the Female Athlete
ACL Injuries



AAOS
AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

Orlando, FL
March 2 2016

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Dept. of Orthopaedic Surgery & Sports Medicine
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Sex Based Considerations in Caring for Common Sports Injuries

Laura M. Bruse Gehrig, MD
Margaret M. Baker, MD
Cordelia W. Carter, MD
Christy Hylden, MD
Mary Lloyd Ireland, MD
Anthony Johnson, MD
Elizabeth G. Matzkin, MD

AAOS
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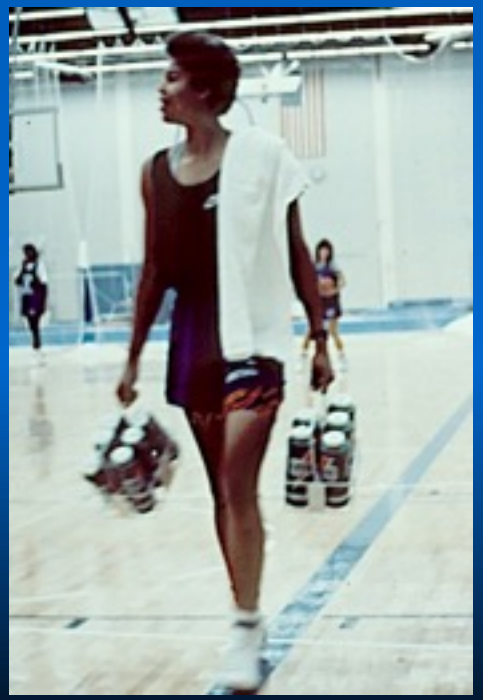
Women's Health Issues Advisory Board

The AAOS Women's Health Issues Advisory Board (WHIAB) seeks to advocate, advance, and serve as a resource on sex and gender differences in musculoskeletal health.

Females suffer from injury/disease in different ways than males. Recognizing sex-related differences is critical to optimizing patient care.

www.aaos.org/women

30 Years After Appreciating Non-contact ACL higher rates in basketball, what progress have we made?



30 Years of Observation has led to many research ideas

- 80 males, 64 females
  - Knee injuries: Number (% of gender)
    - Males, 11 (13%); Females 34 (53%) p<.0001
- 20 (18%) underwent surgery
  - Males 6 (7.5%); Females 20 (31%) – 21 surgeries p=.0007
- ACL reconstructions: 2 males, 8 females

  - M. L. Ireland, C. Wall, "Epidemiology and Comparison of Knee Injuries in Elite Male and Female United States Basketball Athletes" MSSE 1989.Presented at ACSM Annual Meeting Salt Lake City, Utah

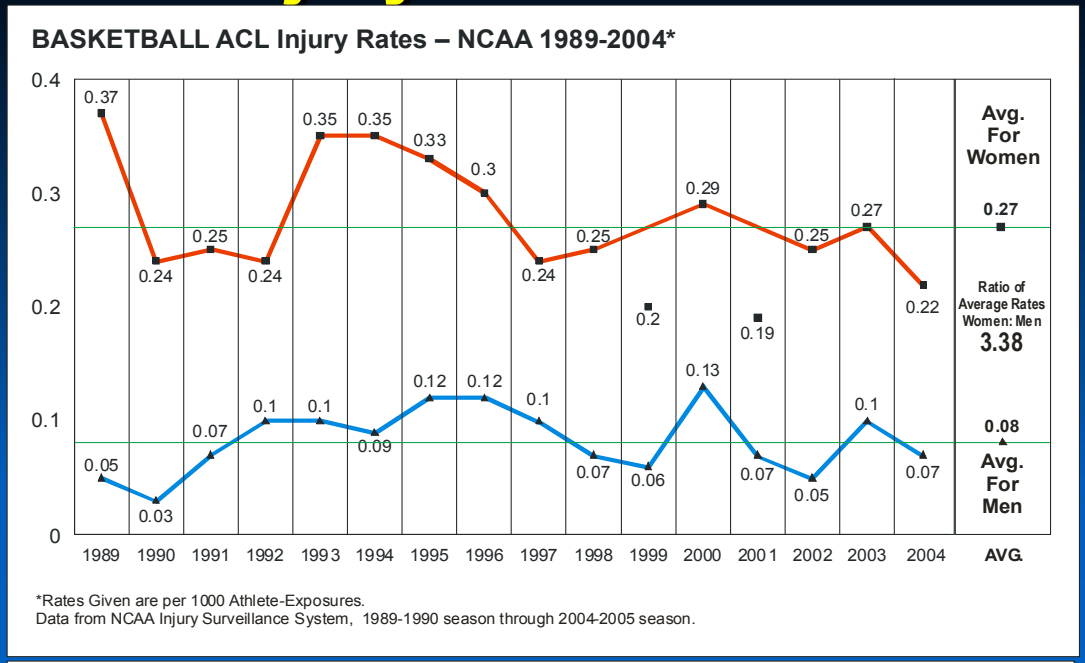
Sex Based Considerations in caring for common sports injuries

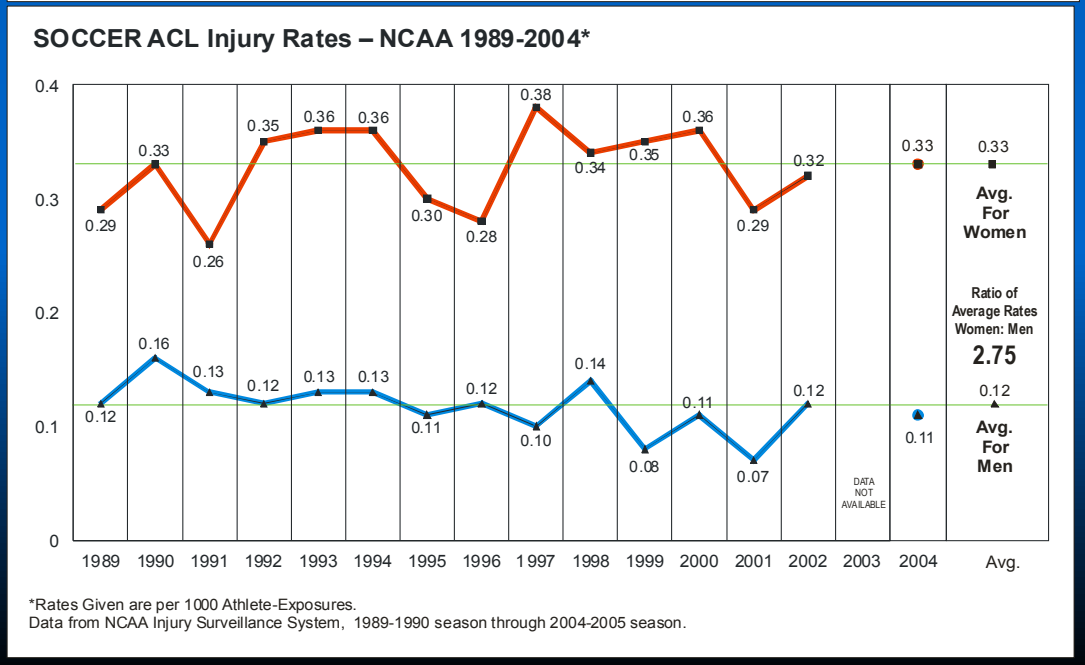
ACL Injuries and Management

- Epidemiology highest Female:Male rate differences[1]
  - Basketball and Team Handball

Renstrom P, Ljungqvist A, Arendt E, Beynnon B, Fukubayashi T, Garrett W, Georgoulis T, Hewett T, Johnson4 R, Krosshaug T, Mandelbaum B, Micheli L, Myklebust G, Roos E, Roos H, Schamasch P, Shultz S, Werner S, Wojtys E, Engebretsen L. Non-contact ACL injuries in female athletes: an International Olympic Committee current concepts statement. *Br J Sports Med* 2008;42:394-412

ACL Injury Rates NCAA 1989-2004





Basketball Women:Men 3.38

Soccer Women:Men 2.75

Sex Differences Incidence 2-8 Times Greater Rates of ACL Tears

- Basketball
- Team Handball
- Netball
- Alpine Skiing
- Soccer

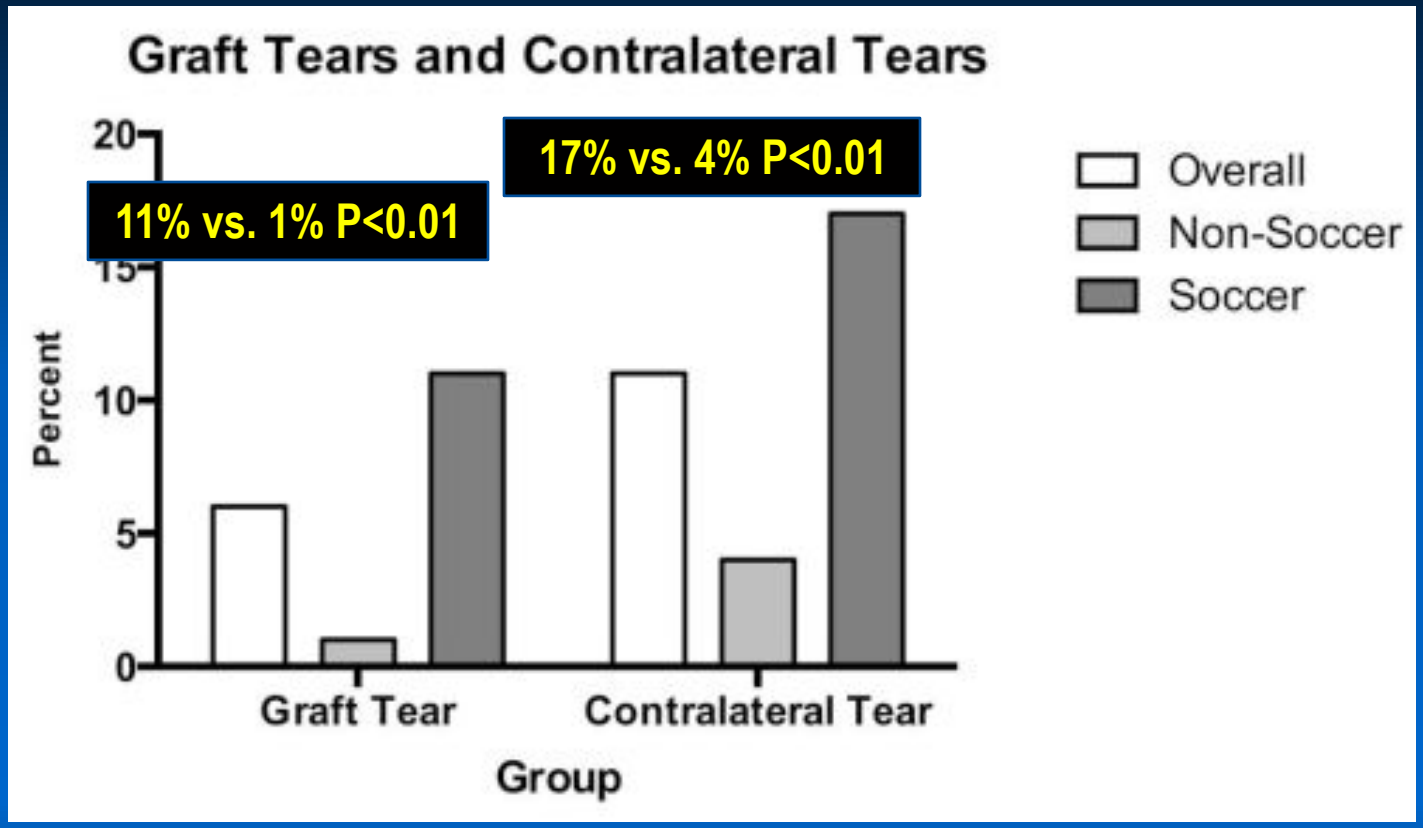
Increased Risk of Second ACL Injury for Female Soccer Players

- 180 Female ACLR Retrospective Study
  - 90 Soccer Athletes
  - 90 Non-Soccer Athletes
- 5.8 year follow-up
- ACL Graft tears and contralateral tears significantly greater in soccer athletes
- Return to Soccer and Older Age were significant factors for ACL rerupture but not contralateral tear.

Soccer Female Athletes More Likely to Tear Contralateral Side than Their Reconstructed Side
Our ACLR is better than the Normal
LET THEM PLAY EARLIER!

Author(s): Melissa M. Allen, MD, Rochester, Minnesota; Alexander H. King, BS, Rochester, Minnesota; Michael J. Stuart, MD, Rochester, Minnesota; Bruce A. Levy, MD; Diane L. Dahm, MD; Aaron J. Krych, MD
Mayo Clinic, Rochester, Minnesota - Presented at AAOS March 2016

Increased Risk of Second ACL Injury for Female Soccer Players



RETURN EARLY OR NOT AT ALL... 17% vs 4% DOESN'T MATTER WHEN THEY RETURN!

Author(s): Melissa M. Allen, MD, Rochester, Minnesota; Alexander H. King, BS, Rochester, Minnesota; Michael J. Stuart, MD, Rochester, Minnesota; Bruce A. Levy, MD; Diane L. Dahm, MD; Aaron J. Krych, MD
Mayo Clinic, Rochester, Minnesota - Presented at AAOS March 2016

Risk Factors Resulting in ACL Injuries

- **NOT modifiable:**
  - Anatomic/Structural
  - Hormonal
- **Modifiable:**
  - Neuromuscular/biomechanical
- Expert think tanks agree that modifiable factors are most important
- Emphasize modifiable factors for return-to-play and prevention programs

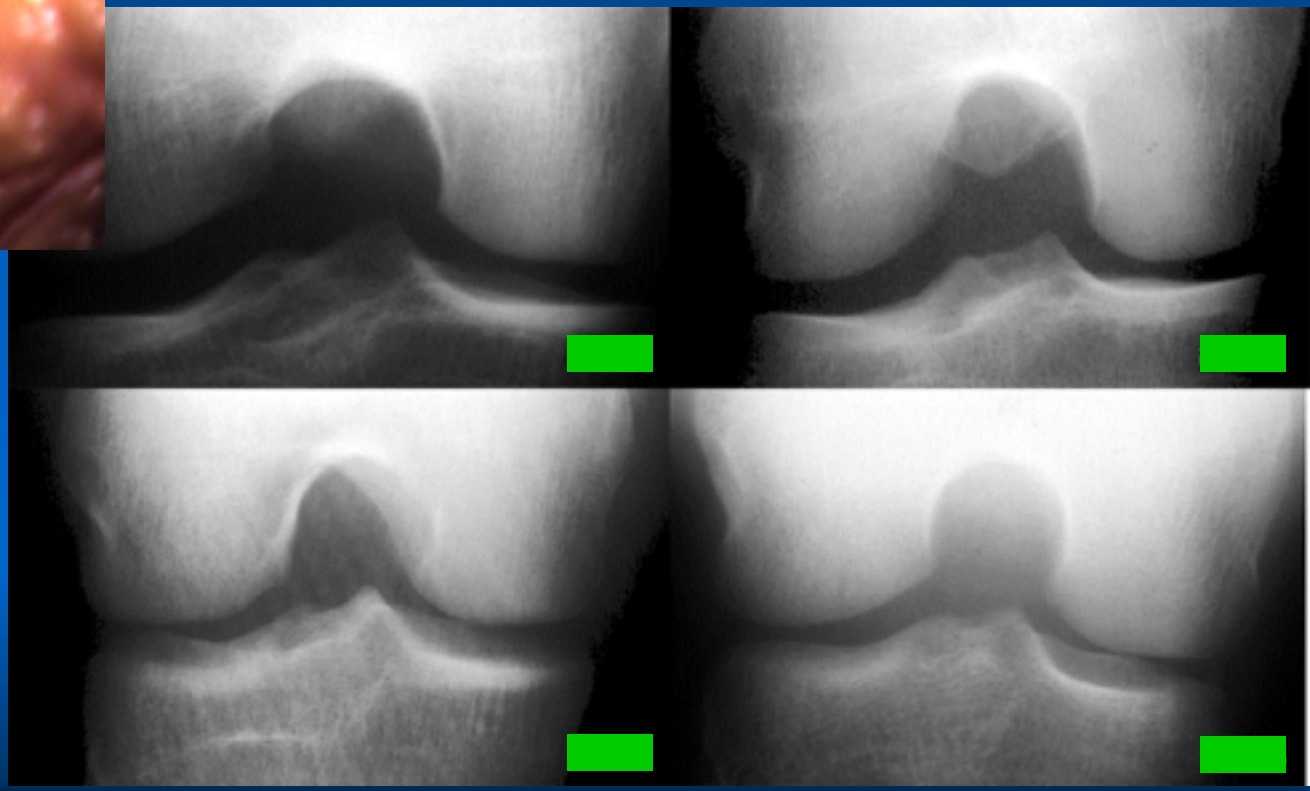
Ireland ML, Durbin T, Bolgla Lori. Gender Differences in Core Strength and Lower Extremity Function During Single Leg Squat. In: ACL Injuries in the Female Athlete: Causes, Impacts, and Conditioning Programs, Noyes FR, Barber-Westin SD Eds, Springer-Verlag, Berlin Heidelburg, 2012.

Anatomic Differences in the Knee
No Sex Differences

- Notch size and shape
- Tibial slope on sagittal measurements
  - Normal: 10° posterior slope
  - Greater Posterior Slope is a risk factor for ACL injury
- Size of ligament
- Femoral condyle size and shape

Notch Size and Shape

- No Sex Differences
- Smaller Notch and Ratios
  = Greater ACL Tear Rate



Ireland et. al., "A Radiographic Analysis of the Relationship Between the Size and Shape of the Intercondylar Notch and Anterior Cruciate Ligament Injury," *Knee Surgery Sports Traumatol. Arthrosc.* (2001) 9:200-205.

Notch View Radiographs
Patient Numbers

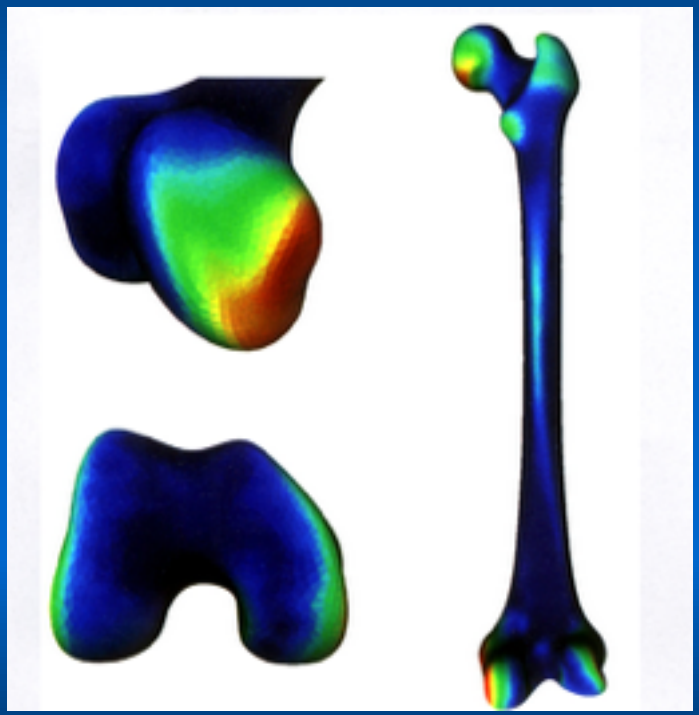
- 108 ACL Injuries
  55 women, 53 men
- 186 Intact ACL
  94 women, 92 men
- Width Femur + Notch
- Ratios Femur/Notch
- Shape A vs. Non-A

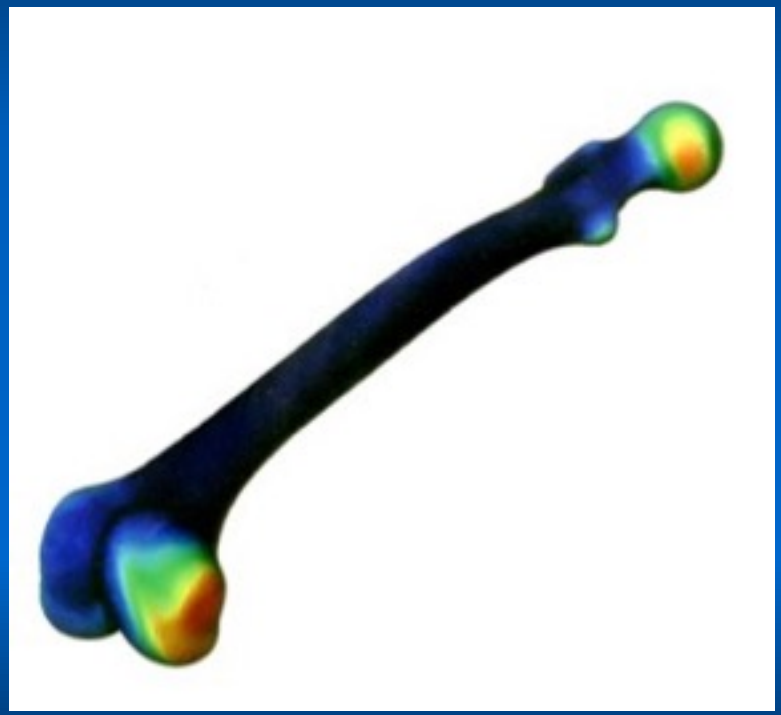
Ireland et. al., "A Radiographic Analysis of the Relationship Between the Size and Shape of the Intercondylar Notch and Anterior Cruciate Ligament Injury," *Knee Surgery Sports Traumatol. Arthrosc.* (2001) 9:200-205.

BONY MORPHOLOGY
Shape and Size of Femoral Condyles

Female Knee

Less wide and significant difference medial more than lateral femoral condyle





Mahfouz MR, et. al., "Analysis of Variation and Automated Measurement of Adult Femora Using Sex-Specific Atlases," AAOS 74th Annual Meeting, 2007, San Diego, Ca.

Tibial Plateau Geometry

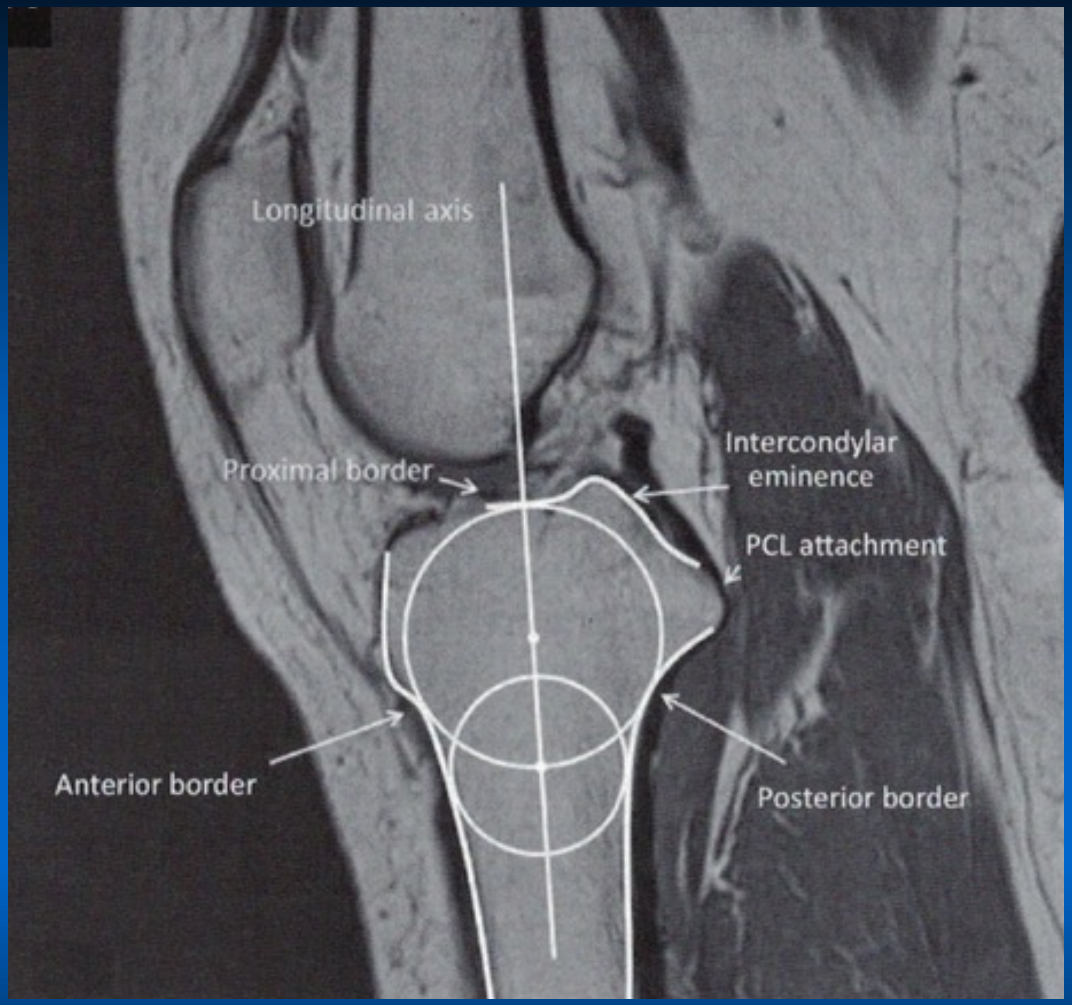
- No Sex Differences
- Tibial Plateau Risk Model:
  - Medial and Lateral Slope
  - Medial Tibial Depth

Odds Ratios	Female	Male
1mm ↓ MTP And 1° ↑ Posterior Slope	3.58	4.18

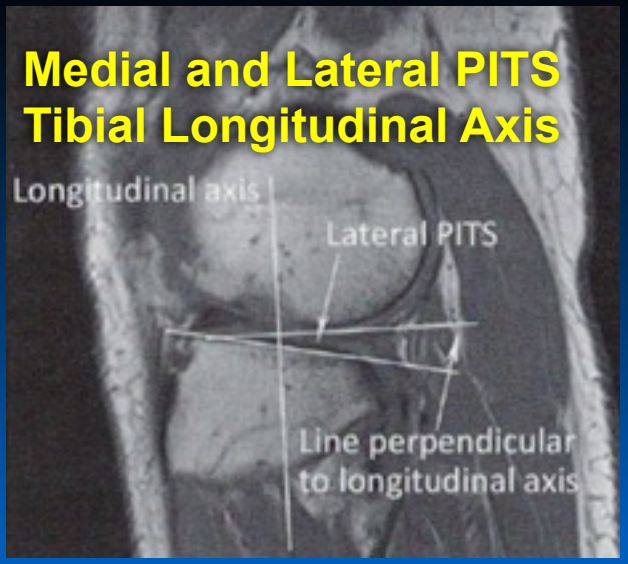
Gibson G, Hashemi J, Mansouri H, Slauterbeck J, Beynnon V. On the Horizon from ORS. *Journal of the American Academy of Orthopaedic Surgeons*. 2010 OCT 18(10):638-641

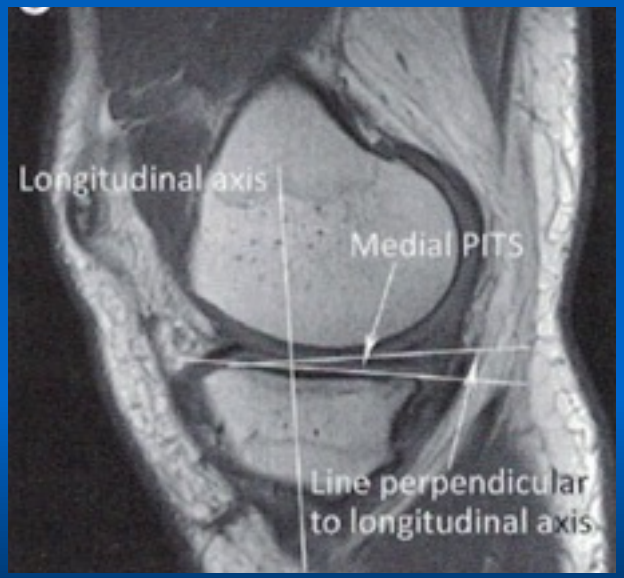
Hashemi J, Chandrashekar N, Mansouri H, et al: Shallow medial tibial plateau and steep medial and lateral tibial slopes: New risk factors for anterior cruciate ligament injuries. *Am J Sports Med* 2013;38(1): 54-62

Central Sagittal Slice



Medial and Lateral PITS Tibial Longitudinal Axis

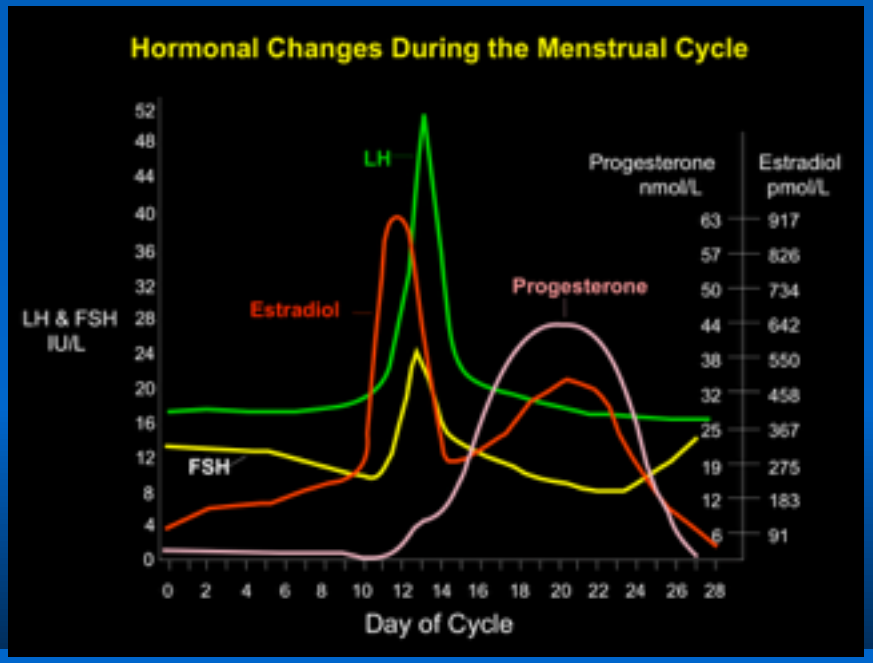




Hudek R,Schmutz S, Regenfelder F, Fuchs B, Koch PP. Novel Measurement technique of the tibial slope on conventional MRI. *Clin Orthop Relat Res. 2009;467(8): 2066-2072* In AJSM 44:2 Feb, 2016

Intrinsic

- Hormonal / Joint Laxity
  - Data are insufficient to make any conclusive statement regarding menstrual cycle of knee laxity and on the rate of ACL injury in females



Sutton K, Bullock J. Anterior Cruciate Ligament Rupture: Differences Between Males and Females. *The Journal of the American Academy of Orthopaedic Surgeons* 01/2013; 21(1):41-50.

The *COL5A1* Gene Is Associated With Increased Risk of ACL Tears in Females

- Gene that encodes alpha1 chain: of
- Type 1 collagen ACL tears
- Type 5 collagen Achilles tendon injuries

Posthumus M, September A, O'Cuinneagain D, Merwe W, Schwellnus M, Collins M. The *COL5A1* Gene Is Associated With Increased Risk of Anterior Cruciate Ligament Ruptures in Female Participants. *Am J Sports Med* NOV;37(11) 2234-40

Hypermobility (excessive joint laxity) associated with increased incidence of musculoskeletal injury

Wolf JM, Cameron KL, Owens BD. Impact of joint laxity and hypermobility on the musculoskeletal system. *J Am Acad Orthop Surg*. 2011 Aug;19(8):463-71.

Extrinsic

- Kinematics
  - Valgus Collapse and increased knee abduction moment
  - 205 female athletes, 9 ACL tears
  - Greater abduction moment predicted ACL injury p<.001

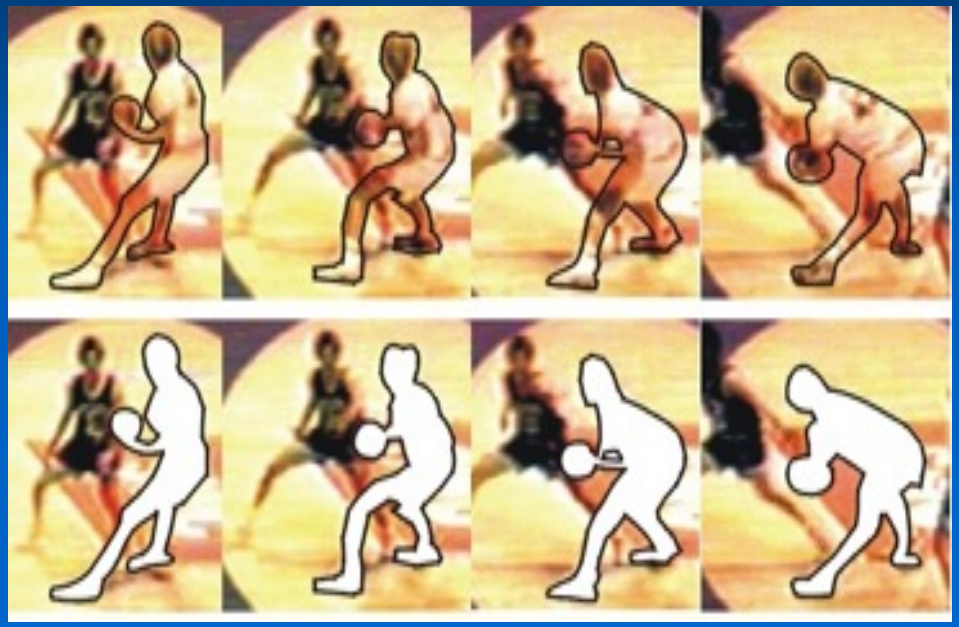
Hewett TE, Myer GD, Ford KR, et al: Biomechanical measures of neuromuscular control and valgus loading of the knee predict Anterior Cruciate Ligament injury risk in female athletes: A prospective study. *AM J Sports Med* 2005;33(4):492-501.

	Male	Female
Pelvis	Level	Contralateral Drop
Hip	No Rotation	Internal Rotation and Adduction
Knee	0° Varus/Valgus	Valgus
Tibia	Neutral	External Rotation
Foot	Flat	Pronation
Back	Flat	Lordotic
Pelvis	Neutral	Anterior Tilt

Ireland ML, Durbin T, Bolgla Lori. Gender Differences in Core Strength and Lower Extremity Function During Single Leg Squat. In: ACL Injuries in the Female Athlete: Causes, Impacts, and Conditioning Programs.Noyes FR, Barber-Westin SD Eds, Springer-Verlag, Berlin Heidelburg, 2012.

Mechanisms of Injury

- No Sex Difference in noncontact Mechanisms
- Weight bearing Pivot Shift



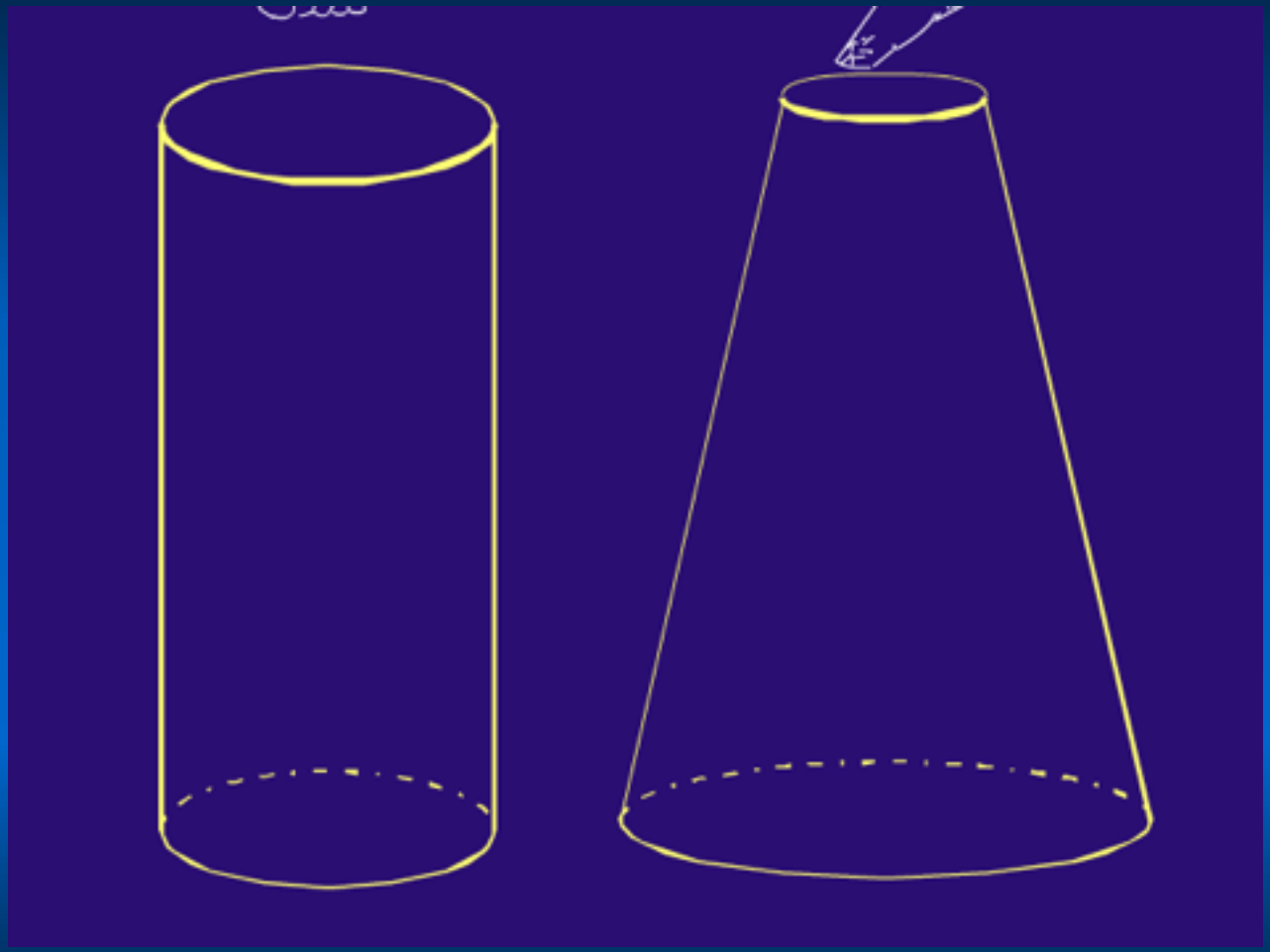
Basketball

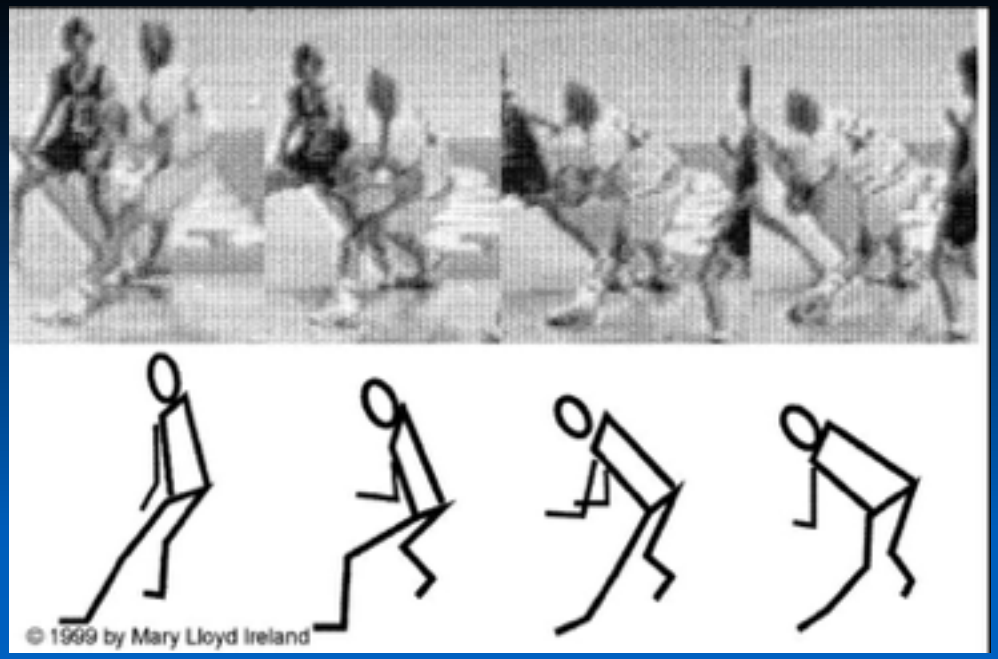
VROOM . . .

- Valgus
- Rotation
- Out
- Of control
- Movement

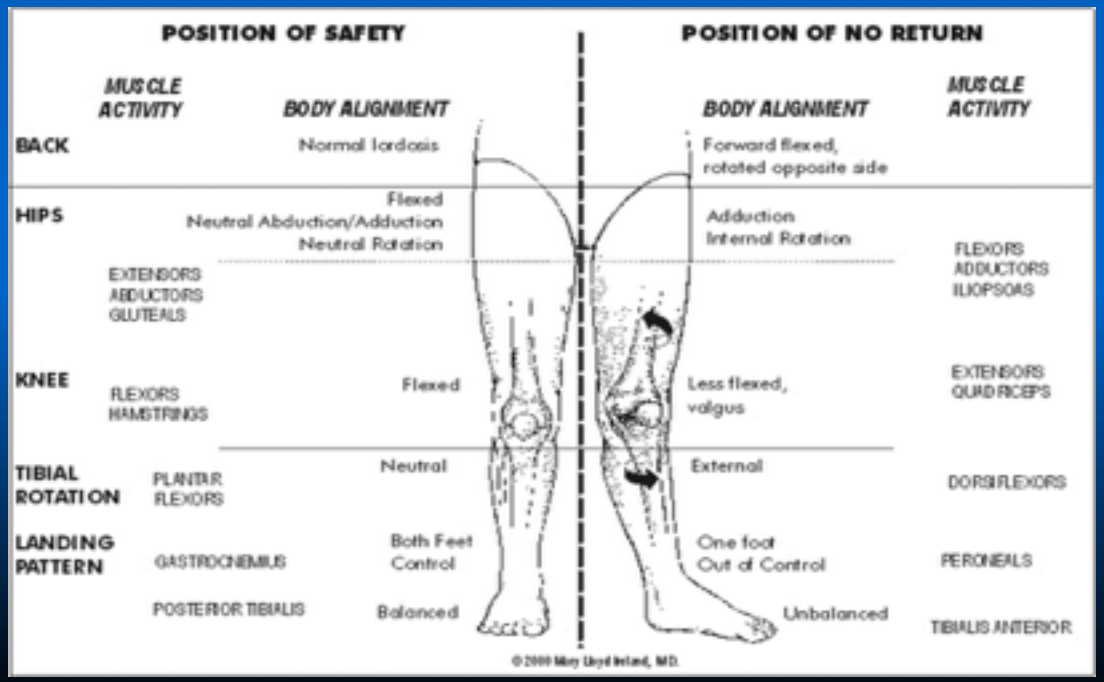
It takes 70 milliseconds to tear the ACL

Knee: Cone of Stability





How do we teach athletes to land in a safe position?



Prevention and post ACLR rehab programs:

No Sex Differences

Griffin LY, Albohm MJ, Arendt EA, Bahr R, Beynnon BD, Demaio M, Dick RW, Engebretsen L, Garrett WE Jr, Hannafin JA, Hewett TE, Huston LJ, Ireland ML,Johnson RJ, Lephart S, Mandelbaum BR, Mann BJ, Marks PH, Marshall SW, Myklebust G, Noyes FR, Powers C, Shields C Jr, Shultz SJ, Silvers H, Slauterbeck J, Taylor DC, Teitz CC, Wojtys EM, Yu B. Understanding and preventing noncontact anterior cruciate ligament injuries: a review of the Hunt Valley II meeting, January 2005. *Am J Sports Med*. 2006 Sep;34(9):1512-32.

What the Prevention Programs have in common?

- Emphasize safe landing positions
- Neuromuscular recruitment
- Should be sport-specific
- Program must be done properly and participation documented
- Look at all lower extremity injury rates, not just ACL tears

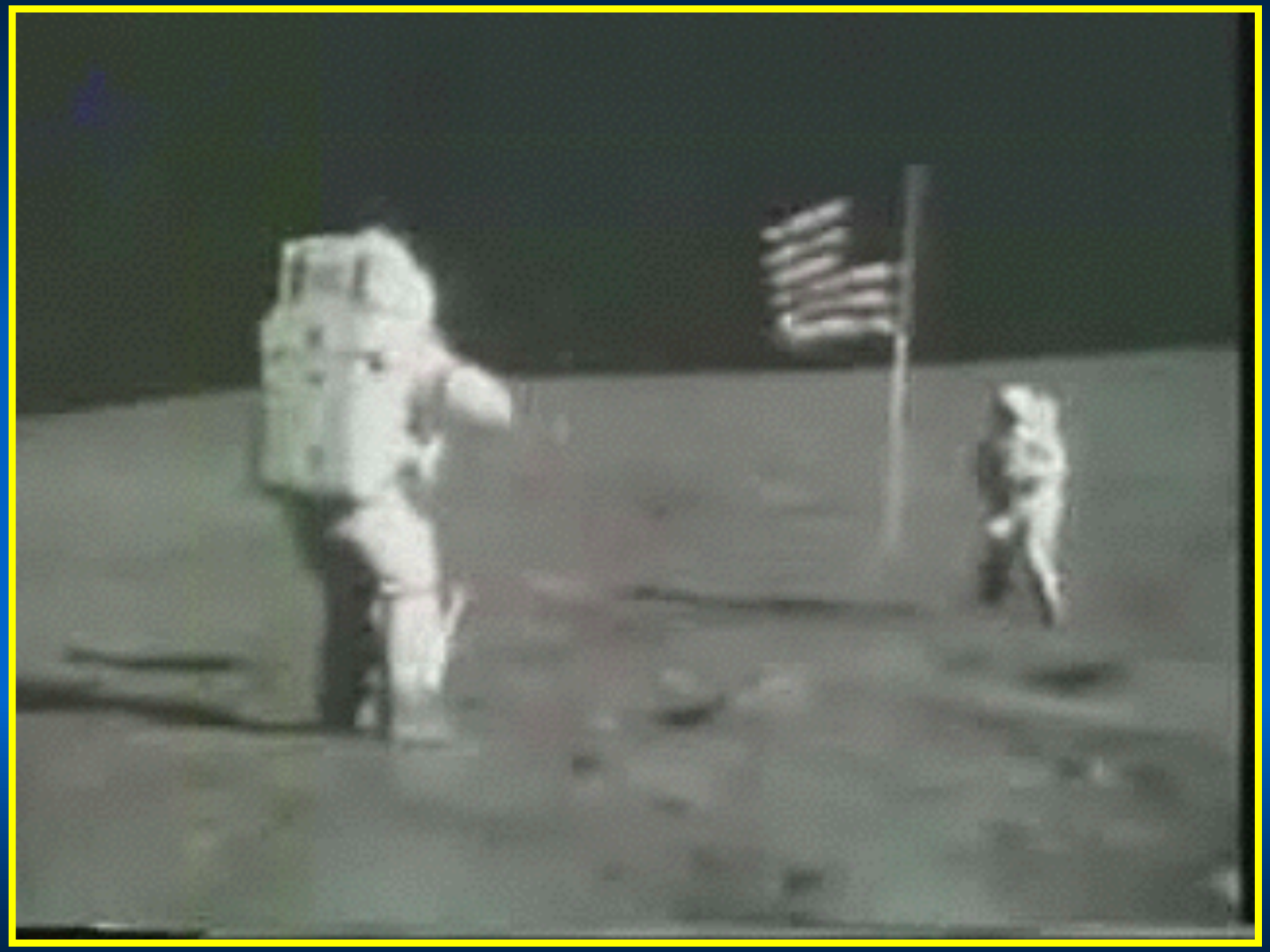
Lower Extremity Injury Prehab Program

Message: Performance enhancement, not injury prevention

Youtube.com/ukyortho

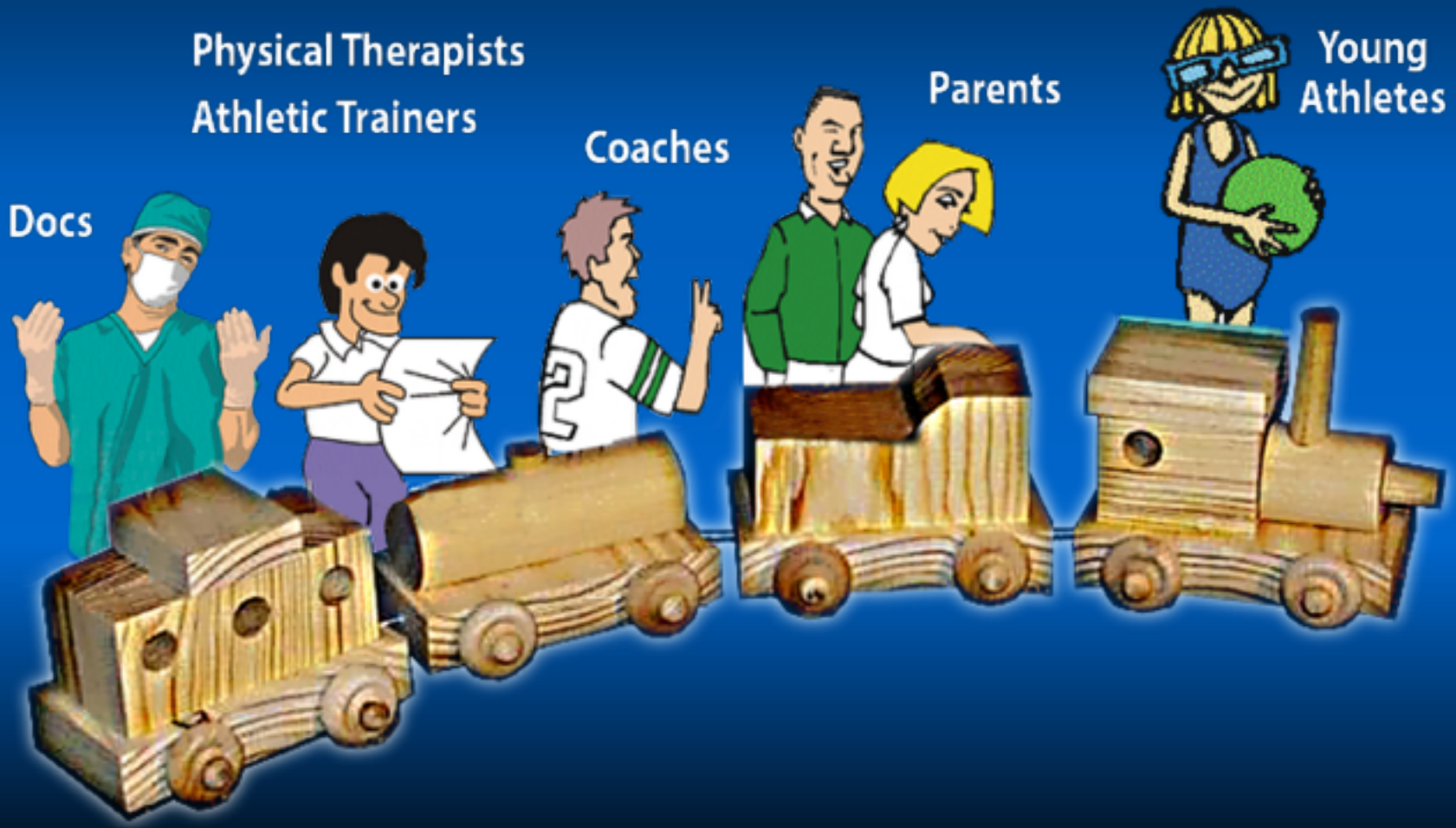
http://goo.gl/ivMHcx

Landing is EVERYTHING!



Difference between
men and women

Who is driving the ACLR RTP Train?



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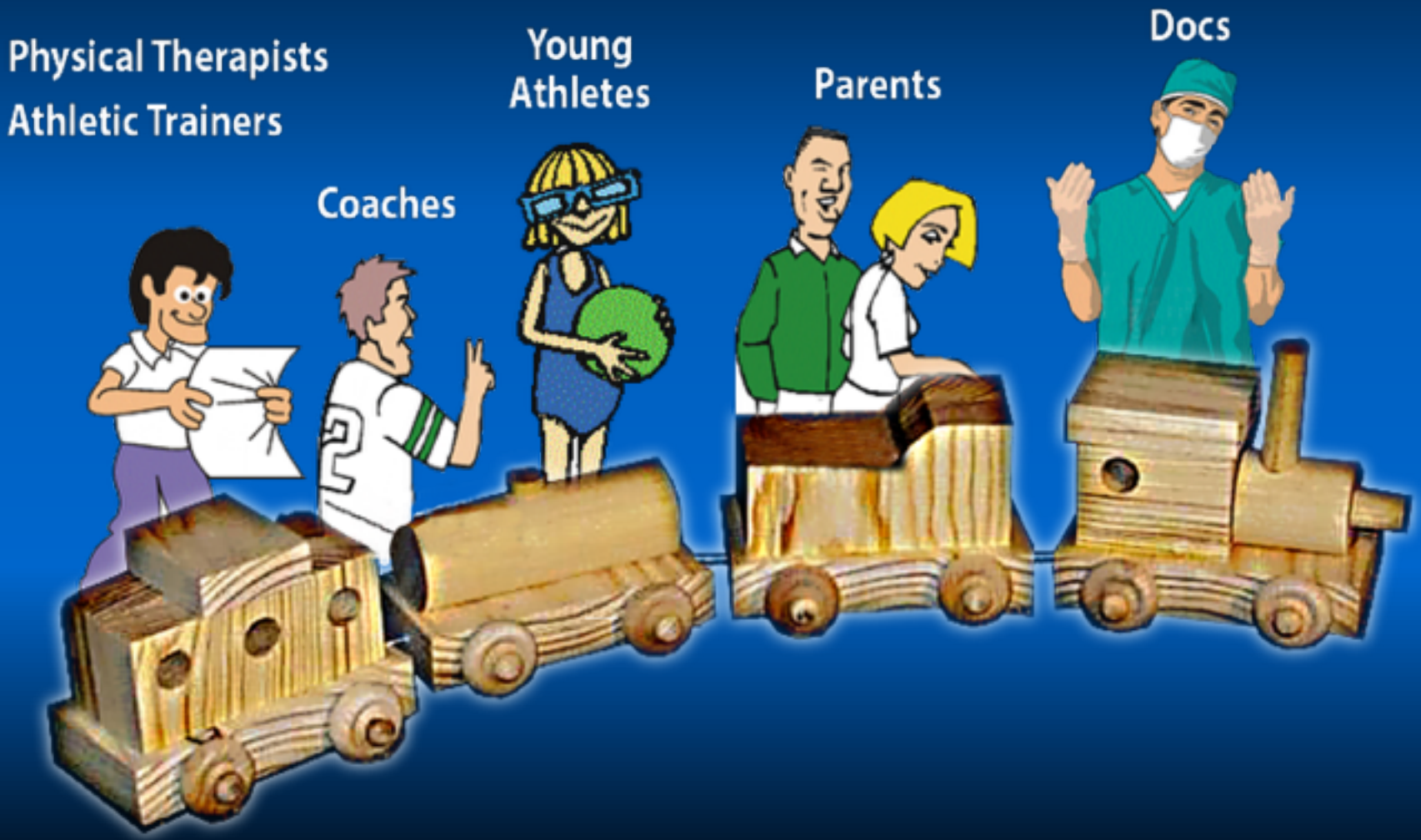

Thank you…….

www.MaryLloydIreland.com

Questions from the Audience