To be or not to be Active with Painful Tendinopathy?
Practical Clinical Applications Based on Current Research Using the Achilles Tendon as a Model

Karin Grävare Silbernagel, PhD, ATC, PT
Why research on tendon?
Why do we have tendons?

A rope?
What does the tendon do?
Tendon - saves energy

Decreased running economy with increased flexibility of the calf (Craib et al 1996)

Chronic stretching program had no negative effect on running economy (Nelson et al 2001)
The tendon improves the explosive power
Controls movement
Stretch-Shortening Cycle - SSC

Results

<table>
<thead>
<tr>
<th>Power [W]</th>
<th>Time [s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>-500</td>
<td></td>
</tr>
<tr>
<td>-1000</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>1500</td>
<td></td>
</tr>
</tbody>
</table>

Eccentric phase

Peak concentric power
Sports utilize the tendon to improve performance.
Metabolism

- Historically thought to be metabolically inert
- Has active metabolism
- Achilles tendon 7.5 times less skeletal muscle
- Healthy tendons have balance between collagen synthesis and degradation
- The low metabolism allows tendon to carry loads and maintain tension for a long time
- Drawback is slow healing
The effect of loading and on tendon

- Adaptive response slower than muscle
- Responds by becoming larger, stronger more resistant to injury
- Increased physical activity larger/stronger tendon callus and shorter time (Andersson T 2009)
- Higher physical activity was associated with a more mature tissue repair (Bring D 2009)
Effect of inactivity on tendon

- Slow effect
- Decreased tensile strength
- Decreased stiffness
- Decreased weight
Tendon injury and immobilization

- During tendon healing the negative effects of immobilization are much more dramatic.

- Two weeks after immobilization structure, biochemical composition and biomechanical strength of the Achilles tendons are deteriorated.

Bring et al 2009, Shizas et al 2010
Recovery from tendon injury

- Increased production of Type III collagen in injured tendon (Maffulli 2000)

- The tendon needs to be exposed to load during healing to improve tendon structure (Kjaer M et al 2007, Aspenberger P 2007)
Effect of Age – similar to disuse

- Loose elastic properties
- Decreased % water
- Increased risk of tendon rupture after 30y/o
- Exercise can counteract the changes that occur with age
Healthy tendon

Overloading

Underloading

“Inadequate loading”

Injured tendon
Tendon injuries

- Tendon injuries have become a major problem in sports (Kannus 1997)

- Estimated that chronic tendon injuries account for approx 50% of all occupational injuries (Almekinders & Temple 1998)

- Often appears benign with slow insidious onset but time off work considerably longer than other injuries

- Tendons heal slowly, patients are incapacitated for months and often full recovery is not achieved
Chronic tendon injuries

Tendinitis

Studies have found no signs of inflammation at the site of injury

(Åström & Rausing 1995, Alfredsson et al 1999)
Stages of tendon healing

- Inflammatory phase
- Repair phase
- Remodelling phase
Classification of tendinopathies

Bonar’s modification of Clancy’s classification of tendinopathies

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

Injured tendon
Mechanotherapy

- The clinical application of mechanotransduction
- Where therapeutic exercise is prescribed to promote repair or remodelling of injured tissue
- Tendon can achieve normalized structure after injury when treated with exercise
- Continued research needed for determining the ideal loading conditions

Khan K & Scott A, BJSM 2009
Exercise is a very potent "medication"
Stages of Rehabilitation

Initial phase

Intermediate phase

Advanced phase

Return to Sports phase
Tendon compared to Muscle

"Function"

Muscle

Tendon

TIME

RECOVERY
Hamstring injury

**Figure 5**  Relative number of subjects in each group plotted against the corresponding time, in weeks, to return to pre-injury level of performance (n = 18 for the sprinters and n = 13 for the dancers).
Tendon injuries

• Achilles tendon one of the most injured tendons especially in athletes involved in running and jumping (Kvist 1994, Josza & Kannus 1997, Alfredsson 2000, Paavola 2000)

• Also found that 1/3 of patients with Achilles tendinopathy not physically active (Rolf & Movin 1997)
Classification of Achilles tendon injury

**Acute injuries**
- Acute total rupture

**Overuse injuries**
- **Partial rupture**
  - Distal bursitis
  - Midportion paratendonitis

**Chronic phase**
- Midportion Achilles tendinopathy

**Acute phase**
- Partial rupture
  - Distal bursitis
  - Midportion paratendonitis
  - Midportion Achilles tendinopathy
Achilles tendinopathy

Clinical syndrome, characterized by a combination of pain, swelling (diffuse or localized) and impaired performance.
Symptoms of tendinopathy

- *Pain* with loading
- *Stiffness*
- Symptoms better with decreased activity but reoccur when activity is resumed
- Many patients have had symptoms on and off for *many years*
Achilles tendinopathy

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

- Consensus that all patients should initially be treated with an exercise program for 3 months (Alfredson & Lorentzon 2000, Kader et al. 2002, Alfredson 2003, Rompe et al. 2007)
Clinical questions

How do we optimize the rehabilitation?

What about the pain?

When can the patient continue running and jumping?

What about return to sport?
Exercise better than wait-and-see

Eccentric Loading, Shock-Wave Treatment, or a Wait-and-See Policy for Tendinopathy of the Main Body of Tendo Achillis

A Randomized Controlled Trial

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How do we optimize the rehabilitation?

Evaluate symptoms and function

Effective treatment protocols
Exercise treatment

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

• Consensus that all patients should initially be treated with an exercise program for 3 months
Exercise – Eccentric exercise program
Curwin and Stanish 1984

Eccentric loading cause of injury

Wanted to achieve greater load in tendon
  – Promote healing,
  – Improve muscle function
  – Reduce pain and symptoms

Increased the load by
  – Eccentric overload – adding external weights
  – Increasing speed of movement
  – Stretching to increase length of tendon

Only minor pain and discomfort allowed

No randomized controlled trials
## Exercise – Eccentric exercise program

**Alfredsson et al 1998**

**Exercise should cause pain**

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Number of exercises</th>
<th>Progression</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heel-drop – knee straight</strong></td>
<td>3 sets of 15 repetitions</td>
<td>Do exercises even if painful and perform until they become pain-free. Add load until exercises again are painful.</td>
</tr>
<tr>
<td>Standing on edge of step. Start with standing on the toes and lower the heel all the way down. Get back up onto the toes by using the other leg</td>
<td>2 times/day</td>
<td>7 days a week for 12 weeks</td>
</tr>
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</tr>
</tbody>
</table>

Has been evaluated in several studies with good outcome
Table 1. Scoring of the included studies for methodological quality according to the Delphi list.

<table>
<thead>
<tr>
<th>Studies</th>
<th>Items</th>
<th>Score</th>
<th>Level of evidence</th>
<th>Degree of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shalabi et al. (2004)</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Alfredson et al. (2003)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Stanish et al. (1986)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Legend: Items: 1a. Was a method of random performed for the treatment allocation? Yes; no.
Exercise for tendinopathy

Explanations for successful treatment with exercise

• Improved muscular strength
• Improved lower leg function
• Repetitive stretching cause increased tensile strength
• Mechanical insult to pain producing nerves
• Blocking circulation to the tendon
• Improving homogeneity of passive structures
• Modulation of neurological stretch response
Does the tendon know the difference between concentric or eccentric muscle contraction?
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
  (Henriksen et al 2009, Hebert-Losier et al 2012)

• 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)
Exercise – Concentric compared to Eccentric loading

- During eccentric contraction greater EMG activity in patients with tendinopathy
  (Reid et al 2012)

- Tendon more compliant in patients with tendinopathy
  (Child et al 2010, Ayra et al 2010)

- A more compliant tendon might need greater EMG activity in eccentric loading

- Tendon pain affect muscle activity
  (Henriksen et al 2011)

- Deficits in both concentric and eccentric strength
  (Silbernagel et al 2006)
Exercise for tendinopathy

The goal of the exercise treatment

- Improve strength, endurance and function
- Promote tendon healing
Eccentric overload training for patients with chronic Achilles tendon pain – a randomised controlled study with reliability testing of the evaluation methods

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¹Sportrehab – Physical Therapy & Sports Medicine Clinic, Sahlgrenska University Hospital, Göteborg, Corresponding author: Karin Grävare

Continued Sports Activity, Using a Pain-Monitoring Model, During Rehabilitation in Patients With Achilles Tendinopathy

A Randomized Controlled Study

Karin Grävare Silbernagel,*++ PT, ATC, PhD, Roland Thomeé,++ PT, PhD, Bengt I. Eriksson,† MD, PhD, and Jon Karlsson,† MD, PhD

From the †Lundberg Laboratory of Orthopaedic Research, Department of Orthopaedics, Göteborg University, Sahlgrenska University Hospital, Göteborg, Sweden, and ‡SportRehab–Physical Therapy & Sports Medicine Clinic, Göteborg, Sweden

## Treatment protocol – Experiment group

### 12 week rehabilitation program

<table>
<thead>
<tr>
<th>Two-legged heel-rise</th>
<th>One-legged heel-rise</th>
<th>Eccentric heel-rise</th>
<th>Quick rebounding Heel-rise</th>
</tr>
</thead>
</table>

![Images of leg exercises](image1.png)
Home exercise program including:

- Stretching
- Two-legged heel-rise
- One-legged heel-rise
- Allowing no pain/increase in symptoms
What about the pain?

- Achilles tendinopathy is painful
- Exercise that loads the Achilles tendon causes pain
- Mechanical loading needed for healing
1. The pain is allowed to reach 5 on the VAS during the exercises.

2. The pain after the whole exercise programme is allowed to reach 5 on the VAS but should have subsided the following morning.

3. Pain and stiffness is not allowed to increase from week to week.

Summary

Both groups showed improvement but

eccentric overload training and pain 
monitoring gave an overall significantly better result
Circulation exercise

Two-legged toe-raise standing on the floor

One-legged toe-raise standing on the floor

Eccentric toe-raise standing on the floor

Two-legged toe-raise standing on a step

One-legged toe-raise standing on a step

Eccentric toe-raise standing on a step

Sitting toe-raise

Quick rebounding toe-raise
Stretching
Home exercises
Rehabilitation exercises
Training specificity
# Follow-up

## Training Diary

<table>
<thead>
<tr>
<th>Week #</th>
<th>Home exercises</th>
<th>Physical activity</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
When can the patient continue running and jumping?
Continued physical activity

- Athletes often recommended an initial period of rest from pain provoking activity
- Patients ask "do I have to stop running"

Continued Sports Activity, Using a Pain-Monitoring Model, During Rehabilitation in Patients With Achilles Tendinopathy

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Treatment protocol

*Active rest group:* Weren't allowed to continue running and jumping during the first 6 weeks of rehabilitation.

*Exercise group:* Were allowed to continue running and jumping with the aid of the pain-monitoring model.
Conclusion

A training regimen of continued, pain-monitored, tendon loading physical activity such as running, might be a valuable option for patients with Achilles tendinopathy.
Continued sports participation (Visnes et al 2005)

- No improvements in symptoms from the patellar tendon with eccentric exercise during the season for elite volleyball players
When is the patient fully recovered?
Schematic illustration of pain and tissue damage in oversuse tendinopathy (Leadbetter 1992)
Function and symptoms

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

Karin Grävare Silbernagel, Roland Thomeé, Bengt I Eriksson, Jon Karlsson

The relationship between symptoms and function

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Fully recovered 90-100 points on VISA-A-S (n=16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passed all strength &amp; jump tests</td>
<td>4 patients 25%</td>
</tr>
<tr>
<td>Passed only 4 of 5 tests</td>
<td>3 patients 19%</td>
</tr>
<tr>
<td>Passed only 3 of 5 tests</td>
<td>9 patients 56%</td>
</tr>
</tbody>
</table>
Conclusion

Pain free ≠ Asymptomatic

Full recovery of muscle-tendon function
Clinical implication

Treatment programs should ensure complete restoration of function along with the relief of pain and symptoms.
Longterm prognosis when treated with exercise alone

- 5 year follow-up

- Evaluate if age, gender, or symptomatic level at the earlier evaluations were related to the effectiveness of the treatment.
What about the long-term prognosis of exercise as treatment?

34 out of 38 patients were evaluated 5 years start of exercise as treatment.

- **Fully recovered**
  - New symptoms: 5
  - No symptoms: 22
  - Continued Symptoms: 7

This group significantly improved as well.

Silbernaegel et al AJSM online Nov 2010
### Results

<table>
<thead>
<tr>
<th>Demographics</th>
<th>ASYMP</th>
<th>CONSYM</th>
<th>NEWSYM</th>
<th>Between group comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total included (Women + men)</td>
<td>22 (11+11)</td>
<td>7 (2+5)</td>
<td>5 (3+2)</td>
<td>0.503</td>
</tr>
<tr>
<td>Treatment group (active exercise/rest)</td>
<td>13/9</td>
<td>4/3</td>
<td>1/4</td>
<td>0.278</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>49</td>
<td>56</td>
<td>51</td>
<td>0.066</td>
</tr>
<tr>
<td>SD</td>
<td>7</td>
<td>8</td>
<td>11.9</td>
<td></td>
</tr>
<tr>
<td>Min-Max</td>
<td>36-59</td>
<td>44-63</td>
<td>35-62</td>
<td></td>
</tr>
<tr>
<td>Time of follow-up</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4.8</td>
<td>4.8</td>
<td>4.7</td>
<td>0.932</td>
</tr>
<tr>
<td>SD</td>
<td>0.15</td>
<td>0.2</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Min-Max</td>
<td>4.5-5.0</td>
<td>4.5-5.1</td>
<td>4.5-4.9</td>
<td></td>
</tr>
</tbody>
</table>

2 patients had received other treatment

- Acupuncture
- Exercise instruction
Level of fear of movement and recovery of heel-rise work

There was a significant (0.005) negative correlation (-0.590) between the level of kinesiophobia and heel-rise work recovery.
Conclusion

The majority of patients who receive exercise as treatment for midportion Achilles tendinopathy have a full recovery and have no symptoms 5 years after initiation of treatment.
Return to sport algorithm

• Symptoms
• Function
• Tissue healing and response to loading
• Progression of exercise loading
## Return to sports algorithm

<table>
<thead>
<tr>
<th>Classification of activities</th>
<th>Pain level during activity VAS</th>
<th>Pain level after activity (next day) VAS</th>
<th>Athletes perceived exertion (in regards to the Achilles tendon) Borg Scale⁸</th>
<th>Recovery days needed between activities</th>
<th>The individual athletes activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>1-2</td>
<td>1-2</td>
<td>6-10</td>
<td>0 days (can be performed daily)</td>
<td>Walking fast for 70 min</td>
</tr>
<tr>
<td>Medium</td>
<td>2-3</td>
<td>3-4</td>
<td>11-14</td>
<td>2 days</td>
<td>Jogging on flat surface for 40 minutes</td>
</tr>
<tr>
<td>High</td>
<td>4-5</td>
<td>5-6</td>
<td>15-18</td>
<td>3 days</td>
<td>Running 90% of desired speed for 30 minutes</td>
</tr>
</tbody>
</table>
# Return to sports algorithm

<table>
<thead>
<tr>
<th>Day</th>
<th>Activity</th>
<th>Symptoms/Perceived Exertion documented by the athlete</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Running 90% for 30 min + Rehabilitation exercises</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Walking 70 min + Rehabilitation exercises</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Walking 70 min + Rehabilitation exercises</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Walking 70 min + Rehabilitation exercises</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Jogging 40 min + Rehabilitation exercises</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Walking 70 min + Rehabilitation exercises</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Walking 70 min + Rehabilitation exercises</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Running 90% for 30 min + Rehabilitation exercises</td>
<td></td>
</tr>
<tr>
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<td>Walking 70 min + Rehabilitation exercises</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Walking 70 min + Rehabilitation exercises</td>
<td></td>
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</table>
To be or not to be active with painful Achilles tendinopathy?

- Exercise (mechanical loading) is needed for tendon healing
- The loading of the tendon is painful, use pain-monitoring model
- Continued tendon loading activity – running – is an option during rehabilitation (use pain-monitoring model)
- Even though symptoms have disappeared the function is not necessarily restored
- Progressive return to activity with planned recovery days
Take home message

*Exercise as treatment is the KEY to successful rehabilitation*
Distal Achilles tendinopathy
Treatment

- More difficult
- Worse prognosis with exercise
- Shoes
Treatment

• Similar but avoid standing in stairs or on a step (to avoid dorsiflexion)

• Know where the pain is coming from

• Follow-up important