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Achilles tendinopathy
Exercise and Return to Running

Karin Grävare Silbernagel PT, ATC, PhD, Associate Professor
Department of Physical Therapy, University of Delaware

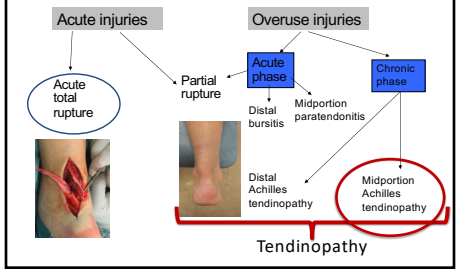


Delaware Tendon Research Group
@UDTendongroup
@kgSilbernagel on twitter

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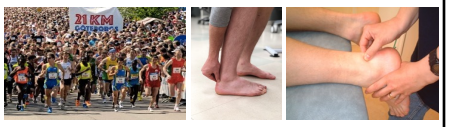
Classification of Achilles tendon injury



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Achilles tendinopathy



- Painful overuse injury
- Cumulative incidence (before 45 years) in male athletes is 18.2%
- Elite track and field athletes 43% current or previous symptoms
- 65% of Achilles tendinopathy injuries in general practice setting not sports related

- Clinical symptom is pain and stiffness limiting physical activity
- Insidious onset with progressive increase in symptoms
- Occurs equally in men and women
- Mostly older athlete (30+) but occurs in all ages
- Often fear of having a rupture

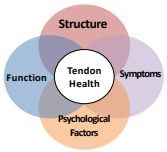
Kujala et al 2005
Janssen et al 2018

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The Domains of Tendon Health and Injury



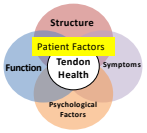
- Majority of clinical trials for tendinopathy focused on improving symptoms
- Symptoms can be relieved with rest but reoccur with loading
- Timeline of recovery different for different domains
- Basic Science research is mainly focusing on tendon tissue (including cellular, molecular, structural and mechanical aspects)

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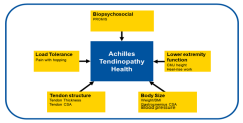
The Domains of Tendon Health and Injury




BMC Musculoskeletal Disorders

RESEARCH Open Access

Data driven model of midportion achilles tendinopathy health created with factor analysis



- Midportion Achilles tendinopathy
- N=99
- Age 50 (18)
- Baseline data from ongoing clinical trial

- 5 uncorrelated factors
- Limitation due to factors included with lack of measure of metabolic syndrome
- Current measure of symptoms is based on 2 factors (VISA-A)

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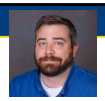
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JOSPT September 2021

[RESEARCH REPORT]

Beyond the Diagnosis: Using Patient Characteristics and Domains of Tendon Health to Identify Latent Subgroups of Achilles Tendinopathy





Objective: To identify subgroups using mixture modeling, compare the clinical presentation among subgroups, and develop a criterion for clinical classification of subgroup membership.

- 145 (73 men) with clinically diagnosed Achilles tendinopathy (both midportion and insertional)
- Age 51 (14) years
- Baseline evaluation November 2014-December 2019

Sex, BMI, symptom duration, injury location, and injury laterality were used for post hoc comparisons across subgroups.

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Summary of results

Three groups

- **Activity dominant (n=67)** least amount of symptoms, most active, low fear, low BMI, and better function
- **Psychosocial dominant (n=56)** highest kinesiophobia and pain catastrophizing, lowest QOL, more female (F 37, M 19)
- **Structure dominant (n=22)** significantly worst tendon structure and function, older. Predominantly overweight-obese men

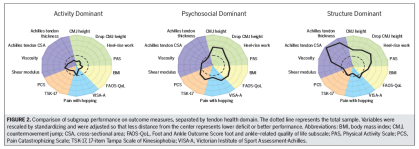


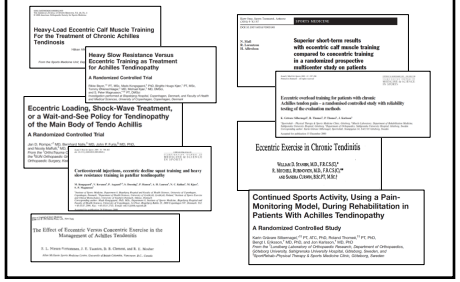
FIGURE 2. Comparison of subgroup performance on outcome measures, separated by tendon health domain. The dotted line represents the total sample. Variables were rescaled by standardizing and were adjusted so that less distance from the center represents lower deficit or better performance. Abbreviations: BMI, body mass index; CMJ, countermovement jump; CSA, cross-sectional area; FAOS-QoL, Foot and Ankle Outcome Score foot and ankle–related quality of life subscale; PAS, Physical Activity Scale; PCS, Pain Catastrophizing Scale; TSK-17, 17-Item Tampa Scale of Kinesiophobia; VISA-A, Victorian Institute of Sport Assessment-Achilles.

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What is the evidence for treatment?



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Components of a rehabilitation program

Exercise (Mechanical loading) to improve Tendon structure

- Tendon cells respond to mechanical stimuli in form of strain (Kalson et al 2011, Moerch et al 2013, Wang 2006)
- Long-term effect – tissue hypertrophy and altered material properties (Kongsgaard et al 2009,2010)
- Loading (Arampatzis et al 2007)
  - Achilles tendon (equal volume)
  - 90% of MVC = 5% strain compared to 55% of MVC = 3% strain
  - 90% resulted in greater stiffness and cross-sectional area
- In vivo human Achilles tendons
  - increased stiffness and size with **low number of loads of long duration** compared to **higher number and faster loads** (volume constant) (Arampatzis et al 2007, 2010, Kubo et al 2001)

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Tendon loading

Parameters affecting loading (stress and strain) on the tendon

- Total amount of load
- Speed of load (viscoelastic tissue)
- Length of time of load (creep)

Strain – Rate sensitivity



When load is applied rapidly the tendon tissue is stiffer

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Does the tendon know the difference between isometric, eccentric, concentric or slow isotonics exercise?



[CLINICAL COMMENTARY]

CHRISTIAN COUPPÉ, PT, PhD[1,4] • RENÉ D. SVENSSON, PhD[2,3] • KARIN GRÅVARE SILBERNAGEL, PT, ATC, PhD[5]
HENNING LANGBERG, PT, PhD, DSc[6] • S. PETER MAGNUSSON, PT, DSc[1,4]

Eccentric or Concentric Exercises for the Treatment of Tendinopathies?

JOSPT
Tendinopathy issue
Volume 45, Issue 11 November 2015, Pages 816-965

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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)
- In animal models no difference in response with contraction type as long as **sufficient** force is applied (Garma et al 2007, Heinemeier et al 2007)
- In humans – concentric knee extension with contralateral eccentric knee extension (reps, sets, time same but 120% more load in eccentric) produced similar magnitude of tendon hypertrophy (Farup et al 2014)
- Summary there is a lack of differential effect of eccentric versus concentric exercise **on the tendon, if load is similar**

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Editorial

Isometric exercise for acute pain relief: is it relevant in tendinopathy management?

Karin Gravare Silbernagel[a,1,2] Bill T Vicenzino,[a,3] Michael Skovdal Rathleff,[4] Kristian Thorborg[5]

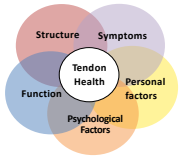
a painful tendon in sporting activities after a substantial and sudden symptom reduction is still unclear.

QUESTION 2: HAS ISOMETRICS PROVEN SUPERIOR IN TENDINOPATHY MANAGEMENT?

As in-season management, there have been suggestions of immediate pain relief

BJSM 2019

- Promoted for injured tendons and focused on effect of pain (Rio et al 2015)
  - Acute effect on pain in patellar tendinopathy (n=6)
- This effect not found in Achilles tendon, Plantar fascia or Lateral elbow (O'Neill et al 2018, Riel et al 2018, Coombes et al 2016)



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Various loading protocols

RESEARCH REPORT JOSPT 2014

Effectiveness of the Alfredson Protocol Compared With a Lower Repetition-Volume Protocol for Midportion Achilles Tendinopathy: A Randomized Controlled Trial

Clinical Outcomes, Structure, and Function Improve With Both Heavy and Moderate Loads in the Treatment of Patellar Tendinopathy

A Randomized Clinical Trial

AJSM March 2021

Conclusion: There was no superior effect of exercising with a high load magnitude (HSR) compared with a moderate load magnitude (MSR) for the clinical outcome, tendon structure, or tendon function in the treatment of patellar tendinopathy in the short term. Both HSR and MSR showed equally good, continued improvements in outcomes in the long term but did not reach normal values for healthy tendons.

Registration: NCT02089607 (ClinicalTrials.gov identifier).

OJSM 2021

Original Research

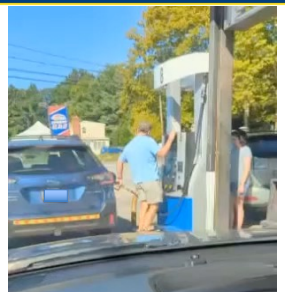
No Difference in Clinical Effects When Comparing Alfredson Eccentric and Silbernagel Combined Concentric-Eccentric Loading in Achilles Tendinopathy

A Randomized Controlled Trial

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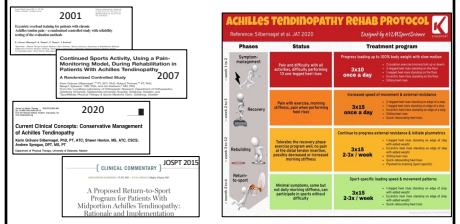
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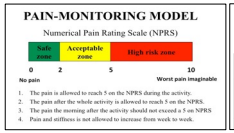


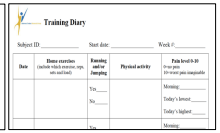
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Components of a rehabilitation program
Symptoms/Pain & Psychological factors



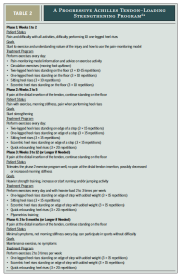


- Use pain monitoring model for Patient pain education and dosing of exercise
- Treatment aimed at achieving higher levels of activity at same pain level

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Not all patients start at phase 1 – adjust as appropriate

4 phases

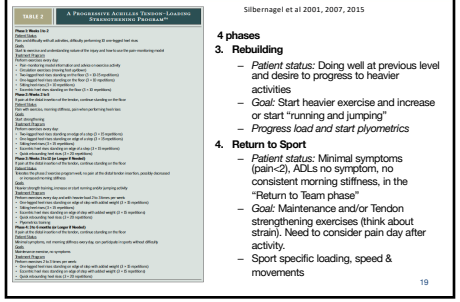
1. **Symptom management**
   - *Patient status:* pain and difficulty with all activities, difficulty performing10 single leg heel rises
   - *Goal:* Start exercise, understand the nature of the injury and how to use the pain-monitoring model
   - *Progress to 100% BW and slow motion*
2. **Recovery**
   - *Patient status:* pain with exercise but pain less than 2-3 with ADLs, morning stiffnes and pain with exercise
   - *Goal:* Start strengthening tendon and muscle
   - *Progress load and speed*

Silbernagel et al 2001, 2007, 2015, 2020

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TABLE 2 — A Progressive Achilles Tendon–Loading Strengthening Program[44]

Silbernagel et al 2001, 2007, 2015

4 phases

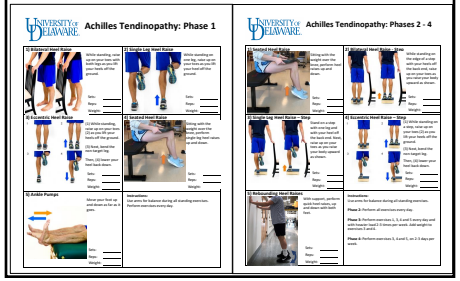
3. **Rebuilding**
   - *Patient status:* Doing well at previous level and desire to progress to heavier activities
   - *Goal:* Start heavier exercise and increase or start "running and jumping"
   - *Progress load and start plyometrics*
4. **Return to Sport**
   - *Patient status:* Minimal symptoms (pain<2), ADLs no symptom, no consistent morning stiffness, in the "Return to Team phase"
   - *Goal:* Maintenance and/or Tendon strengthening exercises (think about strain). Need to consider pain day after activity.
   - Sport specific loading, speed & movements

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1. Symptom management, 2. Recovery phase, 3. Rebuilding phase, 4. Return to Sport phase


Achilles Tendinopathy: Phase 1

Achilles Tendinopathy: Phases 2 - 4

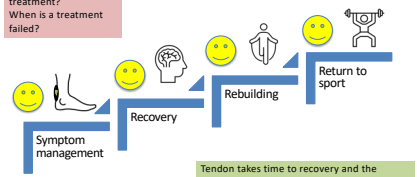
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Are patients happy and exiting at different stages?

What is failed treatment?
When is a treatment failed?



Tendon takes time to recovery and the biology can not be rushed but optimized

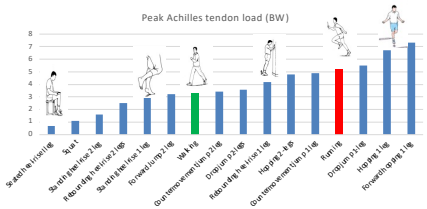
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Exercise Progression to Incrementally Load the Achilles Tendon

Med Sci Sports Exerc 2021 Jan;53(1):124-130

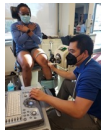


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Does the exercise you prescribe consistently provide the desired strain?







Angel Basas, Carlos Basas

- Pain causes muscle inhibition
- The body has a great capacity to compensate

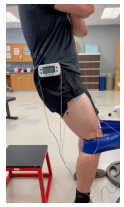
Addition of NMES = doubled the strains in the patellar tendon

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How to individualize treatment?

PAIN-MONITORING MODEL

Numerical Pain Rating Scale (NPRS)

Safe zone	Acceptable zone	High risk zone
0 No pain	2	5	10 Worst pain imaginable

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.

Training Diary

Subject ID:_____ Start date:_____ Week #:_____

Date	Home exercises (include what/s exercise, reps, sets and load)	Running and/or Jumping	Physical activity	Pain level 0-10 0=no pain 10=worst pain imaginable
		Yes_____ No_____		Morning:_____ Today's lowest:_____ Today's highest:_____
		Yes		Morning:_____

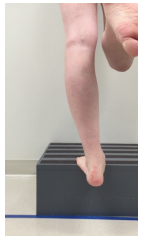
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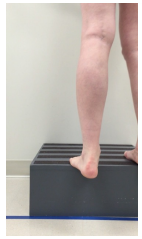
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Eccentric drop exercise or eccentric stretch exercise

Muscular control





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Tendons have decreased tolerance to compression



Adjust position to get "strain" while minimizing compression

Standing plantar flexion

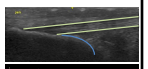
Standing neutral

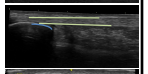
Standing dorsiflexion

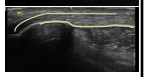












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Optimal loading in Tendon injury

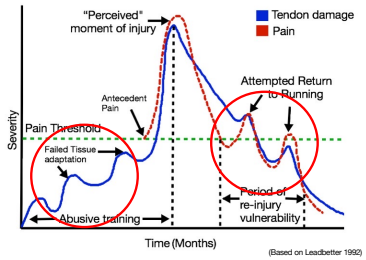
The goal of the exercise treatment

- **Promote tendon healing**
- Reduce symptoms
- Improve muscle strength & endurance (for the muscle the contraction type matters)
- Recovery of neuromuscular function
- Recover sport specific functions - plyometrics

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Tendon overuse injury



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Achilles tendinopathy
Reinjury/Recurrence Rates

- Return to sports after 12 weeks of treatment – 10-86% (Magnussen et al. 2009)
- Return to sport at 1 year – 55-99%
- Reinjury rates of Achilles tendinopathy in football players 27-44% (Gajhede-Knudsen et al BJSM 2013, Hägglund et al. AJSM 2007)
- Recurrence common and reinjury risk high in elite football players with short recovery periods (Gajhede-Knudsen et al. BJSM 2013)

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Athletes balance on the edge of overuse to perform at an ultimate level

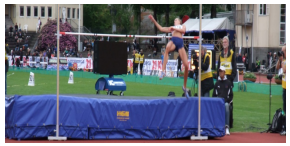


Treat "minor" symptoms of tendinopathy early with "load control" instead of ignoring or just treating the symptoms.

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Change in performance could be early indication of tendon overuse





Elite Athletes
- Are they perpetual tendon over-loaders?
- Low levels of pain related fear?

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[CLINICAL COMMENTARY]

KARIN GRÄVARE SILBERNAGEL, PT, ATC, PhD† • KAY M. CROSSLEY, BAppSc (Physio), PhD†

A Proposed Return-to-Sport Program for Patients With Midportion Achilles Tendinopathy: Rationale and Implementation

JOSPT

November 2015
Tendinopathy Special Issue

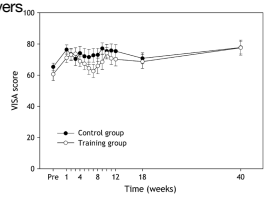
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Continued sports participation

- No improvements in symptoms from the patellar tendon with eccentric exercise during the season for elite volleyball players

(Visnes et al 2005)

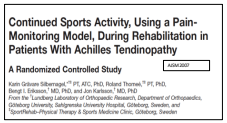


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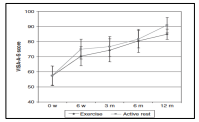
Sports Activity during rehabilitation

The most common question from the patients was: Do I have to stop "running"?


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

A Randomized Controlled Study

AJSM 2007



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Return-to-Sport Program – Achilles Tendinopathy

Factors to consider when planning return to sports

- Tendon healing
- Tendon recovery
- Pain and Symptoms
- Impairments
- Load on the Achilles tendon
- Perceived rate of exertion

Silbernagel & Crossley JOSPT 2015

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Sports Activity during rehabilitation

PAIN-MONITORING MODEL

Numerical Pain Rating Scale (NPRS)

Safe zone	Acceptable zone	High risk zone

0 (No pain) 2 5 10 (Worst pain imaginable)

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.

Thomeé et al 1997, Silbernagel et al 2001, Silbernagel et al 2007

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Recovery days for tendon structure

Magnusson SP, Langberg H, Kjaer M. Nat. Rev. Rheumatol. 6. 262-268 (2010)

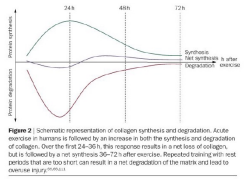


Figure 2 | Schematic representation of collagen synthesis and degradation. Acute exercise in humans is followed by an increase in both the synthesis and degradation of collagen. Over the first 24–36 h, this response results in a net loss of collagen, but is followed by a net synthesis 36–72 h after exercise. Repeated training with rest periods that are too short can result in a net degradation of the matrix and lead to overuse injury.[39,40,52,53]

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Tendon recovery

- Achilles tendon loaded 6-12 times body weight with running
- If recovery between trainings session are inadequate it might lead to further injury instead of recovery
- Tendinopathy a result of collagen degradation occurring to a greater degree than collagen synthesis
- In humans net increase in collagen synthesis first after 37-78 hours after a bout of exercise

Clinical implication

Plan for 3 recovery days between heavy Achilles tendon-loading activities

Magnusson SP, Langberg H, Kjaer M. Nat. Rev. Rheumatol. 6. 262-268 (2010)

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Progression of the load

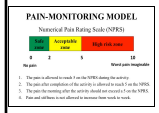
- Strike pattern (Almonroeder et al. 2013)
  - Rearfoot strike pattern loads the Achilles tendon less than forefoot or midfoot
  - Using forefoot or midfoot strike pattern added an additional load of 48 x body weight for each 1.6 km
- High breaking force during running a risk factor (Lorimer et al. 2014)
  - Using shorter step length could be beneficial
- Stiffer running surfaces was related to decreased injury risk

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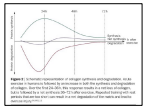
Load progression of Return to Sports for the injured athlete

Pain-monitoring Model



Thomee et al,
Silbernagel et al 2001, 2007, 2015

Recovery days for tendon



Magnusson SP, Langberg H, Kjaer M. Nat. Rev. Rheumatol. 6. 262-268 (2010)

How to individualize the load?



The athlete's rating of perceived exertion of the Achilles tendon

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How to individualize the load?

The athlete's rating of perceived exertion of the Achilles tendon

TABLE 4 — The Borg Category-Ratio Rating of Perceived Exertion Scale[11]

Score	Description
0	Nothing at all
0.5	Very, very weak
1	Very weak
2	Weak
3	Moderate
4	Somewhat strong
5	Strong
6	..
7	Very strong
8	..
9	..
10	Very, very strong

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The Classification Schema for return to sports

Classification of activities	Pain level during activity NPRS (0-10)	Pain level after activity (next day) NPRS (0-10)	The Athlete's RPE (with regards to the Achilles tendon) (0-10)	Recovery days needed between activities	Examples of activities for a runner
Light	1-2	1-2	0-1	0 days (can be performed daily)	Walking for 70 min
Medium	2-3	3-4	2-4	2 days	Jogging on flat surface for 30 min
High	4-5	5-6	5-10	3 days	Running 85% of pre-injury speed for 20 min

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Day	Activity	Symptoms/Perceived Exertion documented by the athlete
1	Jogging 30 min + Rehabilitation exercises	
2	Walking 70 min + Rehabilitation exercises	
3	Walking 70 min + Rehabilitation exercises	
4	Running 85% for 20 min + Rehabilitation exercises	
5	Walking 70 min + Rehabilitation exercises	
6	Walking 70 min + Rehabilitation exercises	
7	Walking 70 min + Rehabilitation exercises	
8	Running 85% for 20 min + Rehabilitation exercises	
9	Walking 70 min + Rehabilitation exercises	
10	Walking 70 min + Rehabilitation exercises	
11	Walking 70 min + Rehabilitation exercises	
12	Jogging 30 min + Rehabilitation exercises	
13	Walking 70 min + Rehabilitation exercises	
14	Walking 70 min + Rehabilitation exercises	
15	Running 85% for 20 min + Rehabilitation exercises	
16	Walking 70 min + Rehabilitation exercises	
17	Walking 70 min + Rehabilitation exercises	
18	Walking 70 min + Rehabilitation exercises	
19	Running 85% for 20 min + Rehabilitation exercises	
20	Walking 70 min + Rehabilitation exercises	
21	Walking 70 min + Rehabilitation exercises	

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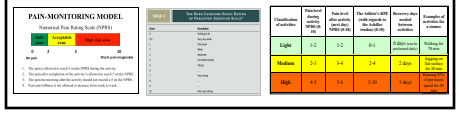
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Follow-up is crucial

Training Diary

Subject ID: _____ Start date: _____ Week #:_____

Date	Home exercises (include which exercise, reps, sets and load)	Running and/or Jumping	Physical activity	Pain level 0-10 0=no pain 10=worst pain imaginable
		Yes_____ No_____		Morning:_____ Today's lowest:_____ Today's highest:_____
		Yes		Morning:



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Principles of Tendon Return-to-Sport program

- Progressively increase the demand on the tendon by controlling intensity, duration and frequency of Achilles tendon loading
- Continue with the rehabilitation exercises (tendon loading) during the return to sport phase (and continue for at least a year)
- Education
  - Easiest to educate about this phase when the athlete has a lot of symptoms
- Training diaries
- Initiate program early when athlete can perform activities of daily living with pain no higher than 2/10

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62 year old runner
Email 2 years after initiation of program
At start of program unable to run

"Been a very good summer. The best pain free, injury free summer in ten years. I did nine races this summer, eight sprint triathlons and one olympic. Generally faster races than last year. Yesterday ran over ten miles with zero issues. One of the sprints I missed a transition area and ran barefoot for 5k in just over eight minute miles. Most of my races I am in the 8.45s range but did one in 8.12s and the 8.05s I mentioned. This is significantly faster."

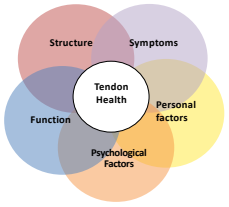
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Success with tendon injuries

Avoid them!





Treat early with load control

- Keep evaluating all domains
- Address all domains of tendon health

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Injury prevention!





Might not be that complicated

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Funding sources



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Delaware Tendon Research Group

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