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Management of Lower Extremity Tendinopathy

David Nolan, PT, DPT, MS, OCS, SCS, CSCS

MGH Sports Physical Therapy
Northeastern University

Learning Outcomes

- Describe the epidemiology of selected lower extremity tendon disorders
- List differential diagnosis considerations for selected lower extremity tendon disorders
- Discuss evidence-based interventions for select lower extremity tendon disorders
Tendon Anatomy

- Collagen bundles
- Extracellular matrix
- Tenocytes
- Epitenon
- Paratenon

Background

- Failed Healing Response
  - Hypercellularity
  - Microtearing
  - Loss of tightly bundled collagen
  - Increased proteoglycan content
  - Neovascularization
  - Absent / minimal inflammation
Intrinsic Factors

- **Age**
  - Prevalence increases with age
    - Predisposition rather than cause
      - ↑ stiffness & limited tolerance to load
      - ↓ proteoglycans
      - ↑ cross-links

- **Body Composition**
  - ↑ waist circumference linked to patellar tendinopathy
  - Tendinopathy increases with increased adipose tissue

- **Range of Motion**
  - ↓ Ankle Dorsiflexion
    - ↑ amount & rate of loading
    - Achilles tendinopathy
    - Patellar tendinopathy

- **Strength**
  - Literature is mixed
    - (+) Association with weakness
    - (-) Association with weakness
Extrinsic Factors

- Corticosteroids
- Training Errors
  - Distance, intensity, technique
- Training Surface
  - Uneven, incline, rigid
- Environment
  - Cold, wet climate
- Footwear / Equipment

Hip Tendinopathy

- Hip Adductor
- Iliopsoas
- Gluteus Medius / Minimus
- Hamstring
Adductor Tendinopathy

- Adductor Longus Anatomy
  - Origin: 37.9% tendon, 62.1% muscle
  - Poorly vascularized
  - Richly innervated at transitional zone
  - Medial fibers attach to symphyseal capsule, intra-articular disk
    - Osteitis Pubis

Adductor Injury

- Eccentric load from hip extension to hip flexion
  - Cutting & kicking
- Risk Factors
  - Limited flexibility
  - Muscle imbalance
- Failed acute management
Adductor Injury

- **Differential Diagnosis**
  - Sports hernia / Athletic pubalgia
  - Osteitis pubis
  - Inguinal hernia
  - Referred pain from lumbar spine

Adductor Injury Management

- **Conservative**
  - Relative rest
  - Strengthening adductor-rectus axis
  - Pelvic stability / balance
    - Randomized to active vs. passive PT
    - Treatment 8-12 wks
    - Active group: 79% return to athletic activity
      - 11.7% of passive group returned
    - Mean of 18.5 weeks
Adductor Surgery

  - Percutaneous adductor tenotomy
    - 48 (68 groins) failed conservative tx
  - Results
    - 60% >= pre-injury Tegner scores
    - 18.5 wks mean RTP
    - 73% excellent or very satisfactory outcome
    - Complications: scrotal hematoma (3), infection (1)
  - Minimal loss of strength

Iliopsoas

- Iliopsoas bursa
  - Communication with hip capsule 15%
- Function
  - Hip flexion, erect posture,
  - Lumbar sidebending
- Internal snapping hip
- Tenderness
- Risk for labral tear
Gluteus Medius / Minimus

- Presentation
  - Common in females
  - Misdiagnosed as “trochanteric bursitis”
    - Pain on palpation
    - Pain with sidelying

- Pfirrmann et al. *Radiol* 2001
  - Hip rotator cuff
    - 4 facets
    - Tendon attachments
    - 3 bursa
Gluteus Medius / Minimus

- **Treatment**
  - Address causative factors
    - ITB contracture
    - Hip flexor contracture
    - Pelvic obliquity
    - Gluteus medius weakness
  - Avoid aggravating factors
    - Lying on painful side
    - Symptomatic walking/running

Hamstring Tendinopathy

- **Anatomy**
  - Biceps femoris
    - Extensive distal insertion
    - Dual innervation
    - MTJ spans entire length
  - Semitendinosus
  - Semimembranosus

- **Function**
Introduction

- Hamstring injury common in high-speed sports
  - Track
  - Football
  - Rugby

- Extreme stretch to region
  - Dancers
  - Soccer

Mechanism

- Sprinting / Terminal swing
  - Preparing for contact
    - Hamstrings are lengthening & decelerating limb
    - Greatest stretch at Biceps Femoris

- Eccentric ability critical for prevention / rehab
Mechanism

- Position of extreme stretch to hamstrings
  - Hip flexion with knee extension
    - Soccer
    - Dancers
  - Semimembranosus & proximal free tendon

Differential Diagnosis

  - Sciatic nerve irritation
  - Ischiofemoral impingement
  - Apophysitis or avulsion (adolescents)
  - Deep gluteal muscle tear
  - Posterior pubic / ischial ramus stress fracture
  - Rupture of proximal hamstring tendon
Location of Injury

- Askling CM. et al. AJSM 2007
  - Location of maximal pain
  - More proximal to ischial tuberosity = ↑ recovery

Intrinsic Risk Factors

- History of a prior strain
  - Rugby
    - 50% hamstring strains recurrent
    - Verrall G. et. al. BJSM. 2001
  - Soccer
    - 53% hamstring strains recurrent
    - Arnason A. et. al. AJSM 2004
Intrinsic Risk Factors

- **Age**
  - Some studies discuss greater risk for older athletes
  - May be more related to other factors

- **Muscle Weakness**
  - Imbalance >20% between eccentric hamstrings & concentric quadriceps
  - 4 fold increase in risk (Heiderscheit BC et al. JOSPT 2010)

- **Flexibility**
  - Theory has always been tight muscles were more susceptible to injury
  - Unsupported in literature

---

**Examination**

Strength Measurements in Acute Hamstring Injuries: Intertester Reliability and Prognostic Value of Handheld Dynamometry

- Reurink G et al. JOSPT 2016
  - HS strength using HHD was reliable
  - Weak correlation strength deficit @15° knee flexion & time to return to play
Extrinsic Risk Factors

- Environmental
  - Rainfall & Temperature
    - Not significant

- Sport-Specific Off-Season training program
  - Likely addressing intrinsic factors

- Warm-Up & Stretching
  - Ineffective at reducing injuries

Rehabilitation

  - 80 elite athletes
  - Stretch 4x vs 1x/day ↓ time to RTS by 1.8 days

- Sherry MA, Best TM. J Orthop Sports Phys Ther. 2004
  - 24 diverse sporting background
Rehabilitation

- Sherry MA, Best TM. *JOSPT* 2004

- Compared traditional program of isolated hamstring strengthening and stretching to a program of progressive agility and trunk stabilization

- Subjects age and gender matched

**Sherry MA, Best TM. *JOSPT* 2004**

- **Traditional Program: Phase I**
  - 10 min low resistance bike
  - Supine HS stretch (4 x 20°)
  - Standing dynamic HS stretch (4 x 20°)
  - PNF-CRS HS (4 x 10° contraction / 20° stretch)
  - Multi angle sub maximal isometrics (10 x 10°)
  - Ice in stretched position (long sit) x 20 min

- **Traditional Program: Phase II**
  - 15 minutes bike / 5 minutes walk
  - Continue Phase I stretches
  - Prone leg curls with ankle weights (3 x 10)
  - Standing T-Band hip extension (3 x 10)
  - NWB foot catches (3 x 30°)
  - Practice without symptoms
    - No high speed maneuvers
    - Ice for 20 minutes if symptoms present
Sherry MA, Best TM. JOSPT 2004

Progressive Agility Program: Phase I
- Low / mod intensity side stepping (3 x 1')
- Low / mod intensity grape vine stepping (3 x 1')
- Low / mod intensity steps fwd / back over tape line (2 x 1')
- SLS balance progression (4 x 20")
- Prone abdominal body bridge (4 x 20")
- Supine bridge & side bridge (4 x 20")
- Ice for 20 minutes in long sitting

Progressive Agility Program: Phase II
- High / mod intensity side stepping (3 x 1')
- High / mod intensity grape vine stepping (3 x 1')
- High / mod intensity steps fwd / back over tape line (2 x 1')
- Single leg windmill touches (4 x 20" alt hands)
- Push up stabilization with trunk rotation (2 x 15 B)
- Feet fast in place (4 x 20")
- PNF trunk pull downs (2 x 15 B)
- Symptom free practice
- No high speed maneuvers
- Ice for 20 minutes if symptoms persist

Bridge Progression
Bridge Progression

- 90° Knee Flexion
  - HS = 75.34% MVIC
  - GMax = 51.01% MVIC
  - GMed = 57.81% MVIC

- 135° Knee Flexion
  - HS = 23.49% MVIC
  - GMax = 47.35% MVIC
  - GMed = 57.23% MVIC
Clinical Pearls

Do the **Correct** exercises the **Correct** way

Rehabilitation
- Sherry MA, Best TM. *JOSPT* 2004

**Results**
- Traditional Program
  - 55% suffered HS strain within the first 16 days of returning to sport
  - 70% re-injured in first year

- Progressive Agility Training & Trunk Stabilization Program
  - 0% suffered HS strain within the first 16 days of returning to sport
  - 8% re-injured in first year
Rehabilitation

- Sherry MA, Best TM. *JOSPT* 2004

  - Return to Sport
    - No statistical difference

    - Traditional Group
      - 37.4 (10 - 95) days

    - Agility & Trunk Stabilization Group
      - 22.2 (10 - 35) days

Heiderscheit BC et. al. *JOSPT* 2010

- Phase One
  - Protection
    - Avoid excessive stretching to prevent scar formation
    - Encourage movement within pain-free range

  - Ice
    - 2-3 times daily

  - NSAIDs
    - Initial time following injury
    - ? Negative effect on muscle function

- Therapeutic Exercise
  - Performed without pain
    - Lumbopelvic isometrics
    - Single-limb balance
    - Short stride stepping drills
    - Avoid isolated resistance

- Progression Criteria
  - Normal walking stride without pain
  - Low speed jogging without pain
  - Pain-free submaximal isometric contraction prone knee flexion
Heiderscheit BC et. al. *JOSPT* 2010

**Phase Two**

- **Protection**
  - Full ROM
  - Avoid end-range lengthening in presence of weakness

- **Ice**
  - Following exercise

- **NSAIDs**
  - Discouraged

**Phase Two**

- **Therapeutic Exercise**
  - Gradual hamstring lengthening to promote fiber regeneration
  - Trunk stabilization
  - Focus on transverse & frontal planes
  - Progress to sagittal plane
  - Submaximal eccentric strength in mid range

- **Progression Criteria**
  - Full strength without pain prone knee flexed to 90°
  - Forward / Backward jogging 50% effort without pain

---

**Frontal Plane**
Heiderscheit BC et. al. JOSPT 2010

- **Phase Three**
  - Protection
    - Unrestricted ROM
    - Avoid sprinting/acceleration
      - Meet return-to-sport criteria
  - Ice
    - As needed after exercise
  - NSAIDs
    - D/C

- **Therapeutic Exercise**
  - Progressive trunk stabilization
    - Transverse plane
    - Unilateral postures
  - Eccentric work at end ranges
  - Agility & sport-specific

- **Return-to-Sport Criteria** *(Limited Evidence)*
  - Full ROM & strength
    - Prone knee flexion at 90° & 15°
    - Isokinetic testing: <5% deficit between eccentric hamstrings & concentric quads
  - Full Functional Ability
    - Running, jumping, cutting
  - Hop testing

---

**Manual Eccentrics**
Progressive Agility & Trunk Stabilization (n = 16)
- 13 completed rehab
  - Reinjury (1); Dropped out (2)
- All subjects showed near-complete resolution of pain & return of strength
  - No subjects demonstrated complete resolution assessed with MRI

Progressive Running & Eccentric Strengthening (n = 13)
- 12 completed rehab
  - Reinjury (1)

Interventions
- Consider Sport Specific Demands
- Consider ROM the muscle group is functioning
  - Program should facilitate strength throughout entire ROM
- Muscle activation increases energy required to strain a muscle to failure (Garrett W. et al. AJSM. 1987)
  - Ability of a muscle to resist length (eccentric contraction) beneficial in avoiding strain injuries
- Focus on eccentric strength at end ranges of motion
Eccentric Training

- Cushman, D & Rho, ME JOSPT 2015
  - 34 yo male triathlete unilateral PHT
  - Pain with running & prolonged sitting
  - Failed 4 weeks of eccentrics & lumbopelvic strength
  - Daily treadmill hip extensor eccentrics
  - ↓ pain in 2 weeks; gradual run in 4 weeks; speed training in 12 weeks
  - VISA-H 23 → 83
  - No recurrence 12 month F/U

Eccentric Progressions
Preventive Effect of Eccentric Training on Acute Hamstring Injuries in Men’s Soccer

A Cluster-Randomized Controlled Trial

Jesper Petersen,1,2 MD, PhD, Kristian Thorborg,1 PT, PhD, Michael Bachmann Nielsen,4 MD, PhD, DMSc, Ebbe Budtz-Jørgensen,8 MSc, PhD, and Per Hølmich,1 MD
Investigation performed at the University of Copenhagen, Copenhagen, Denmark

- Petersen J et al AJSM 2011
  - 942 male Danish soccer players
  - 481 control group
    - Usual training program
  - 461 intervention group
    - 10 week eccentric program

- Acute hamstring injuries
  - Control = 52
  - Intervention = 15

- ↓ new injuries by 60%

- ↓ recurrent injuries by 85%

Table 1: Training Protocol for the Nordic Hamstring Exercise

<table>
<thead>
<tr>
<th>Week</th>
<th>Sessions Per Week</th>
<th>Sets and Repetitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2 × 5</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2 × 6</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>3 × 6–8</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>3 × 6–10</td>
</tr>
<tr>
<td>5–10</td>
<td>3</td>
<td>3 sets, 12–15–8 reps</td>
</tr>
<tr>
<td>10+</td>
<td>1</td>
<td>3 sets, 12–15–8 reps</td>
</tr>
</tbody>
</table>
Summary

- Recognize risk factors & understand how to correct
- Consider specific location of injury
- Eccentrics progressing to end range positions
- Incorporate core stability & agility

Hip Rehabilitation Exercises: Review of the Literature
Strengthening

  - 30 healthy subjects (27 yo ± 8)
    - 19 males & 11 females
  - Surface EMG
    - Rectus Abdominus
    - External Oblique Abdominis
    - Longissimus Thoracis
    - Lumbar Multifidus
    - Gluteus Maximus
    - Gluteus Medius
    - Vastus Medialis Obliquus
    - Hamstrings
Strengthening


**TABLE 1**

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Gluteus Medius</th>
<th>Gluteus Maximus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Scoot-hinge</td>
<td>21 ± 10</td>
<td>21 ± 10</td>
</tr>
<tr>
<td>2. Unilateral-lunge</td>
<td>41 ± 24</td>
<td>40 ± 20</td>
</tr>
<tr>
<td>3. Lateral-shift</td>
<td>41 ± 19</td>
<td>29 ± 13</td>
</tr>
<tr>
<td>4. Quadruped arm/leg extension lift</td>
<td>42 ± 14</td>
<td>56 ± 22</td>
</tr>
<tr>
<td>5. Active hip abduction</td>
<td>39 ± 13</td>
<td>21 ± 16</td>
</tr>
<tr>
<td>6. Dynamic Edge</td>
<td>33 ± 16</td>
<td>19 ± 14</td>
</tr>
<tr>
<td>7. Lunges</td>
<td>29 ± 12</td>
<td>36 ± 14</td>
</tr>
<tr>
<td>8. Bridge</td>
<td>28 ± 17</td>
<td>25 ± 16</td>
</tr>
<tr>
<td>9. Push-up &lt;br&gt;version</td>
<td>21 ± 11</td>
<td>9 ± 7</td>
</tr>
</tbody>
</table>

Strengthening

- DiStefano LJ. et al. *JOSPT*. 2009

- 21 Healthy subjects (22 yo ± 3)
  - 9 males & 12 females
  - Physical activity 60 minutes 3x/week

- Surface EMG of dominant limb
  - Gluteus Medius & Gluteus Maximus

- Performed 8 reps of 12 exercises
  - Randomized order
Strengthening

- DiStefano LJ. et al. *JOSPT*. 2009

**TABLE 2**

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Mean ± SD (% MVIC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side-lying hip adduction</td>
<td>8 ± 3.5 (95%)</td>
</tr>
<tr>
<td>Single-leg squat</td>
<td>64 ± 24 (55, 76)</td>
</tr>
<tr>
<td>Lateral band walk</td>
<td>51 ± 34 (46, 76)</td>
</tr>
<tr>
<td>Single-leg squat</td>
<td>58 ± 25 (47, 79)</td>
</tr>
<tr>
<td>Slalom hop</td>
<td>57 ± 30 (46, 79)</td>
</tr>
<tr>
<td>Transverse lunge*</td>
<td>48 ± 25 (32, 38)</td>
</tr>
<tr>
<td>Transverse lunge*</td>
<td>48 ± 25 (32, 38)</td>
</tr>
<tr>
<td>Forward lunge*</td>
<td>46 ± 21 (38, 59)</td>
</tr>
<tr>
<td>Forward lunge*</td>
<td>42 ± 21 (38, 59)</td>
</tr>
<tr>
<td>Drive with 30° hip flex*</td>
<td>40 ± 22 (33, 53)</td>
</tr>
<tr>
<td>Slalom hop*</td>
<td>39 ± 19 (30, 65)</td>
</tr>
<tr>
<td>Drive with 30° hip flex*</td>
<td>38 ± 20 (25, 50)</td>
</tr>
</tbody>
</table>
**Strengthening**
- DiStefano LJ. et al. *JOSPT*. 2009

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Mean ± SD (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-leg squat</td>
<td>59 ± 2 (47.72)</td>
</tr>
<tr>
<td>Single-leg deadlift</td>
<td>59 ± 28 (46.70)</td>
</tr>
<tr>
<td>Transverse lunge</td>
<td>49 ± 20 (33.58)</td>
</tr>
<tr>
<td>Forward lunge</td>
<td>44 ± 23 (31.54)</td>
</tr>
<tr>
<td>Sideways lunge</td>
<td>42 ± 20 (32.50)</td>
</tr>
<tr>
<td>Side-lying hip abduction</td>
<td>39 ± 18 (31.47)</td>
</tr>
<tr>
<td>Sideways hop</td>
<td>30 ± 19 (23.40)</td>
</tr>
<tr>
<td>Lunge with 60° hip flexion</td>
<td>39 ± 24 (24.54)</td>
</tr>
<tr>
<td>Tenodesis hop*</td>
<td>55 ± 16 (26.43)</td>
</tr>
<tr>
<td>Forward hop**</td>
<td>35 ± 22 (25.45)</td>
</tr>
<tr>
<td>Lunge with 30° hip flexion*</td>
<td>34 ± 27 (21.46)</td>
</tr>
<tr>
<td>Lateral band walk**</td>
<td>27 ± 16 (20.35)</td>
</tr>
</tbody>
</table>

**Strengthening**
  - 26 healthy subjects
  - Surface EMG of dominant leg
    - Gluteus Maximus & Gluteus Medius
  - Performed 18 exercises
    - Randomized order

**ORIGINAL RESEARCH**
**ELECTROMYOGRAPHIC ANALYSIS OF GLUTEUS MEDIUS AND GLUTEUS MAXIMUS DURING REHABILITATION EXERCISES**
Kristen Boren, DPT
Cara Conrey, DPT
Jennifer Le Cognic, DPT
Lindsey Paprocki, DPT
Michael Voight, PT, DBSc, SCS, OCS, ATC, CSCS
T. Kevin Robinson, PT, DSc, OCS
Strengthening


**Gluteus Medius**

<table>
<thead>
<tr>
<th>Exercise condition</th>
<th># Subjects Included for analysis</th>
<th>% MVIC Gluteus Medius</th>
<th>Rank Gluteus Medius</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side plank abd, DL down</td>
<td>21</td>
<td>103.11</td>
<td>1</td>
</tr>
<tr>
<td>Side plank abd, DL up</td>
<td>22</td>
<td>88.82</td>
<td>2</td>
</tr>
<tr>
<td>Single limb squat</td>
<td>22</td>
<td>82.26</td>
<td>3</td>
</tr>
<tr>
<td>Hamstring (Hip Clam) 4</td>
<td>23</td>
<td>76.84</td>
<td>4</td>
</tr>
<tr>
<td>Front plank with Hip Ext</td>
<td>22</td>
<td>75.13</td>
<td>5</td>
</tr>
<tr>
<td>Hamstring (Hip Clam) 3</td>
<td>22</td>
<td>67.40</td>
<td>6</td>
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<tr>
<td>Side-angulated</td>
<td>23</td>
<td>62.91</td>
<td>7</td>
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<tr>
<td>Hamstring (Hip Clam) 2</td>
<td>22</td>
<td>62.45</td>
<td>8</td>
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<tr>
<td>Lateral step-up</td>
<td>21</td>
<td>59.87</td>
<td>9</td>
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<tr>
<td>Skater squat</td>
<td>22</td>
<td>59.84</td>
<td>10</td>
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<tr>
<td>Pelvic Drop</td>
<td>23</td>
<td>58.43</td>
<td>11</td>
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<tr>
<td>Hip circumduction, stable</td>
<td>23</td>
<td>57.59</td>
<td>12</td>
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<tr>
<td>Dynamic Leg Swing</td>
<td>22</td>
<td>57.50</td>
<td>13</td>
</tr>
<tr>
<td>Single limb deadlift</td>
<td>23</td>
<td>56.91</td>
<td>14</td>
</tr>
<tr>
<td>Single limb bridge, unstable</td>
<td>22</td>
<td>54.99</td>
<td>15</td>
</tr>
<tr>
<td>Forward step-up</td>
<td>22</td>
<td>54.62</td>
<td>16</td>
</tr>
<tr>
<td>Single limb bridge, unstable</td>
<td>20</td>
<td>47.42</td>
<td>17</td>
</tr>
<tr>
<td>Hamstring (Hip Clam) 1</td>
<td>22</td>
<td>47.33</td>
<td>18</td>
</tr>
<tr>
<td>Quadruped hip ext, DOM</td>
<td>23</td>
<td>46.67</td>
<td>19</td>
</tr>
<tr>
<td>Gluteus squeeze</td>
<td>21</td>
<td>43.72</td>
<td>20</td>
</tr>
<tr>
<td>Hip circumduction, unstable</td>
<td>23</td>
<td>37.88</td>
<td>21</td>
</tr>
<tr>
<td>Quadruped hip ext, non-DOM</td>
<td>23</td>
<td>22.00</td>
<td>22</td>
</tr>
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</table>
Strengthening


Gluteus Maximus

<table>
<thead>
<tr>
<th>Exercise condition</th>
<th># Subjects Included for analysis</th>
<th>%MVIC Gluteus Maximus</th>
<th>Rank Gluteus Maximus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front plank with Hip Ext</td>
<td>22</td>
<td>106.22</td>
<td>1</td>
</tr>
<tr>
<td>Gluteal squeeze</td>
<td>22</td>
<td>80.72</td>
<td>2</td>
</tr>
<tr>
<td>Side plank abd, DL up</td>
<td>22</td>
<td>72.87</td>
<td>3</td>
</tr>
<tr>
<td>Side plank abd, DL down</td>
<td>21</td>
<td>70.96</td>
<td>4</td>
</tr>
<tr>
<td>Single limb squat</td>
<td>22</td>
<td>70.74</td>
<td>5</td>
</tr>
<tr>
<td>Maker squat</td>
<td>27</td>
<td>66.58</td>
<td>5</td>
</tr>
<tr>
<td>Lateral step-up</td>
<td>20</td>
<td>63.83</td>
<td>7</td>
</tr>
<tr>
<td>Quadruped hip-ext, DOM</td>
<td>22</td>
<td>59.79</td>
<td>8</td>
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<tr>
<td>Single-limb deadlift</td>
<td>21</td>
<td>58.84</td>
<td>9</td>
</tr>
<tr>
<td>Forward step-up</td>
<td>22</td>
<td>54.67</td>
<td>10</td>
</tr>
<tr>
<td>Single limb bridge, stable</td>
<td>21</td>
<td>54.24</td>
<td>11</td>
</tr>
<tr>
<td>Clamshell (Hip,Clam)</td>
<td>22</td>
<td>53.19</td>
<td>12</td>
</tr>
<tr>
<td>Side-lying abd</td>
<td>22</td>
<td>51.13</td>
<td>13</td>
</tr>
<tr>
<td>Single limb bridge, unstable</td>
<td>18</td>
<td>49.75</td>
<td>14</td>
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<tr>
<td>Hip circumduction, stable</td>
<td>22</td>
<td>47.85</td>
<td>15</td>
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<tr>
<td>Dynamic lag swing</td>
<td>22</td>
<td>33.65</td>
<td>16</td>
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<tr>
<td>Hip circumduction, unstable</td>
<td>22</td>
<td>28.87</td>
<td>17</td>
</tr>
<tr>
<td>Clamshell (Hip,Clam) 3</td>
<td>22</td>
<td>26.63</td>
<td>18</td>
</tr>
<tr>
<td>Clamshell (Hip,Clam) 4</td>
<td>22</td>
<td>26.22</td>
<td>19</td>
</tr>
<tr>
<td>Pelvic Drop</td>
<td>22</td>
<td>25.10</td>
<td>20</td>
</tr>
<tr>
<td>Quadruped hip-ext, non-DOM</td>
<td>22</td>
<td>21.04</td>
<td>21</td>
</tr>
<tr>
<td>Clamshell (Hip,Clam) 2</td>
<td>22</td>
<td>12.36</td>
<td>22</td>
</tr>
</tbody>
</table>

Table 6. Top exercises for muscle activation of both gluteus medius and gluteus maximus (>70% MVIC).

<table>
<thead>
<tr>
<th>Exercise condition</th>
<th>%MVIC Gluteus Medius</th>
<th>%MVIC Gluteus Maximus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front plank with Hip Ext</td>
<td>75.13</td>
<td>106.22</td>
</tr>
<tr>
<td>Side plank abd, DL up</td>
<td>88.82</td>
<td>72.87</td>
</tr>
<tr>
<td>Side plank abd, DL down</td>
<td>103.11</td>
<td>70.96</td>
</tr>
<tr>
<td>Single limb squat</td>
<td>82.26</td>
<td>70.74</td>
</tr>
</tbody>
</table>
Strengthening

- Selkowitz DM et al. *JOSPT* 2013
  - Activate gluteus medius and superior gluteus maximus while minimizing TFL
  - Fine-wire EMG
  - 11 exercises
  - 20 healthy subjects
  - Calculated Gluteal to TFL Index for each exercise
    - Not simply looking at EMG values

**TABLE 2**

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Gluteal-to-TFL Activation Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clam*</td>
<td>1.15</td>
</tr>
<tr>
<td>Side step*</td>
<td>0.64</td>
</tr>
<tr>
<td>Untensed bridge*</td>
<td>0.69</td>
</tr>
<tr>
<td>Quadruped hip extension, knee extending*</td>
<td>0.50</td>
</tr>
<tr>
<td>Quadruped hip extension, knee flexed*</td>
<td>0.50</td>
</tr>
<tr>
<td>Side lying hip abduction*</td>
<td>0.26</td>
</tr>
<tr>
<td>Step up*</td>
<td>0.52</td>
</tr>
<tr>
<td>Bilateral bridge*</td>
<td>0.32</td>
</tr>
<tr>
<td>Squat*</td>
<td>0.28</td>
</tr>
<tr>
<td>Hip hike*</td>
<td>0.28</td>
</tr>
<tr>
<td>Lange*</td>
<td>0.28</td>
</tr>
</tbody>
</table>

*Abbreviation: TFL, tensor fascia lata.  
*Exercises in which both gluteal muscles demonstrated significantly higher normalized electromyographic signal amplitude than the TFL.
Strengthening

- Selkowitz DM. et al. *JOSPT* 2013

![Strengthening exercises](image-url)
Strengthening

- Selkowitz DM et al. JOSPT 2013

**Limitations**

- **Healthy subjects**

- CLAM & SIDESTEP used elastic resistance
  - Likely increased EMG amplitudes and GTA Index

- Did not include gluteus minimus
  - 20% of abductor cross sectional area
Strengthening

- Proximal strength
  - Cambridge ED et al Clin Biomech 2012
    - Forefoot resistance: ↑ gluteals vs. TFL
    - Likely due to ER of hips

MacAskill MJ et al IJSPT 2014
- Surface EMG (Gmax & Gmed)
  
  - Weightbearing
    - Forward Step-Up
    - Lateral Step-Up
  
  - Non-Weightbearing
    - 10RM
    - Prone Hip Extension
    - Sidelying Hip Abduction
Summary

Gluteal strengthening shown to be critical in lower extremity function

Consider the quality of tissue, phase of healing and baseline strength

What muscle should be activated and what muscle activation should be minimized

Always treat the cause and avoid chasing symptoms
Patellar Tendinopathy

- **Epidemiology**
  - Volleyball: 23%
    - Ferretti A. *Sports Med*. 1986
    - ↑ GRF during take-off
  - Basketball: 7%
  - Running: 4.8%
  - ↓ Quad and Hamstring flexibility
  - Patellar Maltracking

- **Location of Pathology**
  - Enthesis site
  - Inferior pole of patella
    - Posterior
  - Infrapatellar fat pad highly innervated
  - Palpation may not be useful
    - Sensitivity = 0.56; Specificity = 0.47
Patellar Tendinopathy

- Differential Diagnosis
  - PFPS
  - Osgood-Schlatter’s Disease
  - Bursitis
  - Anterior Meniscal Tear
  - Hoffa’s Disease

- Imaging
  - Radiographs
    - Rule Out Osgood Schlatter’s
  - Computed Tomography (CT)
    - Radiation exposure
  - MRI
    - Sensitivity = 78%; Specificity = 86%
    - Expensive & ↑ scan time
  - Ultrasound
    - Sensitivity = 58%; Specificity = 94%
    - Hypoechoic region
      - Disruption of collagen arrangement
    - Highly operator dependent
Patellar Tendinopathy

- Ultrasound
    - 26 asymptomatic elite junior basketball players
    - 10 of 52 tendons abnormal US
    - Re-assessed post 16 months
    - 4.2 x greater risk patellar tendon pain
  - Fredberg U. & Bolvig L. *AJSM.* 2002
    - 54 asymptomatic elite soccer players
    - US pre/post one season
    - 18 tendons abnormal on exam
    - 25% symptomatic at end of season
  - Asymptomatic hypoechoic regions of the patellar tendon is a risk factor for developing symptomatic patellar tendinopathy

- Interventions
  - Relative rest / reduce tendon load
  - Immobilization contraindicated
  - Modalities
    - Limited evidence
  - Flexibility
    - Quads
    - Hamstrings
  - Cross Friction Massage
    - Limited high quality evidence
    - Increased fibroblastic activity
    - Promote normal collagen alignment
Patellar Tendinopathy

- Interventions
  - Eccentric Exercise
    - Should be painful
    - Drop squats vs. knee extension
      - ↑ athletes in drop squat group returned to sport
    - Squat vs. decline squat
      - ↑ athletes in decline squat group returned to sport
    - Decline squat vs. 10” step down
      - Both improved; decline squat group significantly better VISA scores @ 12 months
  - Open tenotomy vs. single-leg decline squat
    - No difference in VISA scores @ 12 months

- Eccentric Activity
  - ↑ Type I collagen
  - ↑ Tendon stiffness
  - ↓ Neovascularity

- Decline Squat
  - ↑ Patellar tendon force
  - ↑ Patellar tendon strain & quad EMG
Patellar Tendinopathy

- Summary
  - Differential diagnosis is key
  - Consider predisposing factors
    - Flexibility
    - Training errors
  - Eccentric focus
    - What exercise is best?

Achilles Tendinopathy

“ltis”
- Inflammatory process
- Rare given chronic nature of most presentations
- Recover within 2 weeks

“Osis”
- Degeneration within the tendon
- Repetitive microtrauma
- Increase in vascularity
- Recovery may take several months
- Clinical pearl
  - Tendon enlargement will move with tendon; swelling will not
Achilles Tendinopathy

Epidemiology (Paavola M. et al. JBJS 2002)

- Distance runners
- Men > Women
- More common in older athlete

Etiology

- Training errors (Schepsis AA. et al. AJSM 2002)
  - ↑ intensity, change in surface or schedule and inappropriate shoewear

- Lower Extremity Intrinsic Factors (Carcia CR et a. JOSPT. 2010)
  - Abnormal subtalar joint ROM
  - Limited ankle dorsiflexion
  - ↓ plantarflexion strength
  - Foot pronation
  - Co-Morbidities: Obesity, HTN, DM, ↑ cholesterol

- Increased pronation (Ryan M et al. Foot Ankle Int, 2009)
  - 27 runners with mid portion achilles tendinopathy
  - ↑ STJ eversion during mid-stance
  - 13° ± 3° vs. 11° ± 3° (p = 0.04)
Achilles Tendinopathy

Risk Factors for Lower Extremity Tendinopathies in Military Personnel

Brett D. Owens,*† MD, Jennifer Moriatis Wolf,§ MD, Amber D. Seelig,¶ MPH, Isabel G. Jacobson,† MPH, Edward J. Boyko,∥ MD, MPH, Besa Smith,∥∥ MPH, PhD, Margaret A.K. Ryan,*∥∥ MD, MPH, Gary D. Gackstetter,‡‡ DVM, MPH, PhD, and Tyler C. Smith,§§ MS, PhD, for the Millennium Cohort Study Team††

Investigation performed at the Naval Health Research Center, San Diego, California, USA

- Owens BD et al. OJSM 2013
  - >80K Active duty followed x 1 year
    - ↑ BMI
    - Moderate drinking

Achilles Tendinopathy

- Differential Diagnosis
  - Os Trigonum
  - Posterior ankle impingement
  - Medial tendon tendinopathy
  - Bursitis
  - Sural neuropathy
  - Radiculopathy
Achilles Tendinopathy

Biomechanical Variables
- Reule, CA et al. BJSM 2011
  - More oblique STJ axis
    - \(18^\circ \pm 23^\circ\) vs. \(10^\circ \pm 23^\circ\) \((p=0.002)\)
    - STJ axis passes more laterally through Achilles tendon
    - Longer moment lever arm for medial Achilles tendon fibers
  - \(\uparrow\) load in tendon may lead to degeneration

Eccentric Calf Strengthening
- Alfredson H et al. AJSM 1998
  - 15 recreational athletes Dx with Achilles tendinosis
    - 12 men & 3 women (age 44.3 +/- 7 years)
  - Training Program
    - 3x 15 reps, 2x/day for 12 weeks
      - Knee straight (gastroc) & Knee bent (soleus)
      - Body weight initially progressed to external load
  - Results
    - VAS decreased from 81.2 (+/- 18) to 4.8 (+/- 6.5)
    - All 15 subjects returned to pre-injury running level
    - 15 athletes received conservative treatment
      - All underwent surgical intervention
Achilles Tendinopathy

Non-Operative Treatment

Eccentric Training

Knobloch K et al. JOSPT 2007

12 week eccentric program performed daily
↓ paratendinous capillary blood flow by 45%
↓ pain level by 48%

Shalabi A et al. AJSM 2004

3 months of eccentric calf strengthening
MRI evaluation revealed:
14% decrease in tendon volume
23% decrease in intratendinous signal
Results correlated with improved clinical outcome

---

Achilles Tendinopathy


  - 34 patients with Achilles tendinopathy treated with exercise alone

  - 5-Year follow up
    - 80% fully recovered
Achilles Tendinopathy

- Fahlstrom M. et al. 2003
  - 32% patients with insertional Achilles tendinopathy successful with eccentric training into dorsiflexion
    - Compressive forces in dorsiflexion
    - Impingement between tendon, bursa and bone

  - 27 subjects (20 unilateral & 7 bilateral)
    - 12 men, 15 women, mean age = 53.4 yrs (25-77)
  - Mean duration of symptoms = 26.5 months (6-96)
  - Eccentric exercise performed without dorsiflexion
  - 3x15 reps, 2 x/day, 7 days/week for 12 weeks
  - Load increased to create pain during exercise
  - Results: 67% satisfied @ 4 month F/U
    - 18 “satisfied”
      - VAS ↓ 69.9 to 21.0 (p<0.001)
    - 9 “not satisfied”
      - VAS ↓ 77.5 to 58.1 (p<0.006)
Achilles Tendinopathy

Shock-Wave Treatment
Rompe JD et al. AJSM, 2009
68 patients with recalcitrant noninsertional Achilles tendinopathy (4 month F/U)
Group 1: Eccentric loading
  VISA-A ↑: 50 to 73
  Pain ↓: 7 to 4
  “Completely Recovered” or “Much Improved”: 56%
Group 2: Eccentric loading + low-energy shock-wave therapy
  VISA-A ↑: 51 to 87
  Pain ↓: 7 to 2
  Completely Recovered” or “Much Improved”: 82%
1 year follow-up: No difference

Gastrocnemius / Soleus

- Gait function
  - Gastrocnemius
    - Decelerate/control forward progression of tibia on talus
  - Soleus
    - Active around the time of heel strike

- Rehab focus
  - Flexibility
    - Prevent compensatory pronation at midfoot
  - Strength
    - Eccentric contraction key
    - Respect stage of healing / reactivity of tissue
Gastrocnemius / Soleus

- Flexibility
  - Maintain supinatory bias
    - Inverted calcaneus
  - Prevent oblique midtarsal compensation

- Strength
    - Surface EMG medial & lateral heads of gastroc & soleus
    - 20 Healthy lower extremities
    - 10 participants (27yo ± 5)

- Results (% MVIC)
  - Seated toe raise 11%
  - SL Balance on wobble board 25%
  - Prone ankle pumps 38%
  - Supine PF with red TB 45%
  - Normal gait 47%
  - Lateral step-ups 60%
  - SL heel raise 112%
  - SL jumping 129%
Gastrocnemius / Soleus

- Strength
  - Eccentric is key
    - Manual resistance
    - Resisted band
    - Weight bearing

Achilles Tendinopathy

- More Than Just Eccentrics….
  - Tibialis posterior strength
    - Control transverse plane
  - Unstable surfaces
    - Multi plane muscle balance
  - Single leg hopping
    - Control of ground reaction forces
  - Manual Therapy
Achilles Tendinopathy

Heavy Slow Resistance

Beyer R et al, AJSM 2015

RCT Ecc vs HSR for 12 weeks:
Both groups improved; maintained at 1 yr F/U

- Self report measures
- Decreased tendon thickness
- Decreased neovascularization

Patient satisfaction @ 12 weeks ($P = .052$)
- HSR 100%
- ECC 80%

Patient satisfaction @ 52 weeks ($P = .10$)
- HSR 96%
- ECC 76%

---

Posterior Tibial Tendon Dysfunction

- O’Connor K et al. Foot Ankle Int. 2010
  - Associated with flat foot
  - 80% of patients are female and overweight
Posterior Tibial Tendon Dysfunction

- Bluman EM et al. *Foot Ankle Clin.* 2007
- Staging for Posterior Tibialis Dysfunction

<table>
<thead>
<tr>
<th>Stage</th>
<th>Signs/Symptoms</th>
<th>Pathology</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Tender to palpation, pain with heel rise&lt;br&gt;Swelling distal to medial malleolus</td>
<td>Tendon pathology with/without synovitis</td>
</tr>
<tr>
<td>II</td>
<td>Flexible flat foot posture&lt;br&gt;• Forefoot abduction&lt;br&gt;• Lower medial longitudinal arch&lt;br&gt;• Rearfoot eversion</td>
<td>Damage to Spring ligament&lt;br&gt;Hypermobility of talonavicular joint</td>
</tr>
<tr>
<td>III</td>
<td>Non flexible flat foot posture that is more pronounced</td>
<td>Damage to Deltoid ligament&lt;br&gt;Development of joint contractures</td>
</tr>
<tr>
<td>IV</td>
<td>Ankle osteoarthritis</td>
<td>Damage to Deltoid ligament&lt;br&gt;Development of joint contractures</td>
</tr>
</tbody>
</table>

Posterior Tibial Tendon Dysfunction

**Treatment**

- Neville CG & Houck JR. *JOSPT.* 2009
- Brace to control rearfoot eversion & support medial longitudinal arch
  - Solid ankle AFO
    - May limit plantarflexion function
    - Preferred for stage III-IV
  - Hinged ankle AFO
    - Prevention of weakness by allowing for normal function
    - Preferred for stage I-II
Posterior Tibial Tendon Dysfunction

- **Treatment**
  - General leg & foot strengthening
    - Alvarez RG et al. *Foot Ankle Int.* 2006
  - Eccentric exercise
    - Kulig K et al. *Phys Ther.* 2009 & Kulig K et al. *Foot Ankle Int.* 2009
  - Role of Exercise in PTTD
    - Tendon remodeling
    - Prevention of weakness
    - Hypertrophy or lower leg muscles

Tibialis Posterior

- **Anatomical Function**
  - Inverter, adductor, plantar flexor of foot
- **Gait function**
  - Decelerate/control GRF moving foot into eversion & abduction
  - Greater activation in low arch foot types
- **Rehab focus**
  - Strength
    - Eccentric contraction key
    - Works in concert with peroneus longus
Tibialis Posterior

- Strength
  - TB resistance
  - Manual resistance
  - CKC progression

Fibularis Tendons

- Associated with lateral ankle sprain & cavus foot
  - Ogawa BK & Thordarson DB. Foot Ankle Int. 2007
  - Manoli A & Graham B. Foot Ankle Int. 2005

- 77% of fibularis tendon pathology associated with lateral ankle sprain
Fibularis Tendons

- **Examination Findings**
  - Pain along posterolateral region of foot
  - Swelling, clicking, visible tendon subluxation
  - Subtalar eversion weakness
  - Pain with heel rise

- **Fibularis Brevis**
  - Lateral & posterior on foot 2-3cm distal to lateral malleolus

- **Fibularis Longus**
  - Cuboid tunnel or insertion at base of 1st metatarsal

- **Treatment**
  - Restore subtalar eversion to ↓ load on tendon
  - Surgery indicated with subluxation

---

**Fibularis Tendons**

- **Anatomical Function**
  - Abduct & evert the foot in OKC

- **Gait function**
  - Brevis
    - Stabilizes calcaneocuboid joint
  - Longus
    - Stabilize first ray as weight transfers from lateral to medial

- **Rehab focus**
  - Strength focus is OKC & CKC
Peroneals

- Strength
  - OKC:
    - TB Resistance
    - Manual Resistance
  - CKC:
    - Weight shift control
    - 1st ray vs ground

Summary

- Tendinopathy presents many challenges to the sports medicine clinician

- Effective management requires understanding of the pathology at the tissue level

- Modification of training program is paramount in an athletic population

- Interventions should address faulty biomechanics with a bias toward eccentric strengthening
Thank You