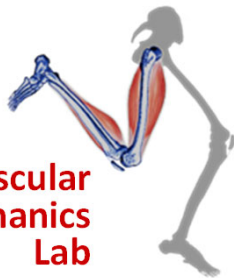


# Load Progression for Lower Extremity Tendinopathy Recovery

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# Disclosure

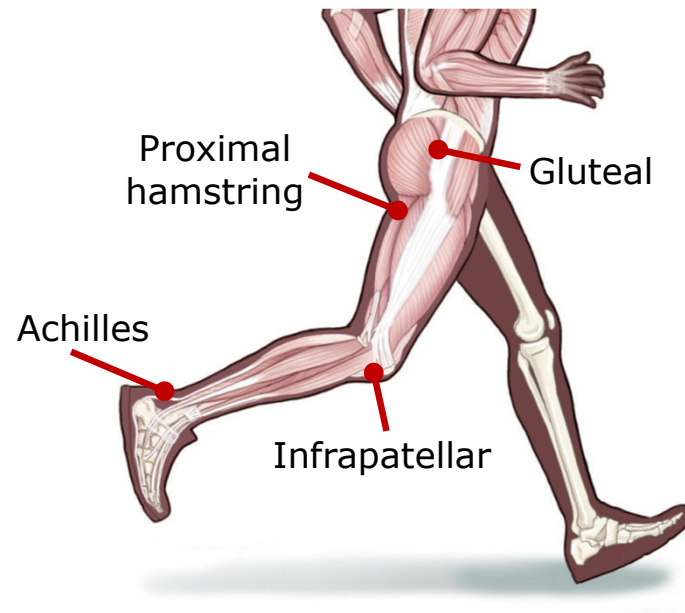
- ☐ I have no actual or potential conflicts of interest in relation to this presentation
- ☐ Research has been supported by:
  - NIH
  - NFL Medical Charities
  - Aircast Foundation
  - NBA-GE Healthcare
  - DJO Global
  - UW Department of Orthopedics and Rehabilitation

# Objectives

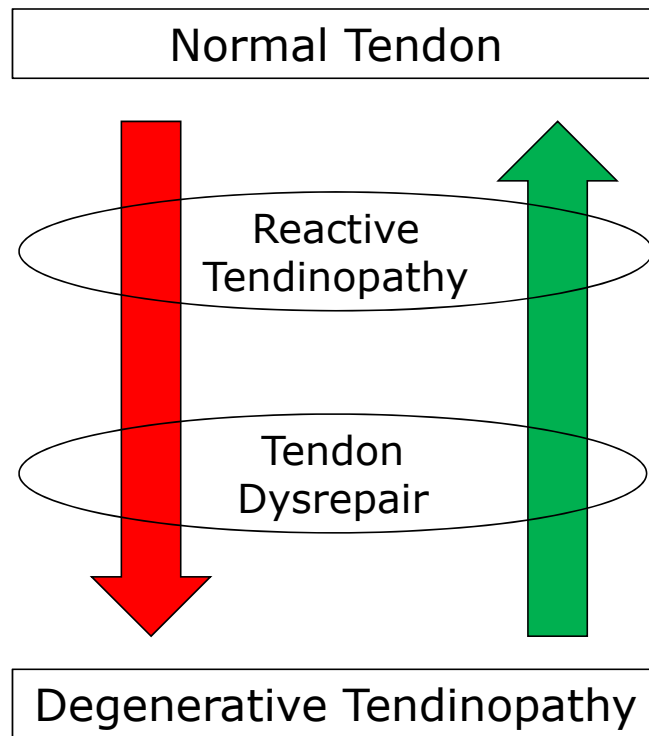
1. Identify the principles (intensity, position, frequency) of progressive loading of tendinopathies to promote recovery
2. Differentiate effective load progression strategies for mid-portion vs insertional tendinopathy

# Tendinopathies

- ❑ Among the most common of running injuries
  - Achilles
- ❑ Prolonged, unpredictable recovery
- ❑ Risk increases with age
  - > 35 y/o
- ❑ Interaction of tissue mechanics and running mechanics

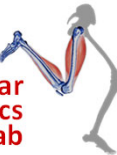


# Tendon Pathology



Results from a failed healing process that causes degenerative changes of the tendon structure, neovascularization, and nerve ingrowth

- ☐ Cells activated and increased
- ☐ Proteoglycans (PG) increased
  
- ☐ ECM disruption from PGs
- ☐ Vascular ingrowth
  
- ☐ Cell death
- ☐ ECM degeneration
- ☐ neovascularization



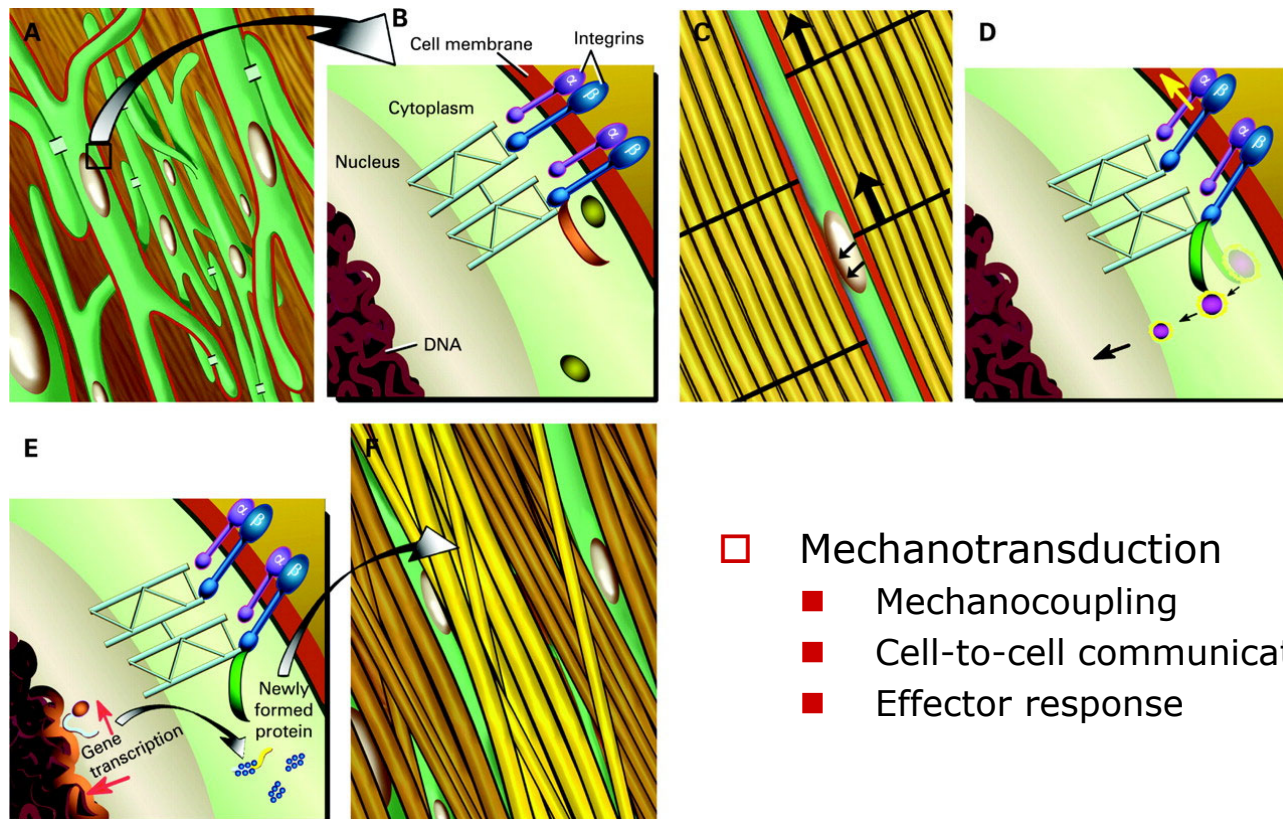
# Common Clinical Presentations

- ❑ Acute episode of increased training or activity levels
  - Likely a degenerative lesion with some reactive aspects
  - Mismatch between load applied and tendon capacity
  
- ❑ Reactive episode after period of time off
  - Injury or off-season followed by (rapid) return to previous level of training
  - Unloading period decrease tendon mechanical properties and tendon capacity to tolerate load

# Resistance Exercise

- Resistance exercise is a positive stimulus for tendon cell activity and matrix restructuring
  - increase collagen production in abnormal tendons
  - improve tendon structure in both the short term and the longer term
  - decrease tendon vessels
  - reduce pain
  
- Mechanical loading causes biochemical response through a process called mechanotransduction

# Mechanotransduction



- Mechanotransduction
  - Mechanocoupling
  - Cell-to-cell communication
  - Effector response

Khan & Scott (2009) Br J Sports Med



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# Heavy Load Eccentric Exercise

- ❑ Strong clinical evidence that eccentric strengthening can be effective in promoting healing of tendinopathies
- ❑ Basic Program
  - 3 x 15 reps with knee straight
  - 3 x 15 reps with knee bent
  - 1-2x daily exercise
  - 12-week program
  - + 10-20% BW as tolerated



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Alfredson H et al (1998) Am J Sports Med  
Silbernagel KG et al (2001) Scan J Med Sci Sports  
de Vos et al. (2007) Br J Sports Med

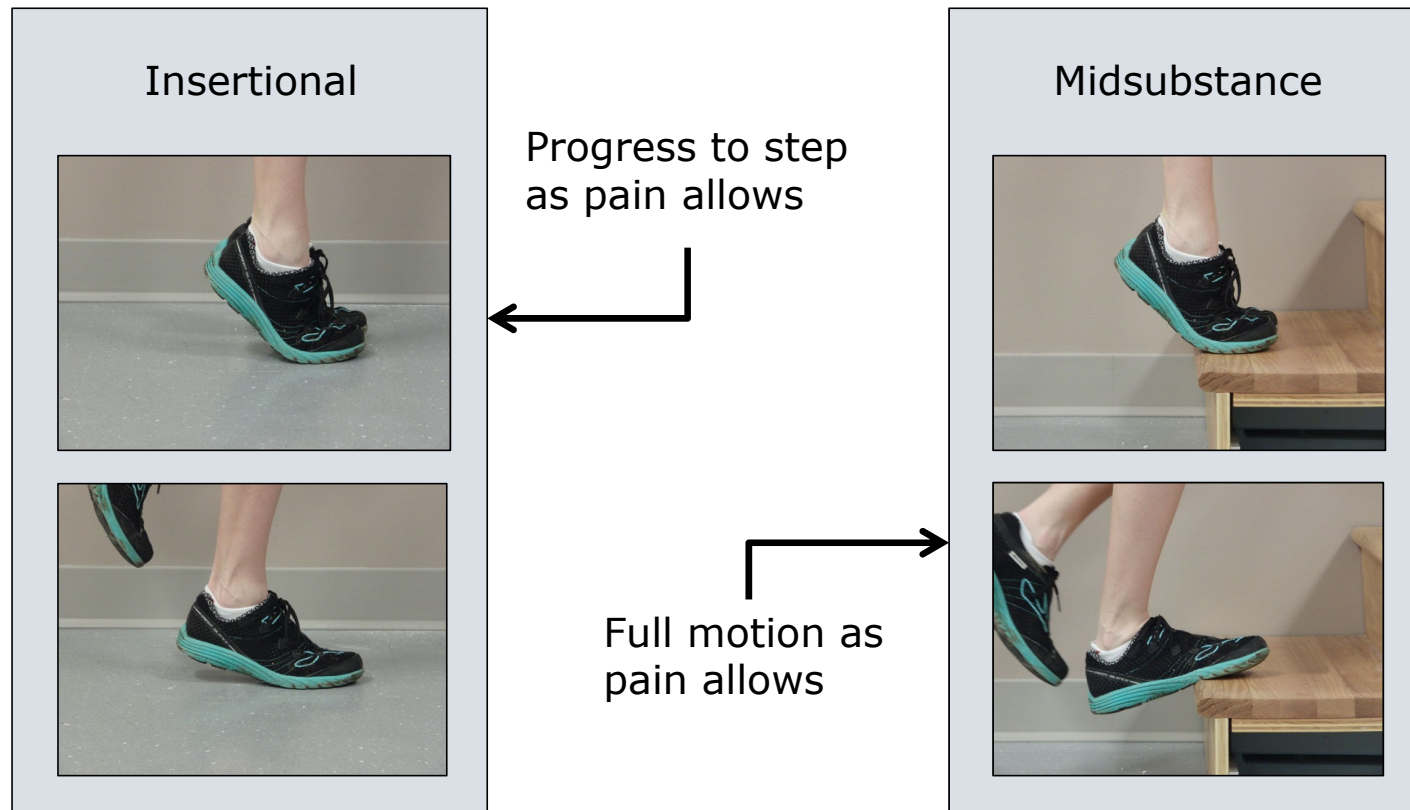


# Refining the Program

- ❑ What aspects of the Alfredson's protocol are the key to success?
  - Eccentrics
  - Full motion
  - 2x/d for 12 wks
  - Knee straight (gastroc) and knee bent (soleus)
- ❑ Concerns with patient adherence (painful)
  - Subsequent risk of recurrence
- ❑ Mid-portion vs insertional



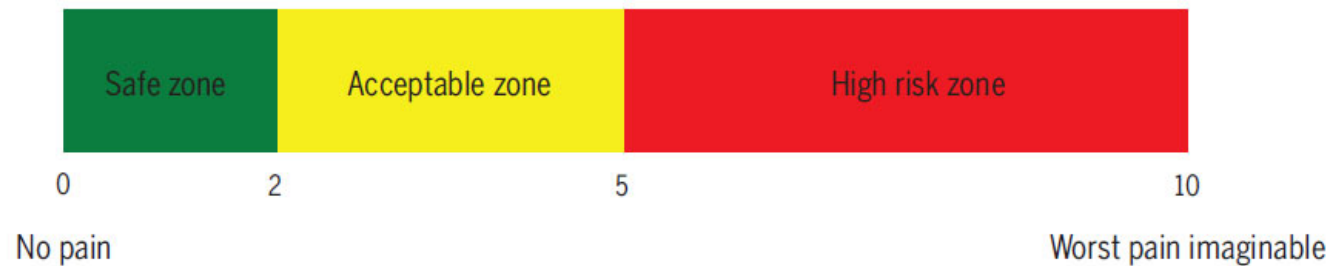
# Heavy Load Eccentrics



# Pain Monitoring

## Pain Monitoring Model

### Numerical Pain Rating Scale (NPRS)



1. The pain is allowed to reach 5 on the NPRS during the activity.
2. The pain after completion of the activity is allowed to reach 5 on the NPRS.
3. The pain the morning after the activity should not exceed a 5 on the NPRS.
4. Pain and stiffness is not allowed to increase from week to week.

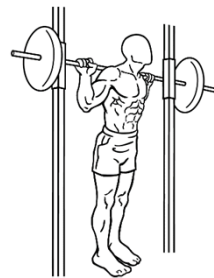
# Pain and Tendon Load Management

## ❑ Tendon load reduction

- Reduce running volume and load (increase step rate, avoid hills) to avoid exacerbation of symptoms
- May need to temporarily avoid over-ground running and substitute other exercise options (cycling, deep water running)
- Address trigger points, joint mobility, and posture as needed

## ❑ Pain management

- Isometric exercises of the involved tendon: 30–60s holds, 3–5 reps, 1–3 sets; start with lower volume if tendon is highly reactive/irritable



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Kountouris and Cook (2007) *Best Pract Res Clin Rheumatol*  
Cook and Purdam (2009) *Br J Sports Med*  
Cook and Purdam (2014) *Br J Sports Med*

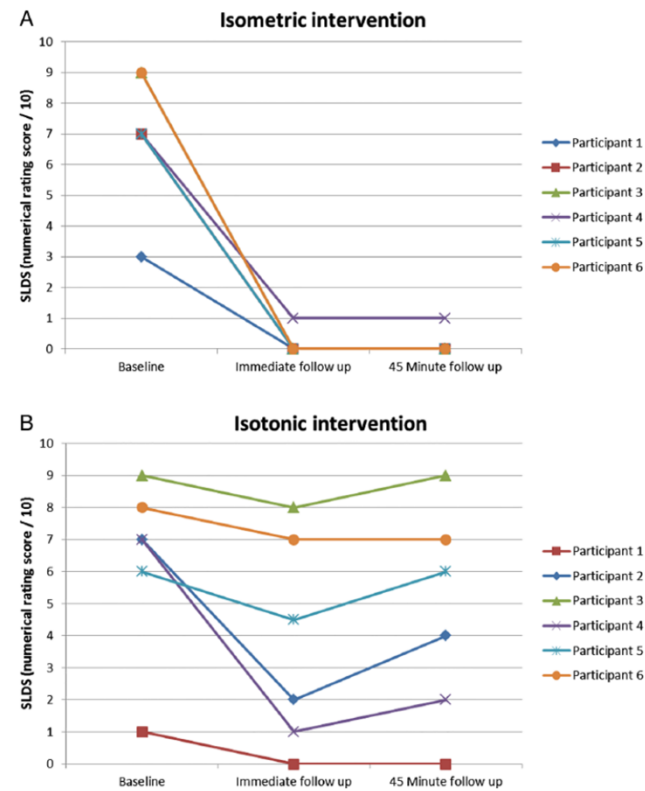
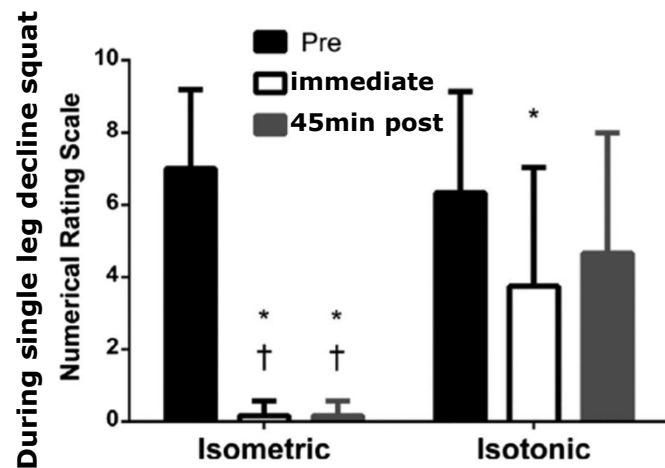
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# Isometrics and Pain Modulation

Table 2 Loading protocols in the study

	Apparatus	Prescription	Recovery (min)	Loading bolus
Isometric	Biodex Pro	5x45 s at 60°	2	70% MVC
Isotonic	Leg extension machine	4x8 repetitions 4 s eccentric phase 3 s concentric phase	2	100% 8RM



Rio et al (2015) Br J Sports Med

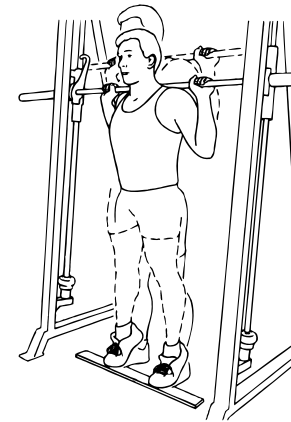


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# Heavy Load Isometrics

- ❑ 30-60s holds
- ❑ 3-5 reps, 1-3 sets
- ❑ start with lower volume if tendon is highly reactive/irritable
- ❑ near maximal effort
  
- ❑ Joint position
  - start near neutral to avoid wrapping tendon over bone
    - ❑ Achilles – avoid dorsiflexion
    - ❑ Hamstring – avoid hip flexion
  - gradually increase tendon wrapping as pain allows



# Tendon Load Adaptation

## Step 1

- Continue isometric exercises and ice for pain management; increase dorsiflexion angle as able
- Improve muscle strength (higher load, 3 sets of 8–15 reps, 3–4 d/wk) and endurance (lower load, 3 sets of 20–30 reps, 5–7 d/wk) based on individual impairments and needs
  - Constrain range of motion to minimize tendon wrapping
  - Emphasis on the eccentric phase initially but not exclusively

## Step 2

- Improve muscle power; increase speed and range of exercises
- Progress to plyometric training, such as jump squats, skipping, jumping rope, double-leg progressing to single-leg hopping (30–60s reps, 4–6 sets with 60s rest between sets, 2–3 d/wk)



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Kountouris and Cook (2007) *Best Pract Res Clin Rheumatol*  
Cook and Purdam (2009) *Br J Sports Med*  
Cook and Purdam (2014) *Br J Sports Med*

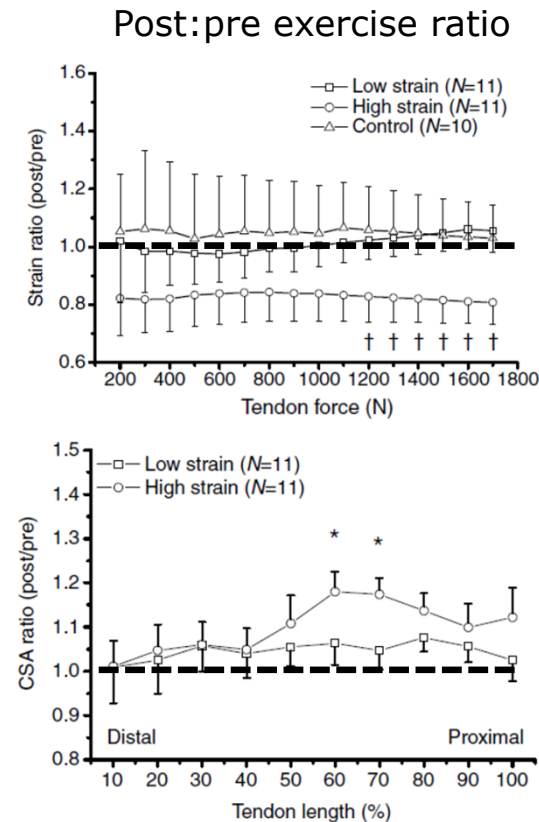
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# High-Magnitude Loading Elicits Tendon Adaptions

- Achilles tendon training program
  - High strain (90%MVC) vs low strain (55%)
    - Randomized between legs
  - 5 sets of **isometric** plantarflexion (knee straight)
    - equal total exercise volume
  - 14wk duration; 4d/wk
- Both groups showed increased plantarflexor strength (20-32%)
- High magnitude loading (90% MVC) caused
  - reduced tendon strain
  - increased tendon CSA
- Training at 55% MVC had no effect on the tendon



Arampatzis et al (2007) J Exp Biol



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# Heavy Slow Resistance



Week	Load
1	3x15RM
2-3	3x12RM
4-5	4x10RM
6-8	4x8RM
9-12	4x6RM

- 6 s/rep, 3x/wk
- bilateral, equal weight bearing

- Compared to typical heavy load eccentric
  - Similar clinical improvements (VAS, VISA-A)
  - Similar reductions in tendon thickness and neovascularization
  - Greater patient adherence and satisfaction
  - Less total loading time

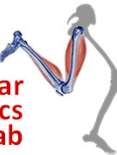
# Basic Achilles Program

	Phase 1	Phase 2	Phase 3
Approximate duration	1-2 wks	2-4 wks	4-12 wks
Repetitions	1-3 x 3-5	3 x 15	3 x 15
Range of motion	fixed	limited	full
Exercises:			
Isometric (5 x 30-60s holds)	•	•	•
2-legged heel raises standing		•	
1-legged heel raises standing		•	•
2-legged heel raises sitting		•	+10-20% BW
2-up/1-down heel raises standing		•	+10-20% BW
Plyometrics		•	•

- ☐ pain < 5/10 is allowable during and after exercise
  - ☒ subside by next day
- ☐ participate in usual activities only if mild discomfort or no pain

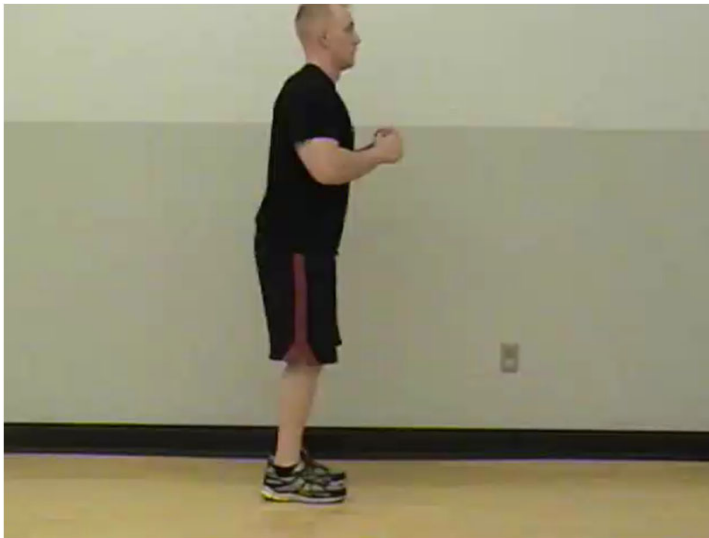
# Bent Knee Strengthening

- ❑ Soleus (deep Achilles) is often not adequately emphasized during the rehabilitation process
- ❑ Restrict dorsiflexion during exercise as needed



# Mild Plyometrics

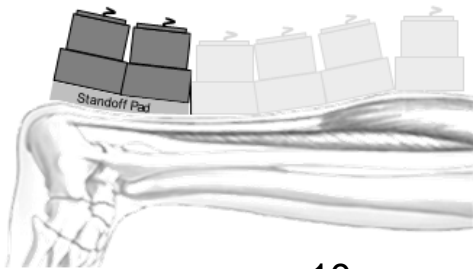
2-leg



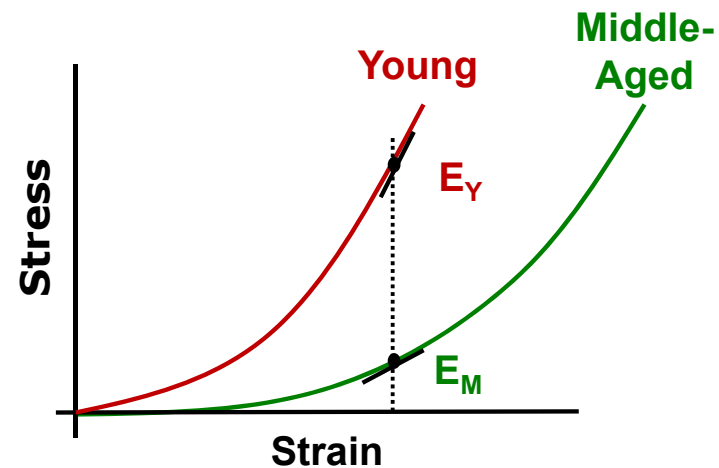
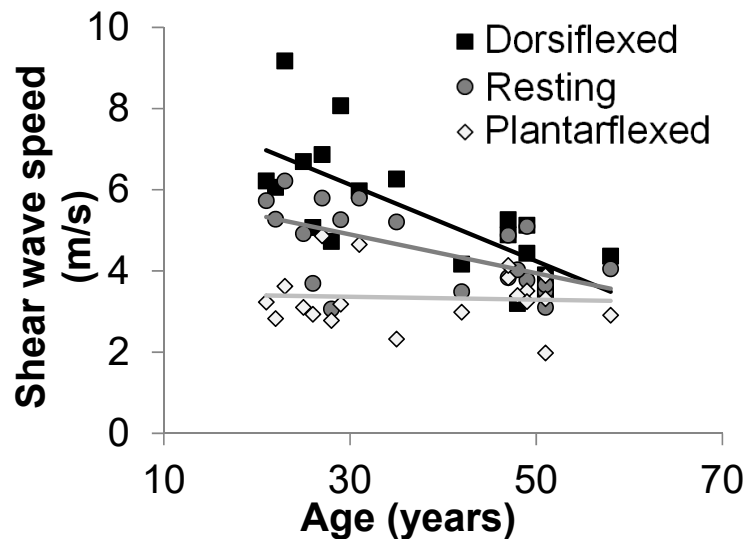
1-leg



# Increased Compliance of Gastrocnemius Aponeurosis with Age



- Middle age and older runners may be more predisposed based on a reduced tendon vasculature and altered tendon compliance



Slane et al. (2015) Physiol Meas



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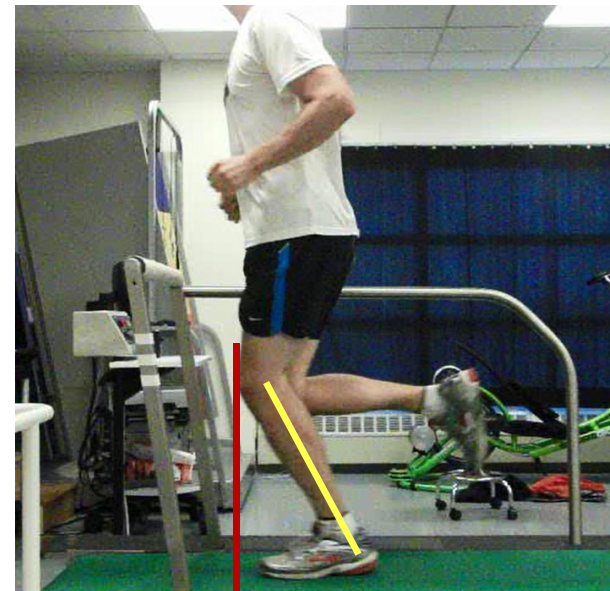
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# Achilles Tendinopathy

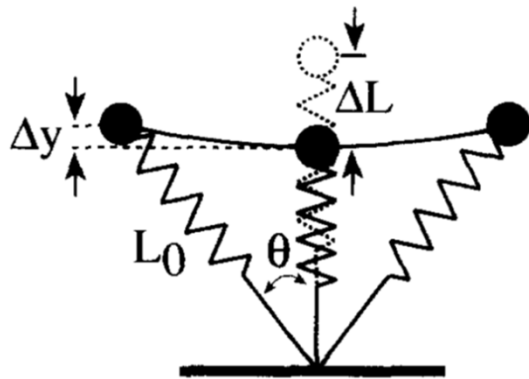
## Provocative Running Mechanics

- Pain is typically during propulsive phase of stance (50-100%)
  - Generally not during loading response
- Excessive ankle dorsiflexion during midstance
  - Should be assessed relative to ankle dorsiflexion observed in weightbearing
  - excessive strain and wrapping prior to initiation of concentric contraction
- If medial insertional pain, look for high rate of pronation during contact



# How to Reduce Dorsiflexion Angle?

- Increased ankle dorsiflexion is related to increased knee flexion
- Reduce both by increasing lower extremity stiffness
  - Spend less time on the ground

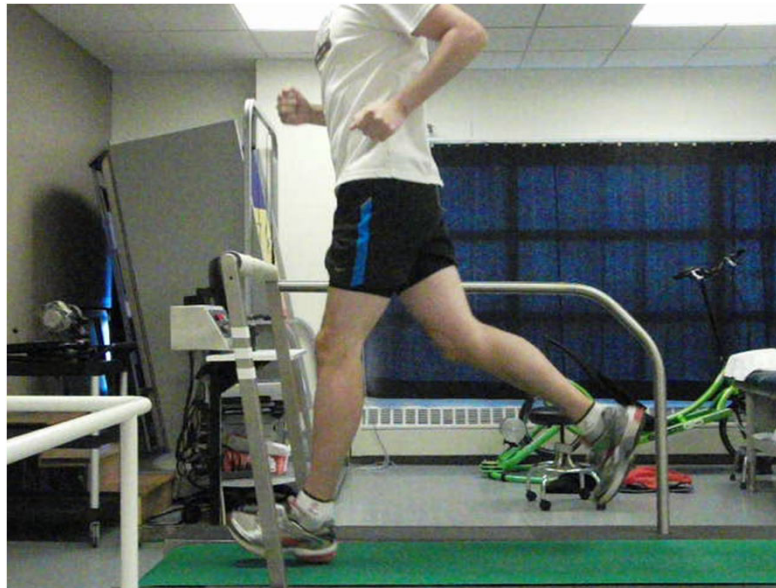




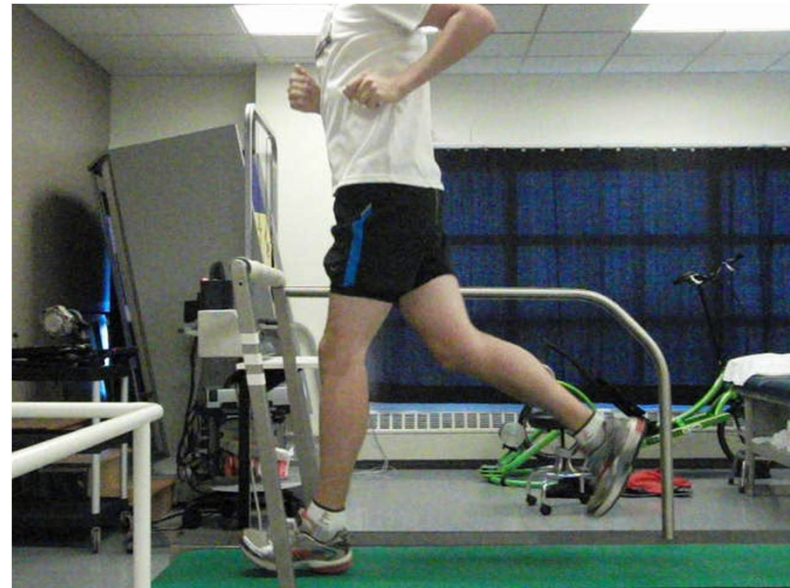
# Goal: Reduce Ankle Dorsiflexion

- Increase step rate → reduces ground contact time → reduces ankle dorsiflexion

9:30 min/mile; 150 steps/min



9:30 min/mile; 160 steps/min



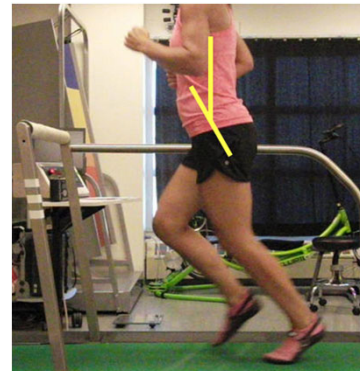
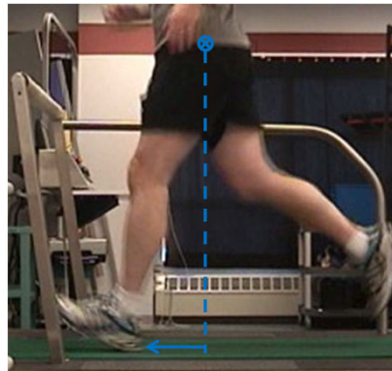
# Proximal Hamstring Tendinopathy

- related to wrapping of tendon around ischial tuberosity
  - Creates compression and shearing on tendon and possibly bursa
  
- Presentation
  - No specific mechanism of injury
  - Pain localized on or adjacent to ischial tuberosity
  - No radiating pain
  - Pain may reduce during running
    - Aggravated by speed work and uphill
  - Pain is provoked near end-range hip flexion and with resisted hip extension in a hip flexed position



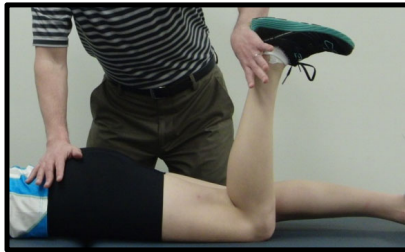
# Provocative Running Mechanics

- ❑ Positions of increased hip flexion
  - Increased wrapping of tendon against ischial tuberosity
  - Examples
    - ❑ Uphill running
    - ❑ Speed work
    - ❑ Foot well ahead of center of mass at contact
    - ❑ Excessive anterior pelvic tilt



# Pain Management

- Isometric exercises of the involved tendon: 30–60s holds, 3–5 reps, 1–3 sets; start with lower volume if tendon is highly reactive/irritable



- Tendon load reduction
  - Reduce running volume and load (increase step rate, avoid hills) to avoid exacerbation of symptoms
  - May need to temporarily avoid over-ground running and substitute other exercise options (cycling, deep water running)
  - Address trigger points, joint mobility, and posture as needed

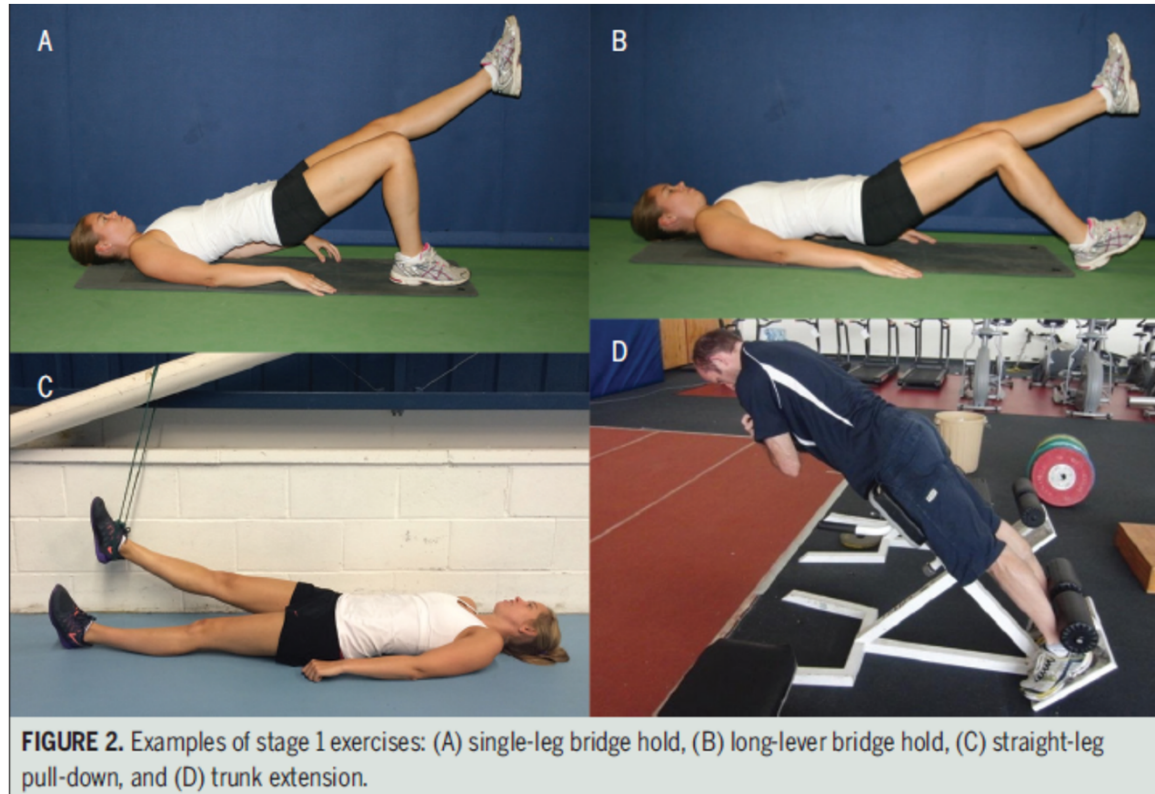


## Tendon Load Progression

**Isometric**  
Limited hip flexion

**Isotonic**  
Progressing hip flexion

**Plyometric**



**FIGURE 2.** Examples of stage 1 exercises: (A) single-leg bridge hold, (B) long-lever bridge hold, (C) straight-leg pull-down, and (D) trunk extension.

Goom et al (2016) *J Orthop Sports Phys Ther*



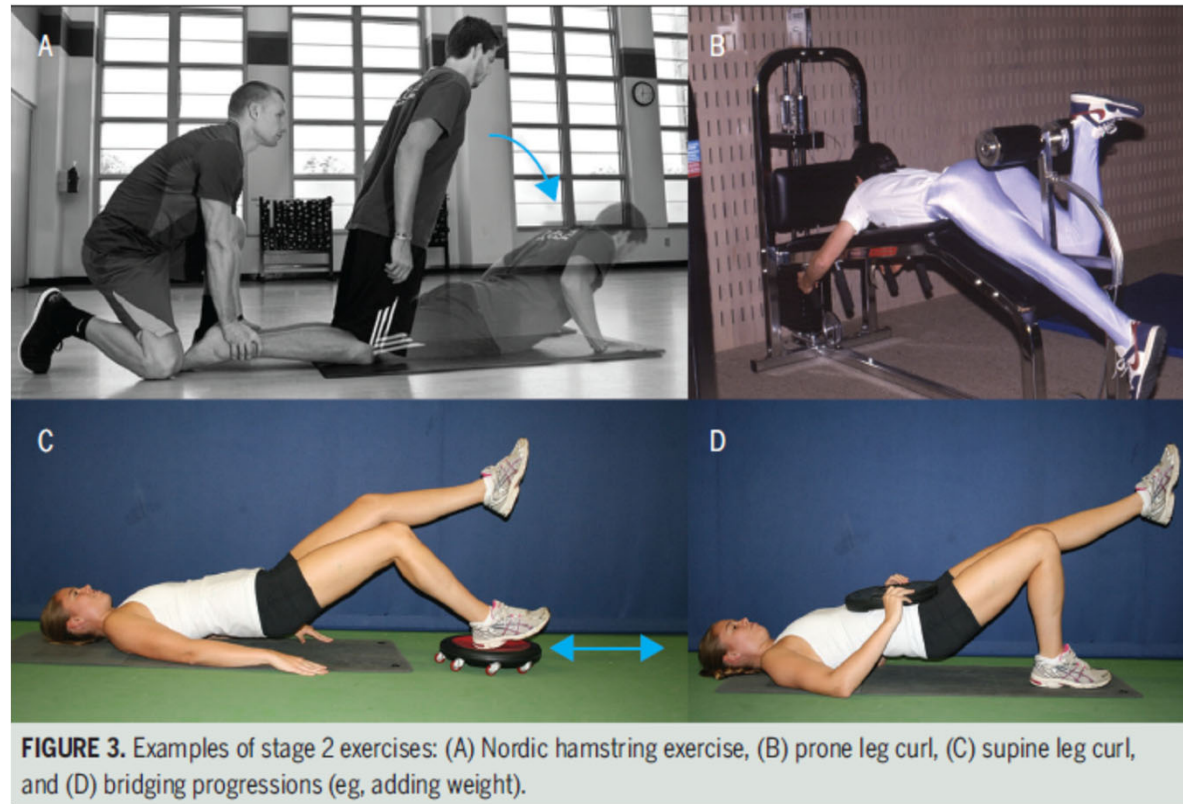
## Tendon Load Progression

**Isometric**  
Limited hip flexion

**Isotonic**  
Progressing hip flexion

**Plyometric**

Limited  
Hip  
Flexion



Goom et al (2016) *J Orthop Sports Phys Ther*



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# Bridged Knee Curls on Physioball

2-leg



1-leg



# Modified Nordic Curls





## Tendon Load Progression

**Isometric**  
Limited hip flexion

**Isotonic**  
Progressing hip flexion

**Plyometric**

Increased  
Hip  
Flexion



Goom et al (2016) *J Orthop Sports Phys Ther*



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# Resisted Terminal Swing



## Exercise Progression

**Isometric**  
Limited hip flexion

**Isotonic**  
Progressing hip flexion

**Plyometric**



FIGURE 5. Examples of stage 4 exercises: (A) bounding, (B) alternate-leg split squats, (C) A-skips, (D) cutting, and (E) sprinter leg curl.

Goom et al (2016) *J Orthop Sports Phys Ther*



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# Tendon Load Progression

## Example Plan

**Isometric**  
Limited hip flexion

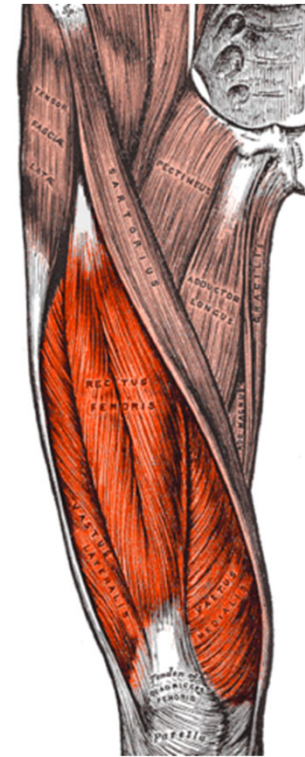
**Isotonic**  
Progressing hip flexion

**Plyometric**

Week	Type	Hip Angle	Frequency
1	Isometrics	0°	1-2x/d
2	Isometrics	20°	1-2x/d
3-4	Isometrics Isotonics	Up to 30°	Alternate days
5-6	Isometrics Isotonics	Up to 50°	Alternate days
7+	Plyometrics Isometrics Isotonics	Progress to full	3 day cycle

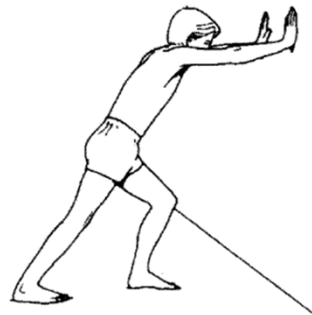
# Passive Tension of Muscle

- Increased passive muscle stiffness (shear wave imaging) of the vastus lateralis in BB and VB players with patellar tendinopathy
  - No difference in RF stiffness
- VL muscle stiffness correlated with proximal patellar tendon stiffness

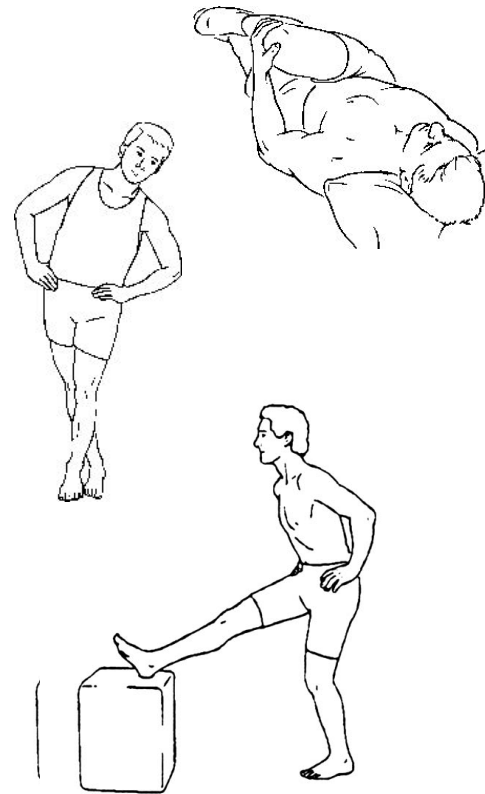


# Stretching: More Harm than Good?

- End range stretching may provoke symptoms due to compressive loading
  - Better to manage restrictions in muscle mobility with massage techniques rather than stretching



Too much tendon wrapping at end range, i.e., increased compression



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Cook and Purdam (2012) Br J Sports Med

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# Practice and Research Gaps

1. Optimal dosage, frequency and intensity of tendon loading has yet to be defined, and is likely highly individual
  - Principles vs protocol
2. Pain model of load progression has not been evaluated with rigorous clinical trials
  - Several are ongoing
3. The application of these loading concepts to older, degenerated tendons is premature



# Take Home Points

1. Identify provocative running/movement mechanics and training habits, and modify
2. Minimize tendon wrapping
  - i.e., limit ankle dorsiflexion, hip flexion
3. Use isometrics at start and throughout rehab to modify pain and condition tendon
4. Progress as tolerated: Motion, Intensity, Volume



# Thank You



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