Tendinopathy
Does one size fit all?

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Conflict of interest

• Associate Editor for Journal of Orthopaedic and Sports Physical Therapy
• No other conflict of interest

Goals and Objectives

• Describe the purpose of tendons and how this relates to function and injury risk
• Review the pathophysiology of tendinopathy
• Review how tendon injury affect tendon and muscle function
• Describe and review the difference between tendon injury in the midportion versus the osteotendinous junction
• Review the effect of exercise as treatment

Why tendons?

• Tendons saves energy
• Improves explosive power
• Controls movement

Various types of tendons

Tendons tolerance to load

• Tolerate tensile forces better than tensile with compressive forces
• Tendon susceptible for injury in areas where compressed around bone
Classification of Achilles tendon injury

**Acute injuries**
- Total rupture

**Overuse injuries**
- Partial rupture
  - Acute phase
  - Chronic phase
  - Distal paratenonitis
  - Midportion paratenonitis
  - Distal Achilles tendinopathy
  - Midportion Achilles tendinopathy

Tendinopathy

Classification of tendinopathies
Bonar’s modification of Clancy’s classification of tendinopathies

- Tendinosis
- Tendinitis/ partial rupture
- Paratenonitis
- Paratenonitis with tendinosis


Tendinopathy – tendon structure

- Collagen fibers thinner and loosely arranged
- Increased amount of proteoglycans
- Increased water content

Tendinopathy: Update on Pathophysiology
Scott et al. JOSPT 2015

<table>
<thead>
<tr>
<th>Stages of tendon healing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inflammatory phase</strong></td>
</tr>
<tr>
<td><strong>Repair phase</strong></td>
</tr>
<tr>
<td><strong>Remodelling phase</strong></td>
</tr>
</tbody>
</table>

Schematic illustration of pain and tissue damage in overuse tendinopathy (Leadbetter 1992)
Risk factors – the individual

- Adiposity - ↑BMI (risk factor for both upper and lower extremity tendinopathies)
- ↑intake of cholesterol result in impaired Type I collagen production
- Smoking – results in worse tendon histology

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>Medical Conditions With Associated Tendon Pathology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Typically Affected</td>
<td>Examples of Medical Condition</td>
</tr>
<tr>
<td>Metatarsus</td>
<td>Osteoarthritis, mechanical pain, stress fracture, gout, psoriasis, skin diseases, post-traumatic arthritis, rheumatoid arthritis, osteomyelitis</td>
</tr>
<tr>
<td>Tendo Achillis</td>
<td>Achilles tendonitis, bursitis, myositis, myositis ossificans, post-traumatic arthritis, rheumatoid arthritis, osteomyelitis</td>
</tr>
<tr>
<td>Tendo Rotator Cuff</td>
<td>Rotator cuff tendinopathy, bursitis, calcific tendinitis, synovitis, rotator cuff tear, adhesive capsulitis</td>
</tr>
<tr>
<td>Tendo Patella</td>
<td>Patellar tendinopathy, patellar tendinopathy, bursitis, chondromalacia patellae, post-traumatic arthritis, osteomyelitis</td>
</tr>
<tr>
<td>Tendo Finger</td>
<td>Finger tendinopathy, bursitis, osteoarthritis, gout, psoriasis, skin diseases, post-traumatic arthritis, rheumatoid arthritis, osteomyelitis</td>
</tr>
</tbody>
</table>

Effect of Age – similar to disuse

- Change in mechanical properties with age
- Decreased % water
- Increased risk of tendon rupture after 30yrs
- Turnover rate of collagen decrease with age which has a negative effect on recovery
- Exercise can counteract the changes that occur with age

Tendon injury and Tendon Function

Changes in mechanical properties and performance

In Symptomatic subjects

- Tendinopathic tendons has lower tendon stiffness and elastic modulus (Aria et al JAP 2010, Child et al AISM 2010)
- Altered Achilles tendon viscoelastic properties affect explosive performance in athletes (Wang et alSIMSS 2012)
- Altered stretch-shortening cycle behavior during submaximal hopping (Debenham et al JSMSS 2014)
- Triceps surae activation is altered in runners with Achilles tendinopathy (Wyndow et al JEX 2013)

In Asymptomatic subjects (tendinosis and previous tendinopathy)

- Asymptomatic runners (previous Achilles tendinopathy) exhibit changes in knee kinetics during running, indicating permanent changes in knee biomechanics (Williams et al JOSPT 2008)
- Achilles tendinosis result in a more compliant tendon (Chang & Kulig 2015)
- The compliant tendon elicit a series of neuromechanical adaptations (Chang & Kulig J Physiol 2015)

Delaware Tendon Research Lab - Establish Tendon Health

Cortes et al. 2015, Suydam et al. 2015  NIH R21 AR067390
Tendon injury and performance

Pilot data

• Mechanical properties evaluated with elastography in patients with Achilles tendinopathy
• Total work done on the heel rise test correlated significantly with the shear modulus on the symptomatic side (r=0.78)

Tendon injury and Muscle function

Chang & Kulig J Physiol 2015

• Tendinotic group
  – History of unilateral Achilles tendinopathy lasting more than 2 weeks
  – Absence of pain during walking and running
  – Confirmed mid-substance tendinosis, 2mm greater A-P dimension
• Measured tendon structure, mechanical properties (stiffness), electromechanical delay, preactivation and relative muscle activation

Function and symptoms

Full symptomatic recovery does not ensure full recovery of muscle-tendon function in patients with Achilles tendinopathy

Chang & Kulig J Physiol 2015
### Relationship between Symptom and Function

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully recovered</td>
<td>90-100 points on VISA-A-S (n=16)</td>
</tr>
<tr>
<td>Passed all strength &amp; jump tests (&gt;80%)</td>
<td>4 patients 26%</td>
</tr>
<tr>
<td>Passed 4 of 5 tests</td>
<td>3 patients 19%</td>
</tr>
<tr>
<td>Passed 3 of 5 tests</td>
<td>9 patients 56%</td>
</tr>
</tbody>
</table>

### Conclusion

**Pain free**

Asymptomatic ≠ Full recovery of muscle-tendon function

- Continue with tendon exercise even if symptoms have disappeared
- Consider tendon loading exercise for prevention
- Again need a measure of tendon health or biomarker for tendon health to continue monitoring improvement

### Osteotendinous junction

Greater echogenicity related to symptom severity

### Insertional considerations

Standing plantar flexion

Standing neutral

Standing dorsiflexion

![Image of Osteotendinous junction](image-url)

**Osteotendinous junction**

**Altered Tendon Characteristics and Mechanical Properties Associated With Insertional Achilles Tendinopathy**

**JOSPT 2014**

**Figure 4**: Age related to shear modulus limb symmetry index (LSI) (n=12)
**Bone - tendon**

- Increased compression of tendon with increased dorsiflexion (both achieved with ankle movement and squatting).
- Decreased with heel lift.
- Consider exercise which minimize excessive stretch and compression.
- Gait training often beneficial in insertional Achilles tendinopathy.

**Exercise - The effect of loading and on tendon**

- Responds by becoming larger, stronger more resistant to injury (Kannus et al 1997).
- Adaptive response slower than muscle.

**Effects of Immobilization**

Effects of immobilization:
- SAID principle: specific adaptation to imposed demand.
- Immobilization:
  - decreases tensile strength and stiffness.
  - causes contractures.
  - effects of immobilization can be minimized if tendon/ligament is elongated when immobilized.

**Eccentric exercise treatment**

- Systematic reviews indicate that eccentric exercise have the most evidence of effectiveness (Kingma et al 2007, Magnusson et al 2009, Woodley et al. 2007).

**Does the tendon know the difference between eccentric and concentric exercise?**
Exercise for tendinopathy

Many different explanations for successful treatment with eccentric exercise

Are these explanations for the effect of the mechanical load produced by any exercise or just eccentric exercise?

Muscle tension

- **Total muscle tension/force**
  - **Passive tension**
    Tension developed in passive elastic component
  - **Active tension**
    Tension developed by the contractile components

Muscle length-tension relationship

Muscle has the ability to generate greater force in eccentric contraction for the same muscle length (use the passive elastic components)

This is not the same as to say just because you are contracting eccentrically the force produced is greater

Exercise – Concentric compared to Eccentric loading

- No differences in peak tendon force (at same loads) (Rees et al 2008, Henriksen et al 2009)
- No difference in tendon length (at same loads) (Rees et al 2008)
- Reduced EMG activity during eccentric contraction compared to concentric but patients with tendinopathy relatively greater % (Henriksen et al 2009, Hebert-Losier et al 2012)

Exercise – Concentric compared to Eccentric loading

- An increase in tendon vibration at high frequencies with eccentric loading which was not found with concentric loading (Rees et al 2008, Henriksen et al 2009)
- Deficits in both concentric and eccentric strength (Silbernagel et al 2006)
- Time to focus on adjusting loading dosage to the specific tendon/injury and individual patient
The goal of the exercise treatment

- Reduce symptoms
- Improve strength, endurance and function
- Promote tendon healing

Rehabilitation of tendons

The tendon load can be increased two ways:

- Increase the external load
- Increase the speed of movement

Type of exercise

Muscle contraction

- Isometric
- Isotonic
  - Concentric
  - Eccentric
- Isokinetic
  - Concentric
  - Eccentric

Rehabilitation phases

0 day 3 months 6 months 9 months 12 months

Acute phase
Recovery phase
Rebuilding phase
Return to activity
Exercise – Comprehensive treatment protocol

Exercise program
• Concentric and eccentric loading
• Divided into 4 phases
• Increasing speed of movement

Exercise – Pain monitoring model

PAIN-MONITORING MODEL

Numerical Pain Rating Scale (NPRS)

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>
| No pain | Acceptable zone | High risk zone | Pain was acceptable

The protective mechanism of pain

Training Diary

Week

<table>
<thead>
<tr>
<th>Home exercises</th>
<th>Physical activity</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Muscular control

Eccentric drop exercise or eccentric stretch exercise

Insertional considerations

Standing plantar flexion

Standing neutral

Standing dorsiflexion
What about the foot?

Intrinsic musculature
- Stabilize the toes
- Dynamic supports of the arches
- Important to activate/exercise intrinsic muscle when foot injuries
- Lumbricals and interossei help flex MTP and extend IP joints

How should exercise delivery be modified?
- Load consideration
  - Consider total load during the week
  - Heavy less often or lighter more often
- Response to exercise
  - Pain monitoring model
  - Important how the response is the next day
  - Training diary
- Consider joints above and below
- Adjust starting and end position of exercise depending on injury and response
- NMES to stimulate muscle activity

Summary – Clinical aspects
- Not all tendons are the same
- Not all overuse tendon injuries are the same
- Consider individual risk factors (age, disease, meds)
- Stiffness in tendinopathy is a sensation not a change in mechanical properties
- Stretching might not be of relevance unless limitation in ROM (need to know if joint, muscle or tendon limiting ROM)
- Exercise has an effect but takes time
- Changes in tendon mechanical properties affect function even if no symptoms

Funding sources
Swedish National Center for Research in Sports
Swedish Research Council
Delaware Biotechnology Institute
University of Delaware Research Foundation
NIH R21 AR067390

The Team!
Thank you!

Delaware Tendon Research Group
STAR Campus, University of Delaware
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