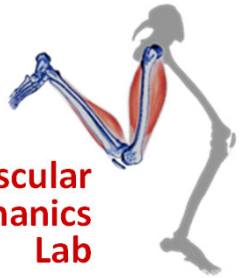
Rehabilitation of Hamstring Injuries: We Can Do Better



UW Neuromuscular Biomechanics Lab

UNIVERSITY OF WISCONSIN BADGER ATHLETIC PERFORMANCE

Bryan Heiderscheit, PT, PhD, FAPTA
Professor
Department of Orthopedics and Rehabilitation
Department of Biomedical Engineering
Doctor of Physical Therapy Program
Director, UW Runners' Clinic
Director of Research, Badger Athletic Performance
Co-director, UW Neuromuscular Biomechanics Lab
heiderscheit@ortho.wisc.edu

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Disclosure

- I have no actual or potential conflicts of interest in relation to this presentation

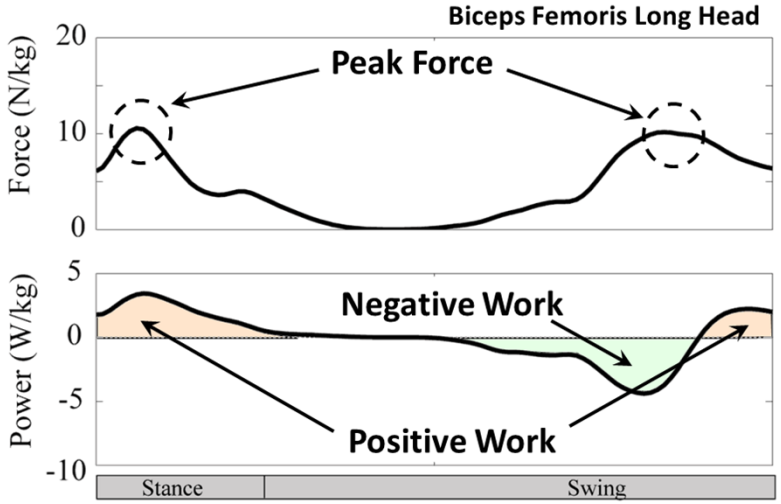
- Research has been supported by:
  - NIH
  - NFL Medical Charities
  - Aircast Foundation
  - NBA-GE Healthcare
  - DJO Global
  - UW Department of Orthopedics and Rehabilitation

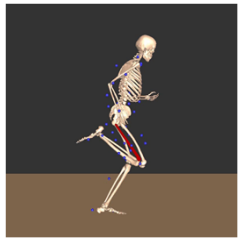
Hamstring Strain Injury

When did the injury happen?

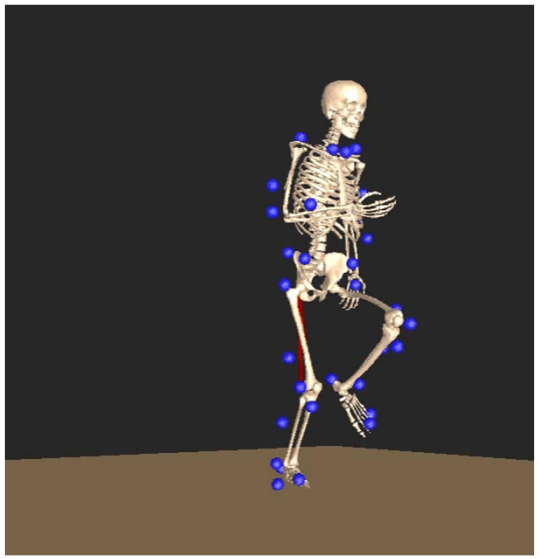
- Most common injury among sprinting athletes
  - Kujala et al. (1997) *Sports Med*
- 2nd most common injury among NFL team, with 8-25 days lost to injury
  - Feeley et al. (2008) *Am J Sports Med*
- Australian Football estimated the cost per hamstring injury in 2012 to be ~$41,000
  - 71% increase over the preceding decade
- 30% re-injury rate
  - Orchard & Best (2002) *Clin J Sport Med*

Injury is Likely during Terminal Swing



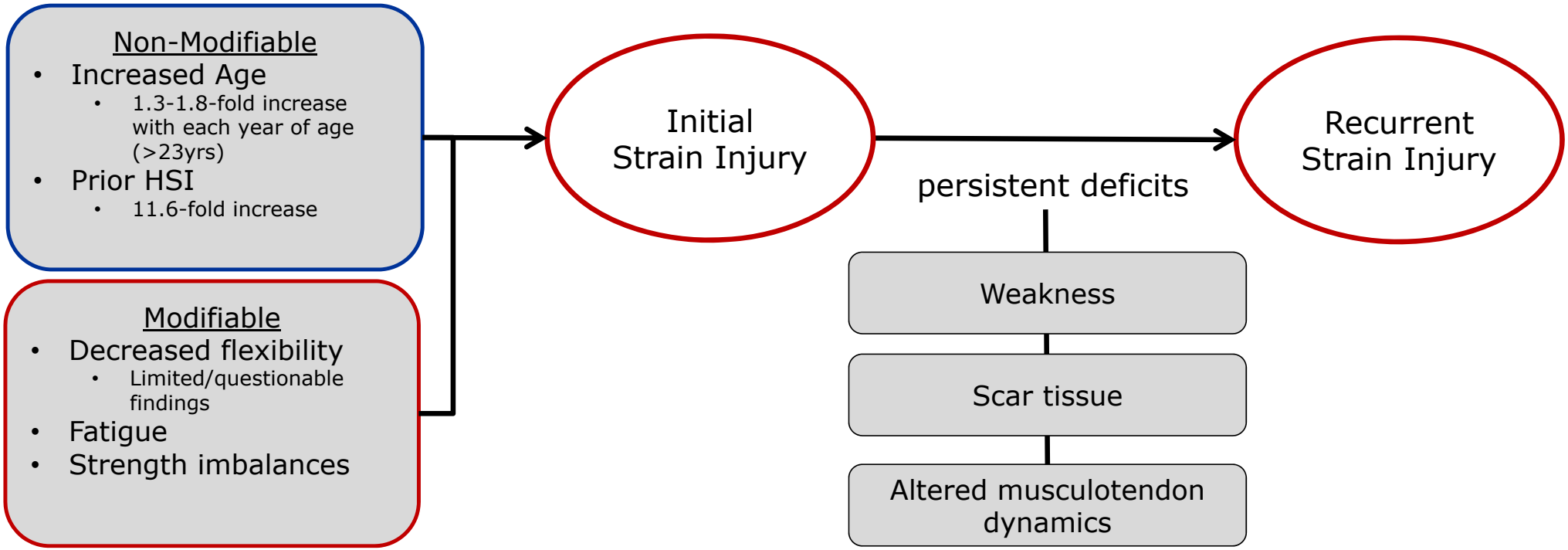


- Biomechanical data from healthy athletes
- Case studies of injuries during biomechanical experiments



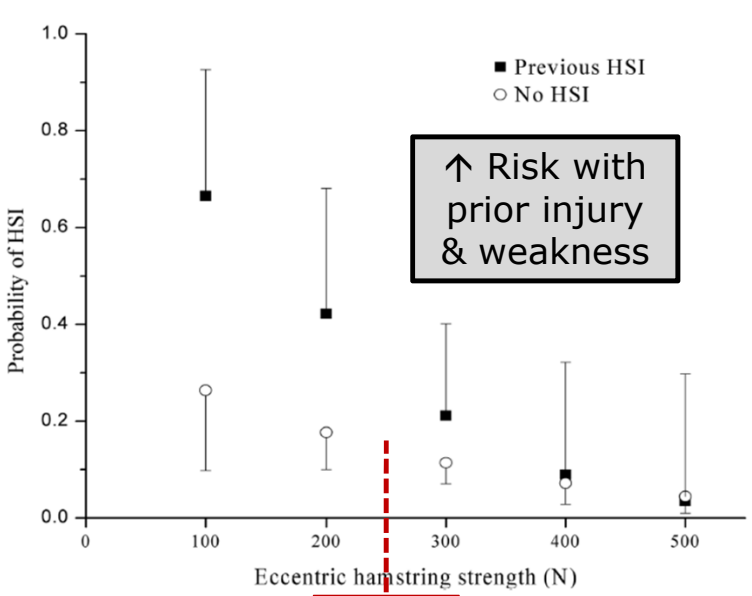
Heiderscheit et al. (2005) *Clin Biomech*
Chumanov et al. (2007) *J Biomech*
Chumanov et al. (2011) *Med Sci Sports Exerc*

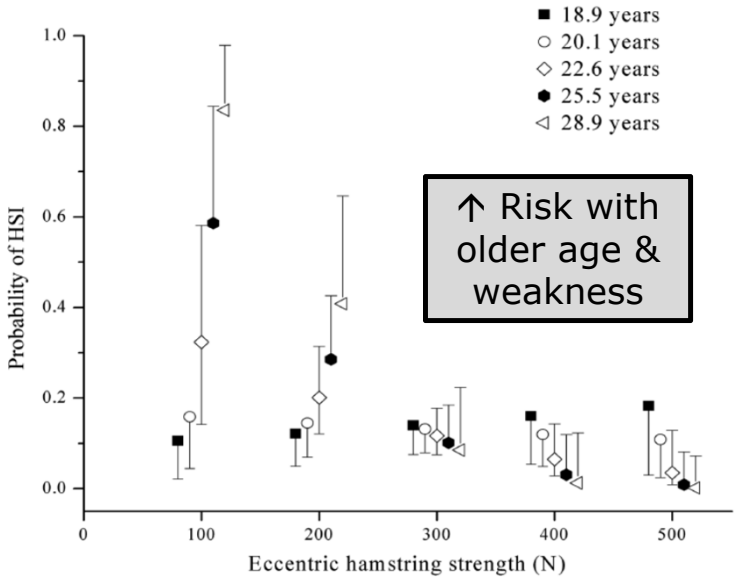
Factors Affecting (Re)Injury Risk



Opar et al. (2012) Sports Med

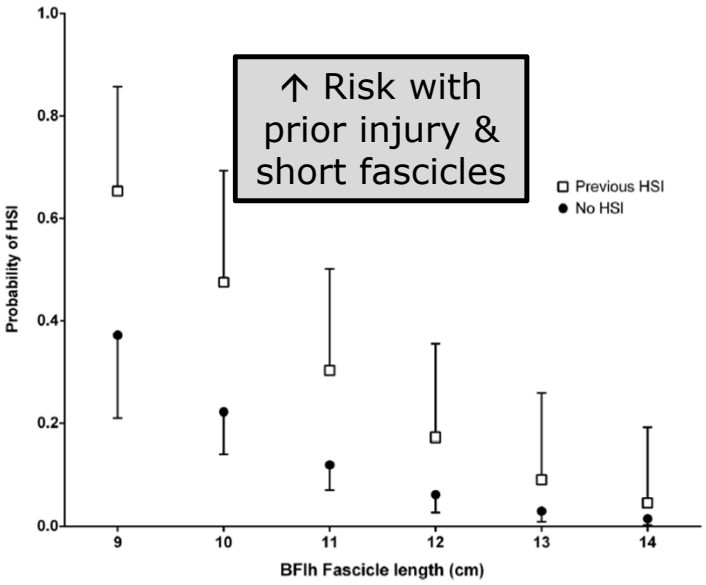
Strength, Age and Prior Injury

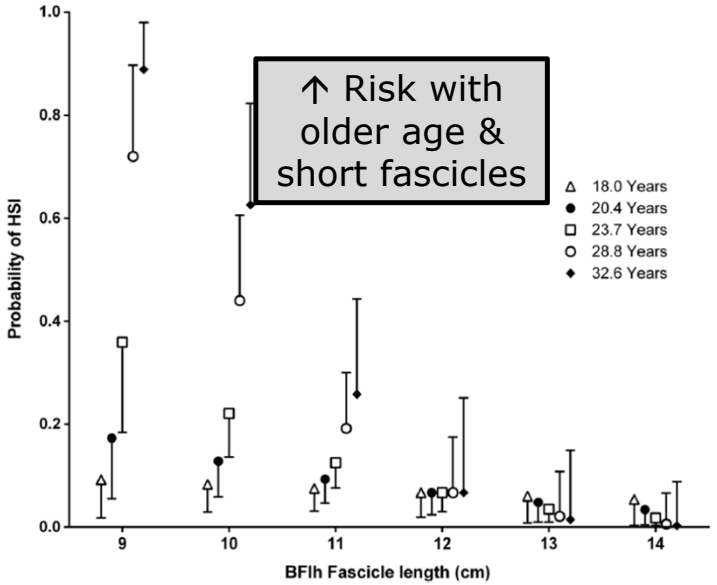




- increased risk associated with history of HSI and age can be mitigated with greater levels of eccentric strength

Fascicle Length, Age and Prior Injury





- increased risk associated with age and history of HSI can be mitigated with <u>longer BFlh fascicles</u>

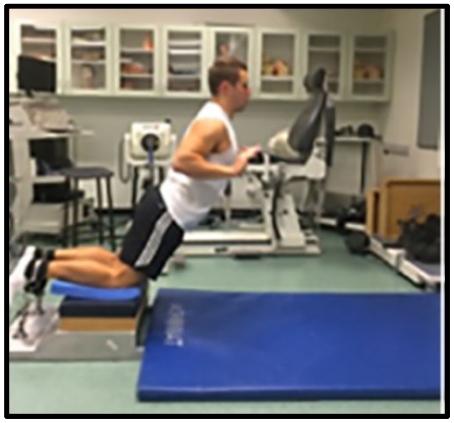
Common Eccentric Exercises

Straight-Knee Bridge

Single leg Deadlift

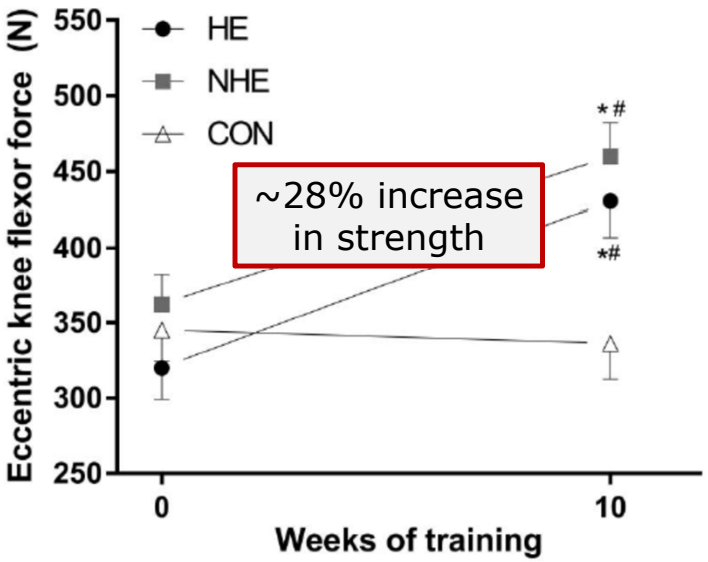
Hip Extension (Glute-Ham Raise)

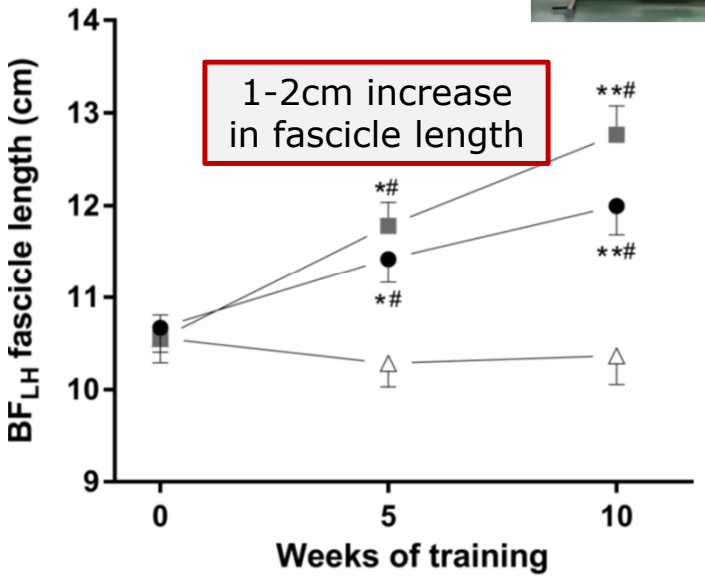
Nordic Hamstring Curl



Effects of Eccentric Training

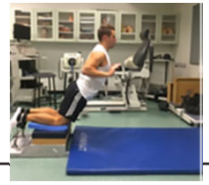
- 30 recreationally active males (22±3.6 yrs)
  - 10-wks eccentric training: Nordic curl (n=10)
  - 10-wks eccentric training: Hip extension (n=10)
  - Control (n=10)





Preventative Effect of Eccentrics

- male professional and amateur soccer teams randomized
  - 10-wk Eccentric training: 23 teams (461 players)
  - Usual training (control): 27 teams (481 players)
  - similar hamstring injury history between groups

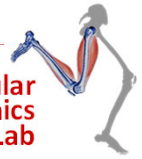


Injury Type	Allocation Group	No. of Injuries	Player Seasons at Risk	Injury Rate Per 100 Player Seasons	NNT (95% CI)	Unadjusted Rate Ratio (95% CI)	Adjusted Rate Ratio (95% CI)
Total	Intervention (n = 461)	15	390	3.8	13 (9-23)	0.292 (0.136-0.631)	0.293[b] (0.150-0.572)
	Control (n = 481)	52	396	13.1			
New	Intervention (n = 461)	12	348	3.1	25 (15-72)	0.380 (0.150-0.965)	0.410[c] (0.180-0.933)
	Control (n = 481)	32	352	8.1			
Recurrent[d]	Intervention (n = 49)	3	42.0	7.1	3 (2-6)	0.156 (0.046-0.525)	0.137[c] (0.037-0.509)
	Control (n = 54)	20	43.7	45.8			

- reduced the injury rate of new injuries by >60% and reduced the rate of recurrent injuries by 85%
  - No effect on injury severity

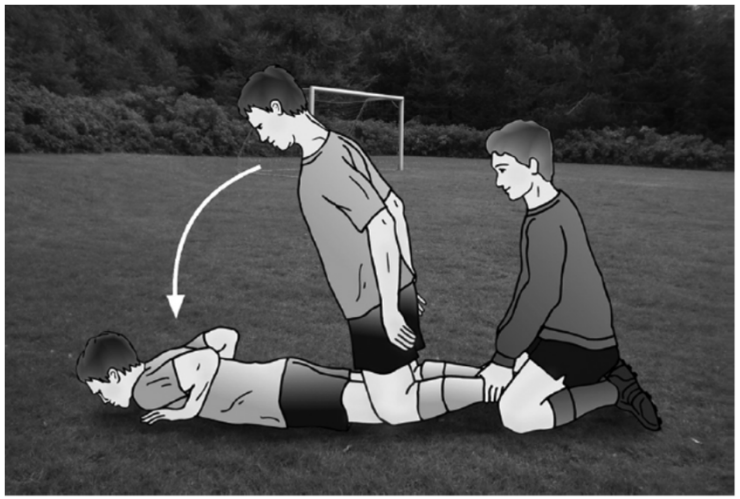
UNIVERSITY OF WISCONSIN BADGER ATHLETIC PERFORMANCE

Petersen et al. (2011) Am J Sports Med



UW Neuromuscular Biomechanics Lab

Nordic Hamstring Curl



Week	Sessions/wk	Sets/Reps
1	1	2 x 5
2	2	2 x 6
3	3	3 x 6-8
4	3	3 x 8-10
5-10	3	3 x 12-10-8
10+	1	3 x 12-10-8

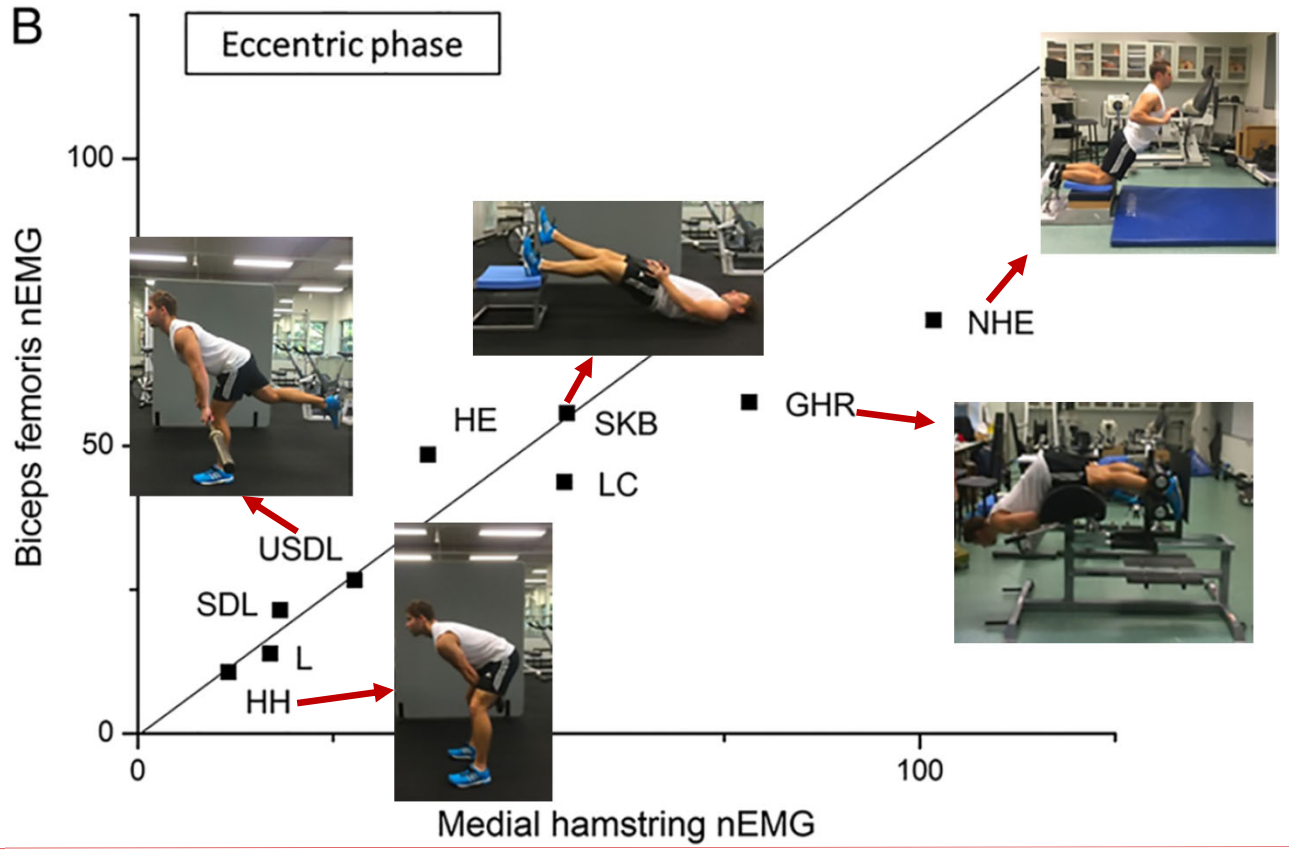
- Allow 3min of rest between sets
- If/when the athlete develops sufficient strength to completely stop the movement in the final 10–20° of the range of motion, s/he should hold a weight plate (range 5-45lbs) to the chest to ensure the exercise is still of supramaximal intensity.

Petersen et al. (2011) Am J Sports Med
Thorborg et al. (2012) Br J Sports Med

Eccentrics In-Season?

- Gradually introduce in the off-season, prior to time of largest spike in hamstring strain injuries
  - Get past delayed onset muscle soreness
  - Achieve gains in eccentric strength
- Being too aggressive from the start could contribute to injury risk
- Must have maintenance program for remainder of year
  - Do not drop it during the season

Hamstring Muscle Activity



Bourne et al. (2017) Br J Sports Med

UNIVERSITY OF WISCONSIN BADGER ATHLETIC PERFORMANCE

UW Neuromuscular Biomechanics Lab

Other Exercise Options

45° Hip Extension

Beneficial Changes to Muscle | Not Studied for Injury Reduction

Week	Sessions/wk	Sets/Reps
1	2	2 x 6
2	2	3 x 6
3	2	4 x 8
4	2	4 x 10
5-8	2	5 x 8-10
9	2	6 x 6
10	2	5 x 5

- Train both limbs in alternating fashion; complete a set on one limb, rest 30 s before training the opposite limb, and then recover for 3 min before the next set
- load held to the chest in week 1 should represent 60–70% of the estimated 1-RM and progressively increased throughout the training period

Other Exercise Options
Single Leg Roman Chair Holds

Beneficial Changes to Muscle | Not Studied for Injury Reduction

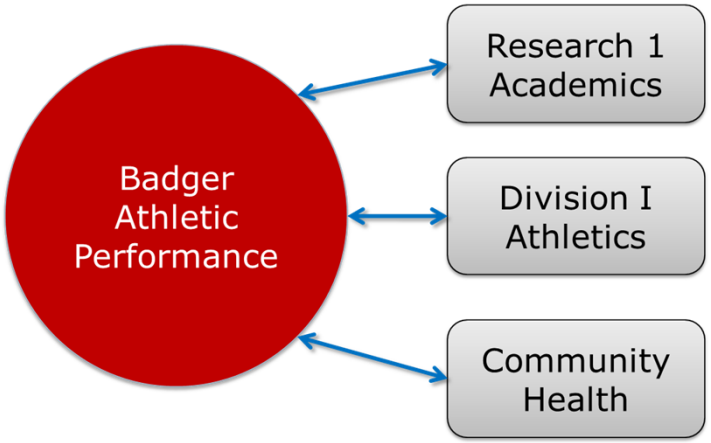
Week	Sessions/wk	Sets/Reps
1	1	3 x 10s hold
2	2	3 x 10s hold with 20-25lb weight
3	3	3 x 10 plate rows with 20-25lb weight
4	3	Same as prior week
5	3	3 x 10 rows with 45lb weight
6	3	Same as prior week

- Train both limbs in alternating fashion; after completing a set on one limb, rest 15-30 s before training the opposite limb, and then recover for 2-3 min before the next set

UW Badger Athletic Performance

Badger Athletic Performance dedicates itself to the mission of maximizing student-athlete's individual on-field performance through the integration of science, training, and injury management

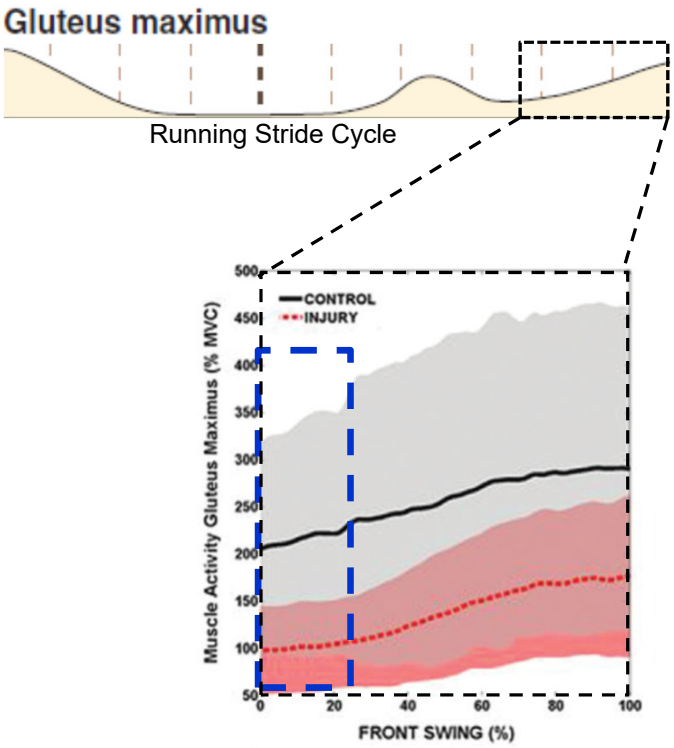
STUDENT ATHLETE PERFORMANCE CENTER



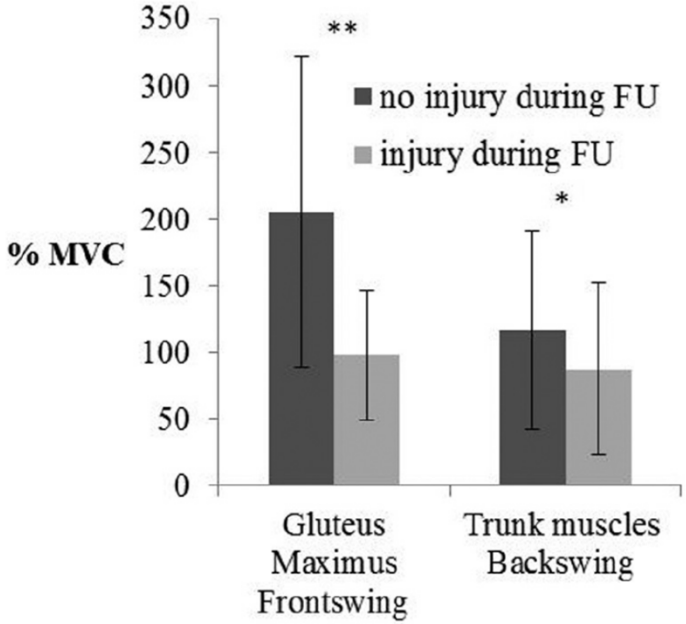
UNIVERSITY OF WISCONSIN BADGER ATHLETIC PERFORMANCE

UW Neuromuscular Biomechanics Lab

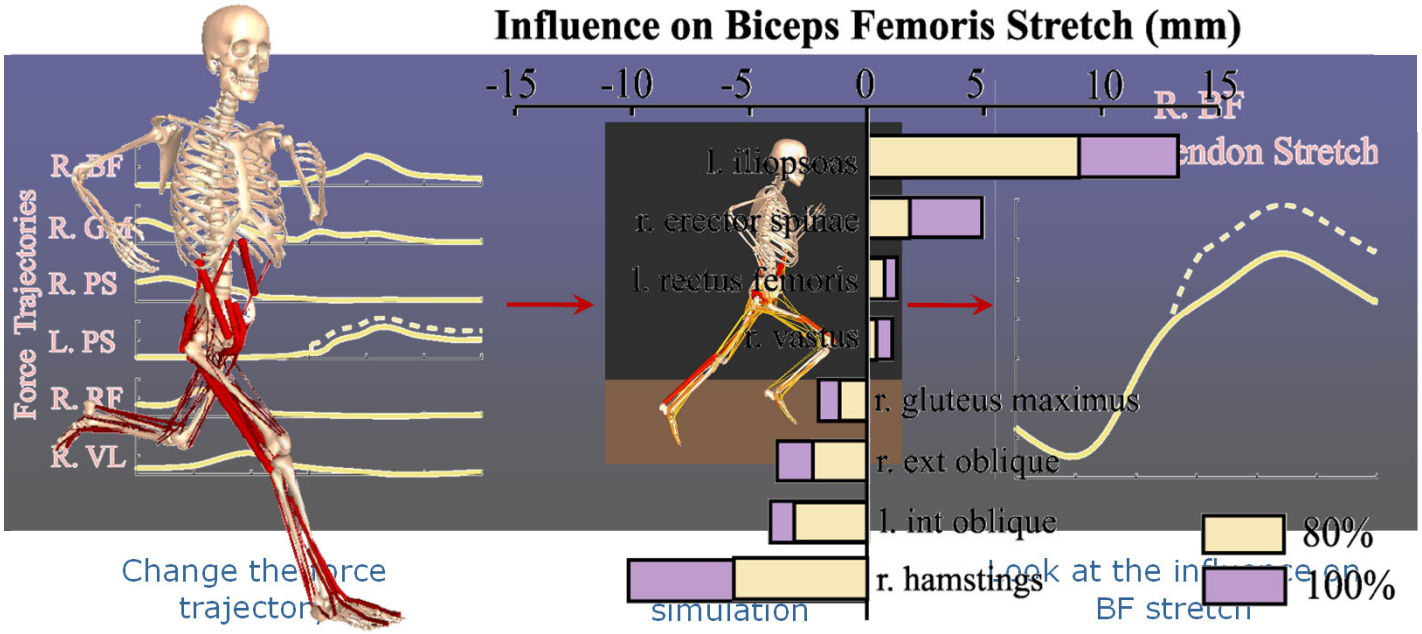
Gluteus Max Activity in Swing



- Hamstring injuries in running have been associated with reduced G. Maximus activity in 2nd half of swing (front swing)



Influence of Adjacent Muscles on Hamstring Stretch during Running

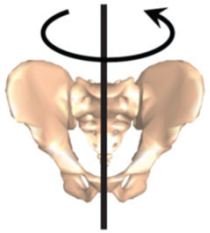


Running Mechanics: Lumbopelvic Control

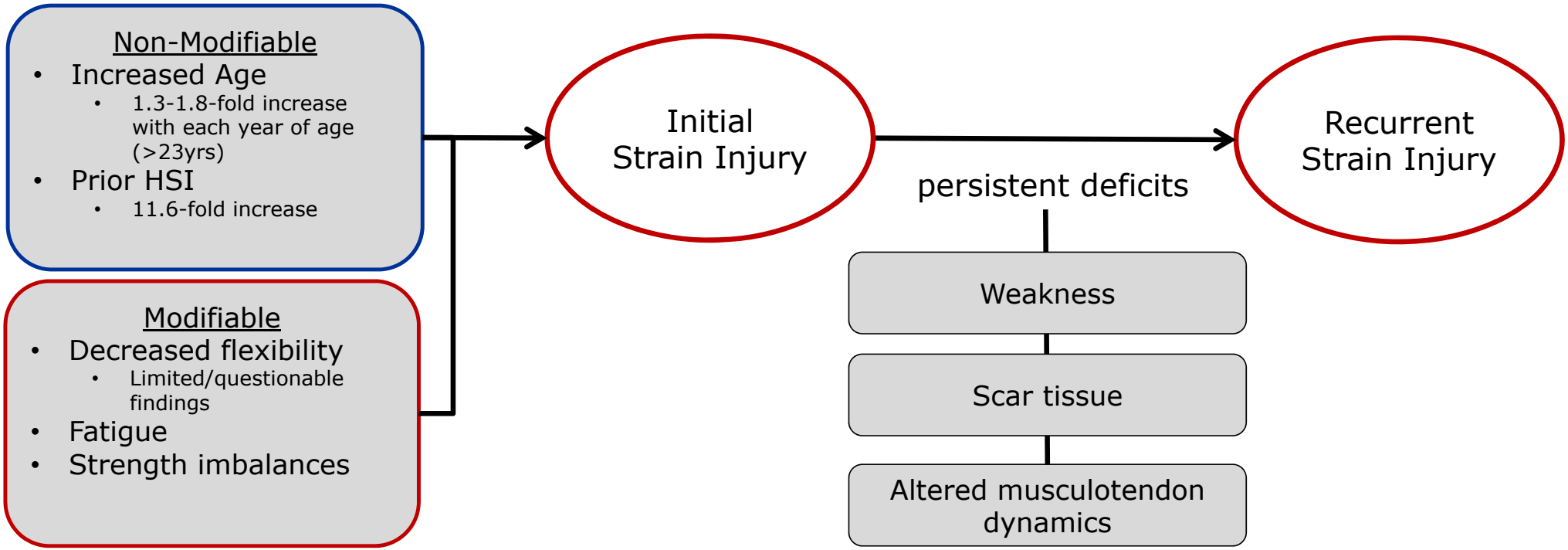
Healthy Limb in Terminal Swing

Injured Limb in Terminal Swing

- Limited left shoulder motion resulted in increased trunk and pelvic rotation
  - Worse at high speeds



Factors Affecting (Re)Injury Risk

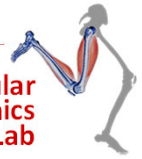


Opar et al. (2012) Sports Med

So Many to Choose From…

	Sherry-Best-Heiderscheit	Askling	Mendiguchia
	SS Stretching and strengthening	C-protocol Conventional exercises	
Lower re-injury rates	PATS Progressive agility and trunk stabilization	L-protocol Lengthening exercises	Rehab Protocol L-protocol + progressive running
	PRES Progressive running and eccentric strength		Rehab Algorithm ECC + core + running + glutes + plyos

UNIVERSITY OF WISCONSIN
BADGER
ATHLETIC PERFORMANCE



UW Neuromuscular Biomechanics Lab

Outcomes from Different Approaches

Rehab Approach	Return to Sport (d)	Re-injuries (n)
SS	37.4 ± 27.6	7/10 (70%) 12 months
PATS-1	22.2 ± 8.3	1/13 (8%) 12 months
PATS-2	25.2 ± 6.3	1/16 (6%) 12 months
PRES	28.8 ± 11.4	3/13 (23%) 12 months
C-protocol	51 ± 21	1/38 (2.6%) 12 months
L-protocol	28 ± 15	0/37 (0%) 12 months
RP	23.2 ± 11.7	6/24 (25%) 6 months
RA	25.5 ± 7.8	1/24 (4%) 6 months

- Not just a result of the exercise selection but it chiefly involves the decision making regarding progression and readiness to return to sport

JOURNAL OF ORTHOPAEDIC & SPORTS PHYSICAL THERAPY
VOLUME 40 | NUMBER 2 | FEBRUARY 2010

[CLINICAL COMMENTARY]

BRYAN C. HEIDERSCHEIT, PT, PhD[1] • MARC A. SHERRY, PT, DPT, LAT, CSCS[2] • AMY SILDER, PhD[3]
ELIZABETH S. CHUMANOV, PhD[4] • DARRYL G. THELEN, PhD[5]

SUPPLEMENTAL VIDEO ONLINE

Hamstring Strain Injuries: Recommendations for Diagnosis, Rehabilitation, and Injury Prevention

Phas

Goals
atr
Protec
han

Phas

Goals
neu
Protec
is p

Phas

Goals
strength through full ROM and speeds; integrate postural control into sport-specific movements
Protection: Avoid full intensity if pain/stiffness is present

ee

ne

rate

RTS Decision Making

Criteria for Rehab Progression

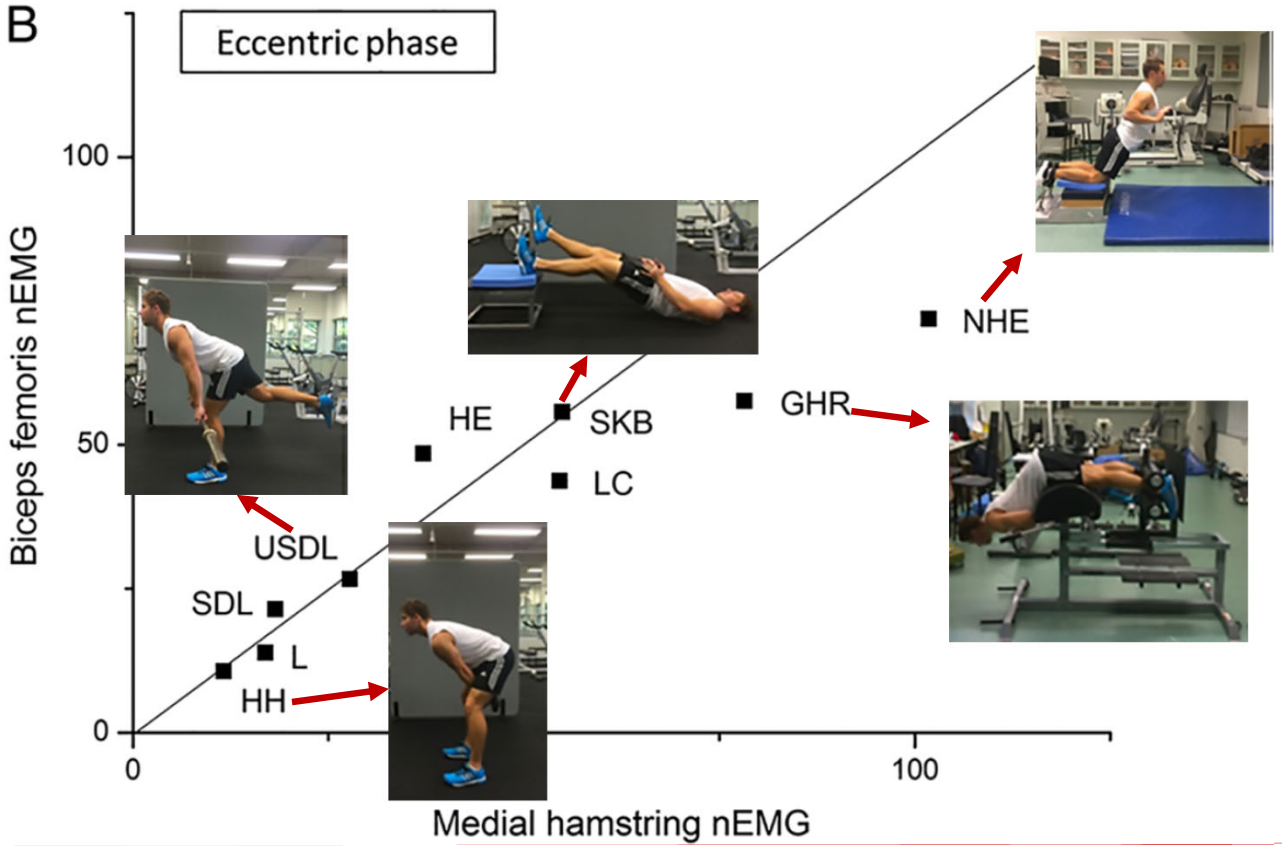
- Progression is largely informed by pain (Hickey et al. Sports Med 2018)
  - Are there more objective factors to consider?

- Daily physical measures may be useful to inform the progression (Whiteley et al. Br J Sports Med 2018):
  - length of palpation pain
  - knee flexion strength at long muscle lengths
  - active knee extension in maximum hip flexion
  - reported pain during daily activity

Phase I
1. Normal walking stride without pain 2. Very low speed jog without pain 3. Pain-free isometric contraction against sub-max (50-70%) resistance during prone knee flexion (90°) manual strength test
Phase II
1. Full strength (5/5) without pain during prone knee flexion (90°) manual strength test 2. Pain-free forward and backward jog, moderate intensity
Phase III
RTS Decision Making

Heiderscheit et al. (2010) J Orthop Sports Phys Ther

Hamstring Muscle Activation



- Intensity of muscle activation should be part of exercise selection
- Also consider:
  - Hamstring muscle length
  - Lumbopelvic position
  - Strictly sagittal (?)

Bourne et al. (2017) Br J Sports Med

Return to Sport Decision Making

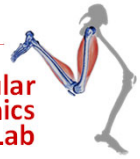
- Full strength without pain
  - 4 reps of max manual strength test in prone knee flexion position (90° & 15°)
  - Isokinetic torque ratios
  - Bilateral symmetry in knee flexion angle of peak concentric knee flexion torque
  - Eccentric knee flexion strength (?)
- Full range of motion without pain
- Replication of sport specific movements near maximal speed without pain
  - incremental sprint test for running athletes
  - Body posture replication

- Apprehension & fear of re-injury

UNIVERSITY OF WISCONSIN
BADGER
ATHLETIC PERFORMANCE

Heiderscheit et al. (2010) *J Orthop Sports Phys Ther*

UW Neuromuscular
Biomechanics
Lab



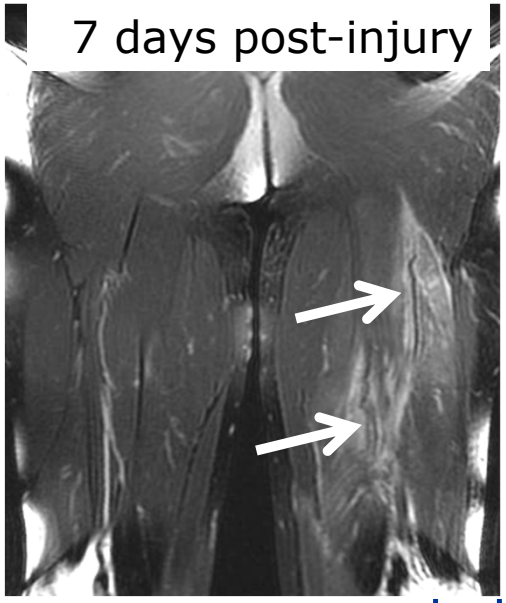
Return to Sport Factor Comparison

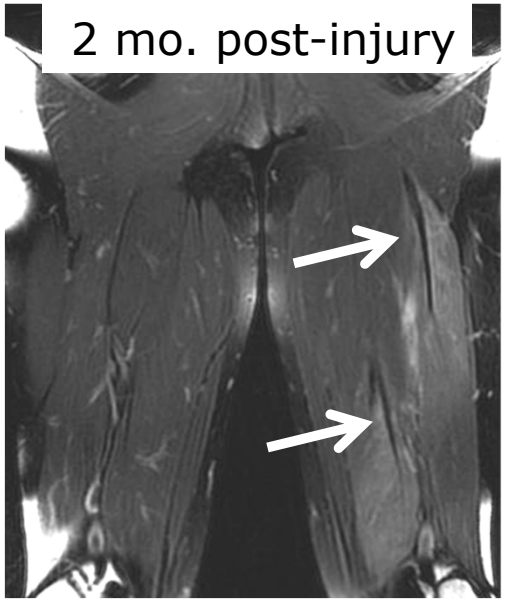
	Sherry-Best-Heiderscheit	Askling	Mendiguchia
Pain			
Palpation	x	x	x
Activity	x		
ROM	x	x	
Strength			
Isometric	x	x	x
Concentric			x
Eccentric			
Sport Movement			
Quality	x		x
Speed	x		x
Apprehension	x	x	x

- Re-injuries most often occur:
  - same location as the index injury
  - early after RTS [median 24 days (IQR, 140 days); 50% within 4wks]
  - radiologically greater severity

(Wangensteen et al. Am J Sports Med 2016)

Post-Injury Remodeling





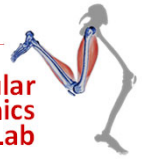
- Persistent edema; (~20%) of muscle
- Evidence of scar tissue

- Edema resolved
- Fully formed scar tissue
  - 92% increase in biceps tendon volume

UNIVERSITY OF WISCONSIN BADGER ATHLETIC PERFORMANCE

Silder et al. (2008) *Skeletal Radiology*
Connell et al. (2004) *AJR*

UW Neuromuscular Biomechanics Lab



Muscle Volume Changes

BFLH	BFSH
-12% **p<0.01	+22% **p=0.06

**Compared to healthy controls

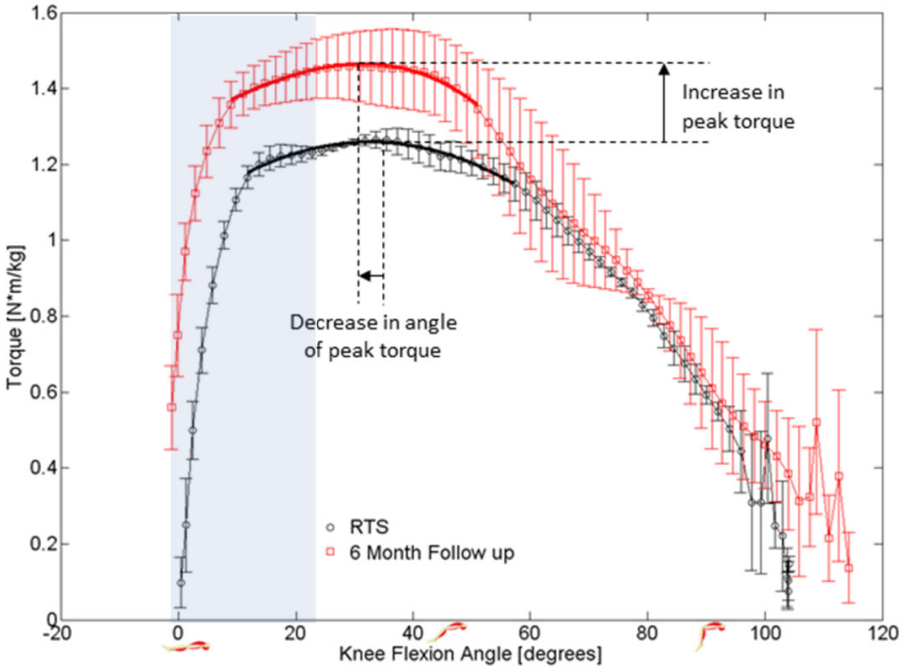
Silder et al. (2008) *Skel Radiol*

UNIVERSITY OF WISCONSIN BADGER ATHLETIC PERFORMANCE

UW Neuromuscular Biomechanics Lab

Strength Deficits at Long Muscle Length

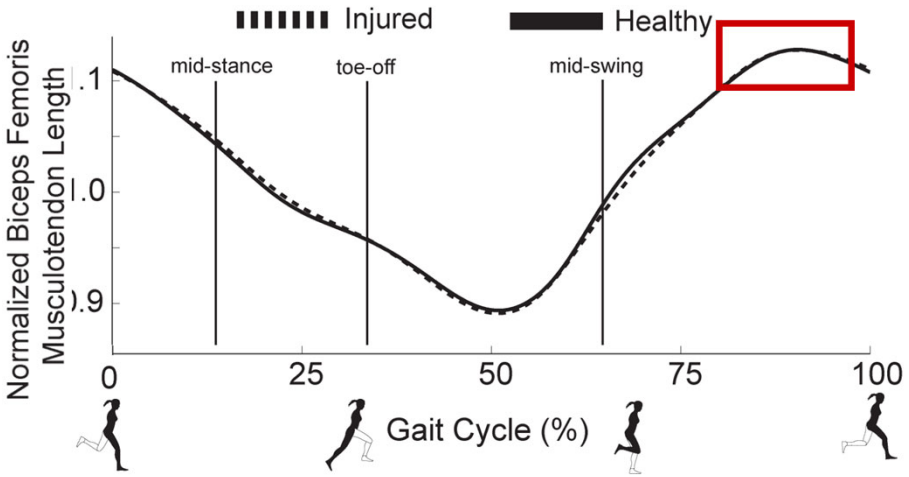
- Strength loss at longer muscle lengths may contribute to re-injury risk
- Residual deficits in torque-angle relationship addressed with eccentric training



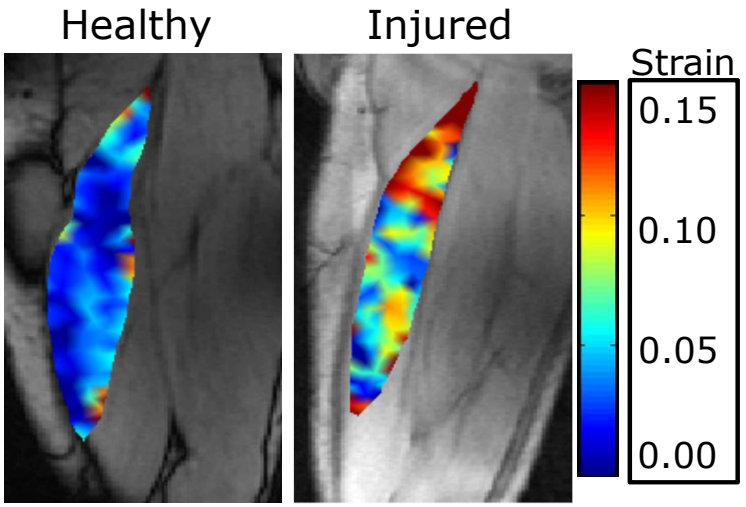
long ← Hamstring Length → short

Dynamic Deficits and Fascicle Strain

No significant bilateral differences in peak musculotendon stretch



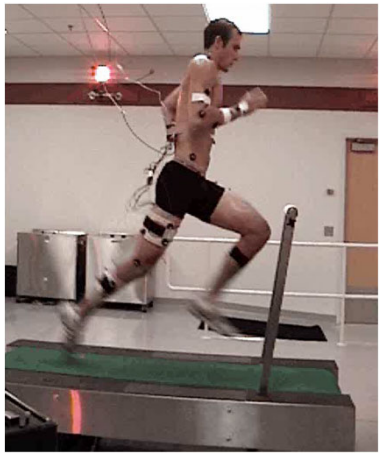
Inertial Loading



- Strains greater for injured subjects adjacent to injury site

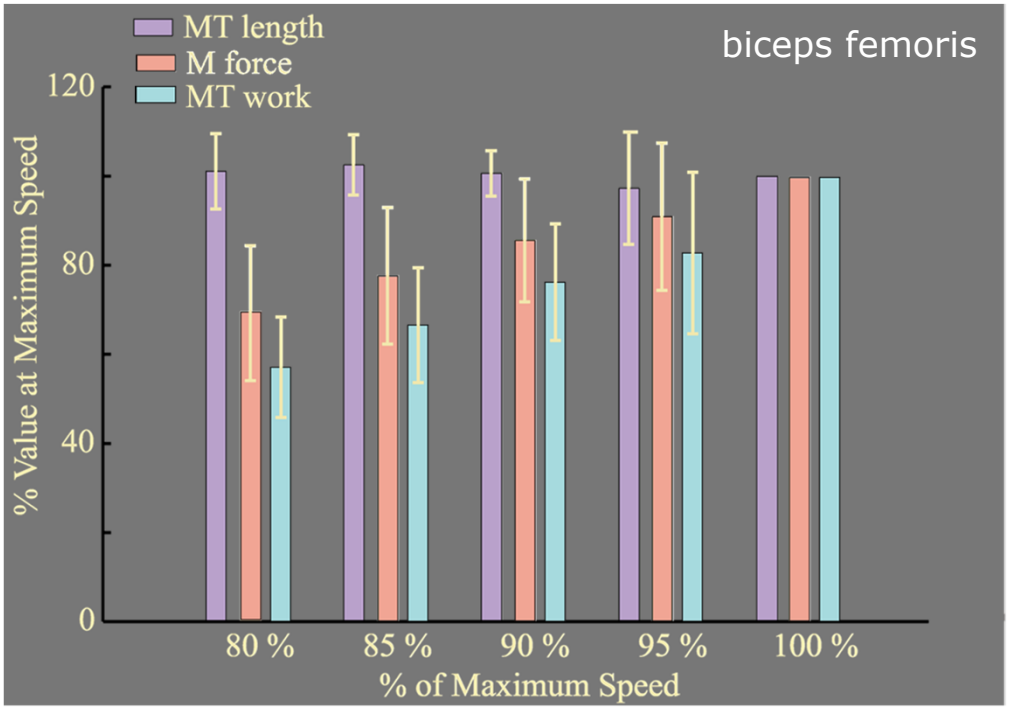
Silder et al. (2010) Clin Biomech
Silder et al (2010) J Biomechanics

What are Hamstring Loads during Sprinting?



Measured Kinematics

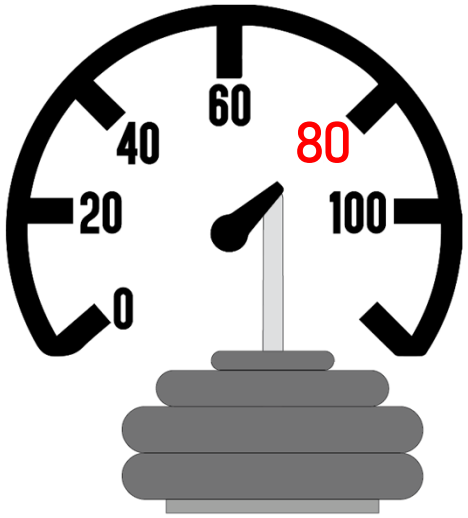
Forward Dynamics



- 80% to 100% running speed:
  - Force increases by ~50%
  - Negative work increases by ~70%

Chumanov et al. (2007) *J Biomech*
Chumanov et al. (2011) *Med Sci Sports Exerc*

Hamstring Load during Sprinting

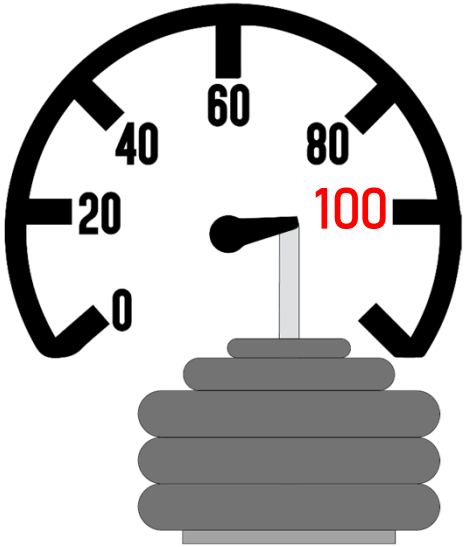


265 lbs

25% ↑ Speed

30% ↑ Muscle Force

50% ↑ Eccentric Load



335 lbs

UNIVERSITY OF WISCONSIN BADGER ATHLETIC PERFORMANCE

UW Neuromuscular Biomechanics Lab

Summary

- Progression-based rehabilitation approaches
  - Phase 1: protect scar development and minimize atrophy
  - Phase 2: build strength and neuromuscular control of trunk and pelvis
  - Phase 3: symptom-free, normal strength, sport-specific movements
- Even with effective rehabilitation approaches, at return to sport
  - On average, 20% of muscle shows evidence of injury
  - Clear evidence of scar tissue formation
  - On average, 10% strength deficit
- Suggestive of needing better return to play criteria
- Eccentric strength and progressive high speed running are critical components to mitigate re-injury risk

Thank You

UNIVERSITY OF WISCONSIN
BADGER
ATHLETIC PERFORMANCE

heiderscheit@ortho.wisc.edu

www.ortho.wisc.edu/bap | @UWBadgerAP