Achilles Tendinopathy

Beyond Eccentrics

- This session will review the evidence and current knowledge concerning treatment of individuals with Achilles tendinopathy. Achilles tendinopathy has been reported to have an incidence of 2.35 per 1,000 adults. Gradual loading of the Achilles tendon has been reported to reduce symptoms and improve lower leg function in 80% of individuals. This session will address how to implement the evidence-based rehabilitation guidelines as well as provide for additional rehabilitative considerations, particularly in the case of the patient that falls in the 20% of non-responders. These rehabilitation considerations include length of recovery in tendon healing, portion of the tendon affected (insertion versus midportion versus paratenon), and demographics/comorbidities of the tendinopathic individual. Several other treatment modalities (such as Laser, Shock-wave and injections) have been proposed to be beneficial in combination with exercise and this session will review the evidence and utility of some of these. In addition, kinesiophobia has been high-lighted as a possible barrier for recovery of Achilles tendinopathies. Hence, it might be beneficial to consider psycho-social factors in the case of an individual who is not responding to an eccentric only program.

Objectives

- Upon completion of this session you would be able to:
- Differentiate between common Achilles tendon pathologies (insertional tendinopathy, midportion tendinosis, paratenonitis)
- Identify rehabilitative concerns and prognosis specific to area of tendinopathy (insertional versus midportion tendinopathy)
- Assess barriers for response to typical treatment strategies
- Have a better understanding on how to individualize the rehabilitative plan of care for individuals with different types of Achilles tendinopathy

Differentiation of tendon pathology

Not all tendons and not all people are the same

Jennifer A. Zellers, PT, DPT
CSM 2017

Overview

- Describe the regional differences in tendinopathy
  - Between tendons
  - Between Achilles tendon regions
- Consider other possibilities in differential diagnosis
- Identify individual differences in tendinopathy

Differences between tendons

Not All Tendons Are Created Equal: Implications for Differing Treatment Approaches

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J Orthop Sports Phys Ther 2015;45(11):829-832. doi:10.2519/jospt.2015.0114

JOSPT, 2015

Differences between tendons

Differences between tendons

Mechanisms of Tendon Injury and Repair

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J Orthop Res, 2015

Proximal to distal regional differences in the Achilles tendon

Insertion **Midportion**

Superficial to deep differences in the Achilles tendon


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Non-uniform displacements within the Achilles tendon observed during passive and eccentric loading

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J Biomech, 2014

Peritendinous structures can hurt, too

Paratenonitis

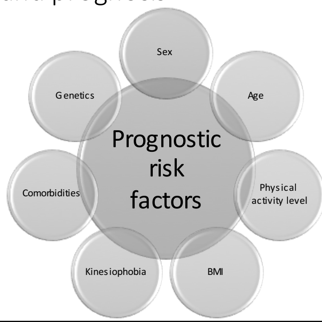
Retrocalcaneal bursitis

Other Diagnoses to Consider

- Anomalous soleus muscle
- Lower leg compartment syndrome
- Os trigonum syndrome
- Plantar fasciitis
- Posterior tibial stress syndrome
- Referred pain from lumbar spine
- Stress fracture of the ankle or lower leg
- Tarsal tunnel syndrome
- Tenosynovitis or dislocation of peroneal tendons
- Tenosynovitis of the plantar flexors of the foot
- Total Achilles tendon rupture
- Tumors of the Achilles tendon

Silbernagel, 2006

Individual factors and prognosis



Magnan et al., 2014
Wise et al., 2012
Holmes et al., 2006
Scott et al., 2015

Sex

- Differences between sexes in response to eccentric training (males obtain greater benefit) (Knobloch et al., 2010)
- No differences in 5-year outcomes between males and females (Silbernagel et al., 2011)
- Females do not respond as well as males to surgical intervention for recalcitrant Achilles tendinopathy (Maffulli et al., 2008)
- Differences between sexes in tendon microcirculation in individuals with Achilles tendinopathy (Knobloch et al., 2008)
- Females demonstrate poorer functional outcome compared to males after Achilles tendon rupture (Silbernagel et al., 2015)
- Females reported more symptoms after surgery for Achilles tendon rupture (Silbernagel et al., 2015)

Age

- Trend toward increasing age being associated with continued symptoms at 5-year follow-up (Silbernagel et al., 2011)
- Most cases of Achilles tendinopathy observed in the 41-60 year age group (de Jonge et al., 2011)
- A study investigating Masters athletes (age range 35-94 years) did not find an association between age and development of Achilles tendinopathy (Longo et al., 2009)

BMI

- A systematic review by Gaida et al. (2009), reported BMI as a risk factor for tendinopathy (not specific to a given tendon) in about half of studies including BMI as a variable
- In Achilles tendon rupture, higher BMI associated with poorer outcome on Achilles tendon Total Rupture Score (Olsson, et al., 2014)
- Higher BMI (25.0+) associated with increased risk of developing Achilles tendinopathy compared to other foot and ankle disorders (Klein et al., 2013)
- Individuals with higher BMI are not more likely to undergo non-conservative management compared to individuals with BMI less than 25.0 (Klein et al., 2013)
- Men with larger waist circumference and older age demonstrated more asymptomatic tendon pathology; Women with peripheral fat distribution demonstrated more asymptomatic tendon pathology (Gaida et al., 2010)

Kinesiophobia

- Higher levels of kinesiophobia related to lower levels of work performed on the heel-rise test (Silbernagel et al., 2011)

Physical Activity Level

- Prolonged recovery and increased symptoms in non-athletic individuals after surgery for Achilles tendinopathy (Maffulli et al., 2006)
- Physical activity related to growth factors and cytokines involved in Achilles tendinosis in gender-dependent fashion (Bagge et al., 2011)

Comorbidities

- Corticosteroid use (Blanco et al., 2005)
- Fluoroquinolone use (Chhajed et al., 2002; Van der Linden et al., 1999)

Genetics

- Family history of Achilles tendinopathy associated with increased risk of developing symptoms (Kraemer et al., 2012)
- Collagen disorders (Hay et al., 2013)
- Differences in signalling cascades that increase risk of Achilles tendinopathy (Nell et al., 2012)

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Combined Sections Meeting, 2017

Insertional Achilles Tendinopathy: biomechanical considerations and implications for treatment

Jeff Houck, PT, PhD
George Fox University

In Collaboration Ruth Chimenti, DPT, PhD
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Clinical Presentation of Insertional Achilles Tendinopathy

- Illustrative Sample
- Pathology
- ROM
- Strength
- Movement Deficits

(Hu & Flemister, 2008)

Who gets Insertional Achilles Tendinopathy Illustrative Sample

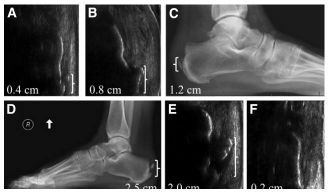
- Not strongly associated with activity (NOT exclusive to runners) (See Age and BMI data)
- No gender preference
- Disability is significant
  - VISA-A < 50 %!

	IAT (n=20)	Controls (n=20)	*P*-value
Age (yrs)	58.6± 7.8	58.2± 8.5	0.863
Sex	55% female	55% female	1.000
Height (m)	1.7± 0.1	1.7± 0.1	0.999
Weight (kg)	87.5± 17.5	87.5± 16.0	0.187
BMI (kg/m^2)	30.4± 5.4	27.9± 5.3	0.158
VISA-A (%)	47.6± 26.8	100.0± 0.0	**0.001**

Utility of Ultrasound for Imaging Osteophytes in Patients With Insertional Achilles Tendinopathy

Chimenti et al, Archives of Physical Medicine and Rehabilitation 2016;97:1206-9

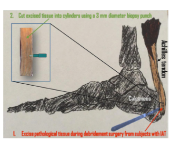
- Detected osteophytes with US
- Larger osteophytes on involved side AND compared to controls
- Association of osteophyte length and symptom severity?

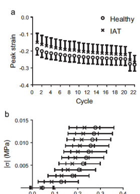


Mechanical Testing of IAT Tissue

Bah et al, J of Mechanical Behavior of Biomedical Materials. 53 (2016) 320-328

- Compression loading may contribute to tendon disease
  - How does IAT damaged tendon respond to compression compared to non-damaged tendon?





Compression against bone

↓

Metaplasia of Tendon

Differentiate into Cartilage Like Tendon

- Rounded cells
- Increased type II collagen
- Increased GAG content

↓

Ca^{++} Deposits

Ultrasound strain mapping of Achilles tendon compressive strain patterns during dorsiflexion

Ruth L. Chimenti[a,*], A. Samuel Flemister[b], John Ketz[b], Mary Bucklin[c], Mark R. Buckley[c], Michael S. Richards[d]

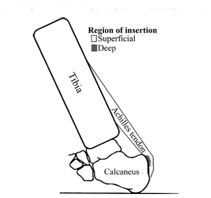
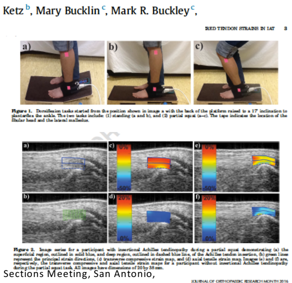


Fig. 1. During ankle dorsiflexion the posterior-superior prominence of the calcaneus impinges on the deep side of the Achilles tendon insertion.



Chimenti et al, JOR, 2016

DOI 10.1002/jor.23338

Ultrasound strain mapping of Achilles tendon compressive strain patterns during dorsiflexion

Ruth L. Chimenti [a,*], A. Samuel Flemister [b], John Ketz [b], Mary Bucklin [c], Mark R. Buckley [c], Michael S. Richards [d]

Is there increased compression of the anterior/deep tendon (opposite bone) In-Vivo, during movement in IAT Tendons?

Study

Sample: 10 IAT, 10 controls

Methods: US elastography

Results: Transverse compressive and axial tensile strain

Tendon adapts to handle compressive load against the calcaneous

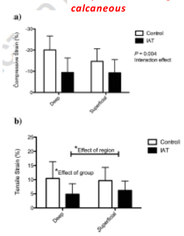


Figure 3. Ultrasound elastography was utilized to measure the (a) transverse compressive strain and (b) axial tensile strain of the Achilles tendon while participants performed a partial squat. For transverse compressive strain, there was an interaction effect between group and tendon region. For axial tensile strain, there were main effects of group and tendon region. Data are [illegible] ±SD, * $p < 0.05$.

Chimenti et al, JOR, 2016
DOI 10.1002/jor.23338

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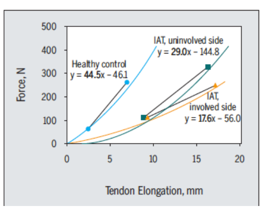
Altered Tendon Characteristics and Mechanical Properties Associated With Insertional Achilles Tendinopathy

How does In-Vivo WHOLE IAT tendon respond to tension compared to health controls?

Study

- **Sample:** 20 participants with IAT, 20 age and gender matched controls
- **Methods:** WHOLE tendon passive strain using US and Dynamometer
- **Result:** Tendon Strain, Stiffness, echogenicity were consistent with increased tendon compliance.

WHOLE Tendon measurements in IAT indicate greater compliance



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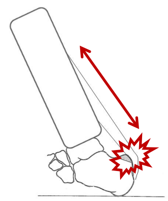
Pathology: Review

Impingement vs Compression vs Tension?

- **Impingement:** (Chimenti et al, Archives of Physical Medicine and Rehabilitation 2016;97:1206-9)
  - Deep side or underside of tendon opposite calcaneous (Chimenti et al, JOR, 2016 DOI 10.1002/jor.23338)
- **Compression - Metaplasia into cartilage:** (Bah et al, J of Mechanical Behavior of Biomedical Materials. 53 (2016) 320-328)
  - Rounded cells
  - Increased type II collagen
  - Increased GAG content
  - High prevalence of Ca^{++} deposits (Kang et al, 2012)
- **Tension - WHOLE Tendon Behavior:** Increased Tendon Compliance to Tension (Chimenti et al, JOSPT, 44(9), 2014)

Range of Movement: Pathology and ROM?

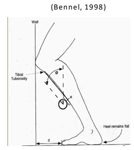
- Clinical Tests of ROM
  - ANKLE ROM
    - Lunge Testing
      - Foot ROM
      - Talocural ROM
    - Supine DF ROM
- Functional ROM
  - Stair descent
  - Stair ascent



(DiGiovanni et al., 2002; Jonsson et al, 2008)

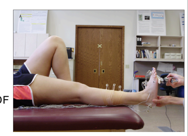
Ankle ROM (knee extended and flexed)

(Bennel, 1998)



- **Lunge Test**
  - Knee extended (gastroc + soleus)
  - Knee flexed (soleus and ankle joint)
    - Reliability

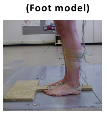
    (Powden et al Manual Therapy 20 (2015) 524-532)
      - Inter clinician MDC = 4.6 degrees/ 1.6 cm
      - Intra clinician MDC = 4.7 degrees/1.9 cm
      - Average 30-50 degrees ankle DF
- **Supine DF ROM**
  - Knee straight
    - Average 18.1 degrees ankle DF (Moseley et al, Clin Biomechanics, 2001)
    - < 5 degrees associated with variety of foot problems (DiGiovanni et al, JBJS, 2002)
- **ROM Discrepancy**
    - Lunge test > Supine DF tests
    - Validity-Athletes Lunge more correlated to activity than Supine DF
      - (Dill et al, Journal of Athletic Training 2014;49(6):723–732)



Studies of Ankle Lunge and Supine DF Tests

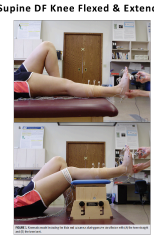
- **Key Points of Methods**
- **3D Motion Analysis**
  - Talocurual joint (Calc-Tibia)
  - Mid foot (Calc-metatarsals)
- **Positions**
  - Lunge DF (knee extended/flexed)
  - Supine DF (knee extended/flexed)
    - Standardized moment(torque)
- **Clinical Outcomes**
  - VISA-A
  - VAS Pain

3D Motion Analysis (Foot model)



Lunge Knee Extended & Flexed

Supine DF Knee Flexed & Extended



Chimenti et al, JOSPT, 2016
Chimenti et al, Clinical Biomechanics, 2016

Supine DF

- Knee extended ~ 15 degrees
- Knee Flexed ~ 22 degrees
- No Differences due to IAT

TABLE 3 — Differences in Ankle DF Between Participants With IAT and a Control Group Without Tendinopathy Pain*

	IAT	Control	P Value for ANOVA Effects: Group	Knee Position	Interaction
Passive DF			.956	<.001†	.026†
Knee straight	15.5 ± 5.5 (12.5, 18.6)	14.4 ± 2.1 (13.0, 15.6)			
Knee bent	21.1 ± 5.5 (17.7, 24.4)	22.7 ± 4.5 (19.7, 25.7)			
Active DF			.105	<.001†	.303
Knee straight	19.2 ± 7.1 (15.7, 22.8)	22.0 ± 4.3 (20.0, 24.0)			
Knee bent	24.1 ± 6.2 (20.9, 27.3)	27.9 ± 6.0 (25.1, 30.6)			

Abbreviations: ANOVA, analysis of variance; DF, dorsiflexion; IAT, insertional Achilles tendinopathy.
**Values are mean ± SD (95% confidence interval) degrees unless otherwise indicated.*
†Statistically significant difference (P≤.05).

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Lunge Test

- Knee extended ~ 21 degrees
- Knee Flexed ~ 22 degrees
- Significant Differences due to IAT with **knee flexed (lunge test)**

*powered for 5 degrees

*Pain

*contribution of midfoot (r=0.81 midfoot vs whole foot)

Table 2
Single-segment and multi-segment kinematic model motion during the lunge test with the knee straight and with the knee bent.

	Single-segment foot model: Ankle DF (°)	Multi-segment foot model: Rearfoot DF (°)	Forefoot DF (°)	Rearfoot eversion (°)
Knee straight				
Controls	24.4 (22.1 to 26.8)	21.3 (18.8 to 23.7)	5.6 (4.1 to 7.1)	1.0 (−1.8 to 3.8)
IAT	21.0 (16.6 to 25.5)	16.5 (13.1 to 19.9)	6.5 (3.2 to 9.9)	1.2 (−1.2 to 3.6)
Knee bent				
Controls	32.2 (28.7 to 35.8)	27.5 (23.9 to 31.1)	7.6 (5.6 to 9.5)	1.1 (−1.6 to 3.8)
IAT	22.8 (17.6 to 27.9)	17.6 (13.4 to 21.7)	6.8 (4.4 to 9.2)	0.2 (−2.4 to 2.8)

Values are mean (95% confidence interval).

R.L. Chimenti et al. / Clinical Biomechanics 36 (2016) 40–45

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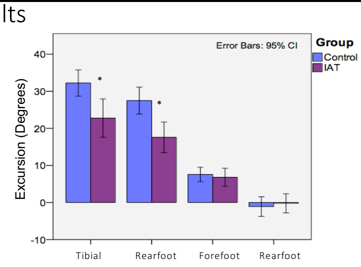
Results



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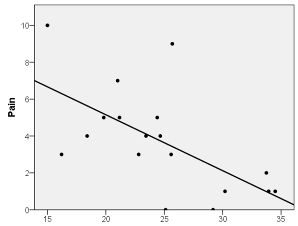
Correlations with Pain and Function: *IAT only*

	Pain	VISA-A (%)
Static Lunge Test Df (⁰)	r= -0.62 ***P*= 0.006**	r= 0.47 ***P*= 0.035**

Ankle DF as measured by lunge test is correlated to symptoms (VAS Pain)



Discussion

Gastrocnemius contracture clinical theory

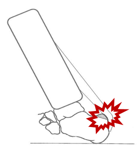
- Not supported
  - No differences in degrees of Static or Dynamic Df

Impingement clinical theory

- Supported
  - IAT group > % End-Range Df
  - Df correlated to pain and function

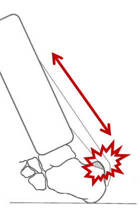
Foot Movement

- Foot Motion may mater



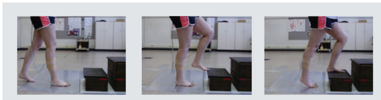
Range of Movement: Pathology and ROM?

- Clinical Tests of ROM
  - ANKLE ROM
    - Lunge Testing
      - Foot ROM
      - Talocural ROM
    - Supine DF ROM
- Functional ROM
  - Stair descent
  - Stair ascent



(Digiovanni et al., 2002; Jonsson et al, 2008)

Functional ROM – Stair Ascent



❑ **3D motion analysis variables**:

- 2) Stair Ascent Df (⁰)
- 3) End-Range Df (%) $= \frac{\text{Stair ascent Df}}{\text{Lunge test Df}} * 100$

❑ **Association of Df ROM (Dynamic) with clinical variables:**

- Pain
- Self-reported Function

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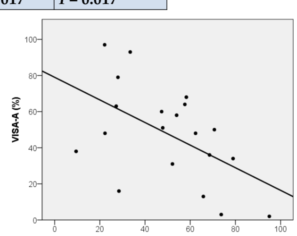
Results: IAT vs. Controls

	IAT	Controls	*P*-value
Static Lunge Test Df (⁰)	24.8± 5.5	27.5± 5.1	0.116
Dynamic Stair Ascent Df (⁰)	[redacted]		
End-Range Df (%)	[redacted]		

Correlations with Pain and Function: *IAT only*

	Pain	VISA-A (%)
Dynamic End-Range (%)	r= 0.53 ***P*= 0.017**	r= -0.53 ***P*= 0.017**



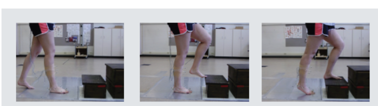
Conclusions

- ❑Limited Df was not common for participants with IAT
- ❑End-range Df was associated with greater pain and lower function
- ❑Calf stretches
  - May aggravate symptoms if prescribed unnecessarily
  - Consider non-weight-bearing
- ❑Strategies to reduce *dynamic* Df
  - Heel lifts, shoewear (slight heel, avoid being barefoot)

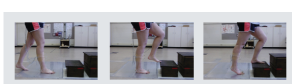
Clinical Presentation of Insertional Achilles Tendinopathy

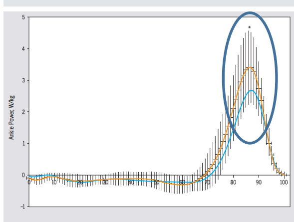
- Illustrative Sample
- Pathology
- ROM
- Strength
- Movement Deficits

Stair Ascent Data



Ankle Power





- Decreased Ankle Power in patients with IAT
  - 25 % decrease
- Correlated to symptom severity
  - VISA-A r = - 0.59; p <0.01
  - VAS Pain r = -0.55; p< 0.01

Conclusions

- ❑Strategies to reduce *dynamic* Df
  - ❑Improve push off power
  - ❑Eccentric control of ankle DF during functional tasks
- ❑Goal: Decrease excessive ankle DF

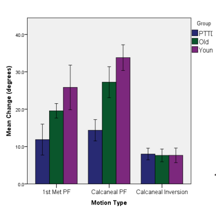
Clinical Presentation of Insertional Achilles Tendinopathy

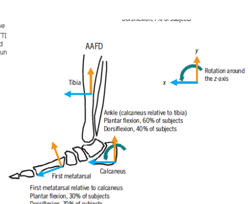
- Illustrative Sample
- Pathology
- ROM
- Strength
- Movement Deficits

Foot Function and Heel Raises?

Heel Rise Height

- Height
  - Ankle PF
  - Mid foot PF

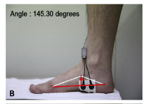




JOURNAL OF ORTHOPAEDIC & SPORTS PHYSICAL THERAPY | VOLUME 44 | NUMBER 4 | APRIL 2014 |

4 week Foot Exercise Intervention

(Jung et al, 2011)

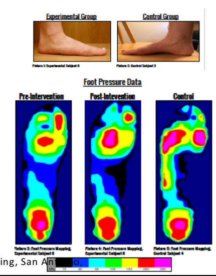


- Doming (Short Foot Exercises)
- Seated PT resistance exercise
- Standing trunk/hip rotation against resistance exercise

Combined Sections Meeting, San Antonio, 2017 Jeff Houck, PT, PhD 28

Influence of Foot Exercise on Function

- **Sample:** 8 pain free participants with severe flatfoot (FPI > 6)
- **4 week Intervention**
  - "Doming" (short foot)
  - PT thera-tube resistance
  - Standing trunk/hip rotation
- **Outcomes**
  - Improved foot pressure patterns
  - Increased heel rise ability (~28 %)
  - Improved foot posture



Combined Sections Meeting, San Antonio, 29

Targeted Interventions for Insertional Achilles Tendinopathy

- Activity limitations
  - Avoid DF activities (Consider heel lifts and shoe wear to decrease DF)
    - Stairs
    - Squats
    - Hills
- Pathology/Strength - Tissue Remodeling
  - Heavy Slow resistance
  - Consider extremely HIGH loads
  - Consider foot specific strengthening
- Movement Deficits
  - Integrate strength gains with gait training
- ROM
  - No stretching

Combined Sections Meeting, San Antonio, 30

Activity Limitations – Stop or limit Tendon Impingement

- Avoid DF activities Stairs
  - Squats
  - Hills
- Consider heel lifts
- Modify shoe wear
  - Consider high heels?

Addressing Tendon Pathology

- **Pathology/Strength - Tissue Remodeling**
  - Heavy Slow resistance
    - No benefit of eccentric over heavy slow resistance
      - Less pain
      - Less reps/greater compliance
      - Same clinical effects
  - Consider extremely **HIGH** loads
    - Muscle/Tendon unit built for high loads
  - Consider foot specific strengthening
    - Make the foot a rigid lever
    - Ensure COP is distal during push off

Ideas for Gait Training

- Targeting Specific Movement Changes
  - Improve Plantar flexion power
    - High rate and high moment plantar flexion activities
      - Limit ROM to less than only PF activities
  - Focus on eccentric control of DF during gait
    - Early heel off is desirable (eliminate late heel off)

STOP - NO stretching

- ROM
  - No stretching

Questions / Discussion

- What challenges/opportunities have you experienced in the clinic?

It takes a village!

- George Fox University
  - Jeff Houck, PT, PhD
  - Student collaborators
- University of Iowa
  - Ruth Chimenti, DPT, PhD
- University of Rochester Medical Center
  - Mark Buckley, PhD
  - A. Samuel Flemister, MD
- Ithaca College
  - Students and collaborators

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Achilles Tendinopathy

Beyond Eccentrics

Karin Grävare Silbernagel PT, ATC, PhD
Department of Physical Therapy

Conflict of interest

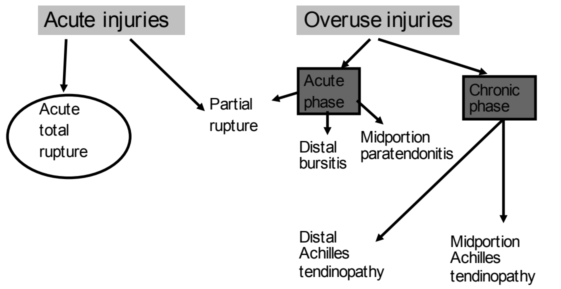
- Editor for Journal of Orthopaedic and Sports Physical Therapy

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

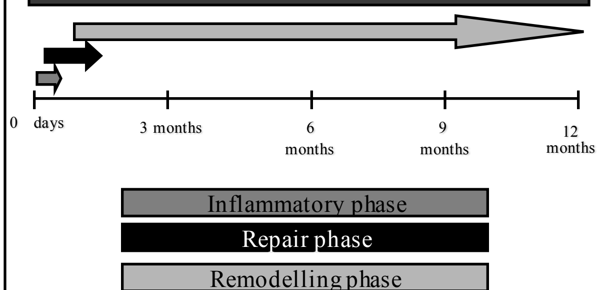
JOSPT

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

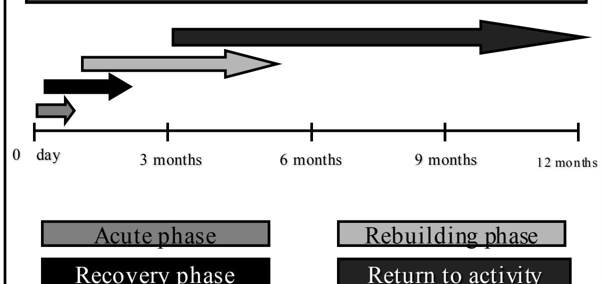
Classification of Achilles tendon injury



Stages of tendon healing



Rehabilitation phases



Tendon injury and Tendon Function

Changes in mechanical properties and performance

In Symptomatic subjects

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

7

Tendon injury and Tendon Function

Changes in mechanical properties and performance

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)

8

Summary – Clinical aspects

- 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 is “the medication” but takes time
- Not all overuse tendon injuries are the same
- Changes in tendon mechanical properties affect function even if no symptoms

Evaluation of Outcome

Knee Surg Sports Traumatol Arthrosc
DOI 10.1007/s00167-006-0150-6

SPORTS MEDICINE

Evaluation of lower leg function in patients with Achilles tendinopathy

Karin Grävare Silbernagel · Alexander Gustavsson · Roland Thomeé · Jon Karlsson

[CLINICAL COMMENTARY]

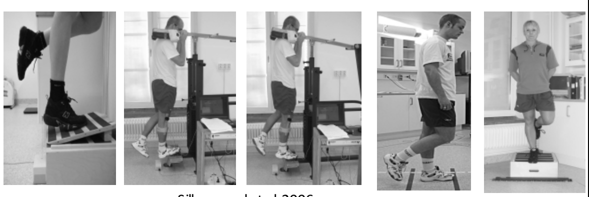
JOY C. MACDERMID, PT, PhD · KARIN GRÄVARE SILBERNAGEL, PT, PhD, ATC

Outcome Evaluation in Tendinopathy: Foundations of Assessment and a Summary of Selected Measures

JOSPT Tendinopathy issue November 2015

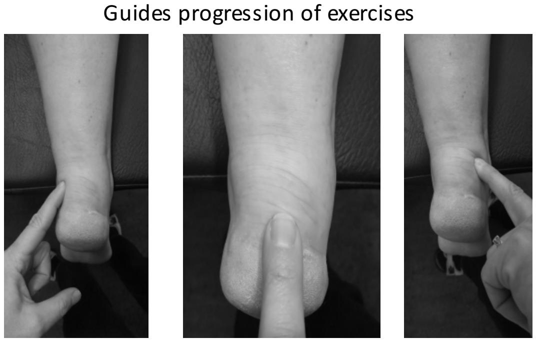
Outcome measures

Patient reported outcome measures
- Injury Specific: VISA-A, ATRS
- Joint specific
- Physical activity
- Quality of life



Silbernagel et al 2006

Achilles tendon insertion palpation
Guides progression of exercises



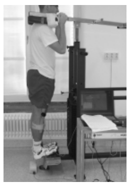
Function and symptoms

ORIGINAL ARTICLE

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

Br J Sports Med 2007;000:1–5. doi: 10.1136/bjsm.2006.033464



Relationship between Symptom and Function

Table 1 Effect sizes comparing baseline test results with those at the 1-year follow-up

Test	Effect size	n
CMJ	0.05	33
Hopping	0.40	32
Drop CMJ	0.25	33
Concentric toe-raise	0.24	34
Eccentric toe-raise	0.48	34
Toe-raise for muscular endurance	0.43	32
Test battery score with CMJ	0.75	19
Test battery score without CMJ	0.73	19
VISA-A-S questionnaire score	2.10	37

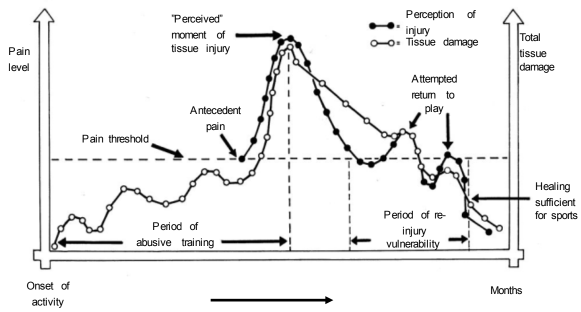
CMJ, counter movement jump; VISA-A-S, Swedish version of Victorian Institute of Sports Assessment—Achilles questionnaire.

Function \ Symptom	Fully recovered 90-100 points on VISA-A-S (n=16)
Passed all strength & Jump tests (>89%)	4 patients **25%**
Passed 4 of 5 tests	3 patients **19%**
Passed 3 of 5 tests	9 patients **56%**

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 measure of tendon health or biomarker for tendon health to continue monitor improvement



Schematic illustration of pain and tissue damage in oversue tendinopathy (Leadbetter 1992)

Summary

- Pursue the use of reliable and valid outcome measures for **all aspects** (pain, symptoms, function, tendon health)
- Recovery of symptoms does not mean full recovery
- Consider changes in athletic performance as an indication of tendon overuse

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

[CLINICAL COMMENTARY]

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

Eccentric or Concentric Exercises for the Treatment of Tendinopathies?

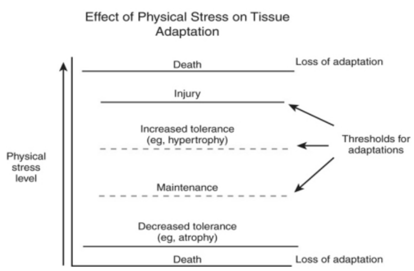
JOSPT

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

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?

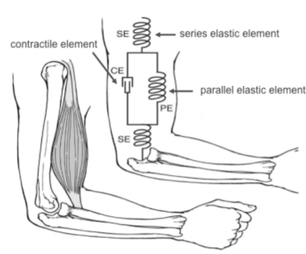


Exercise

20

Muscle tension

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



The total amount of muscle tension is then transmitted to the tendon

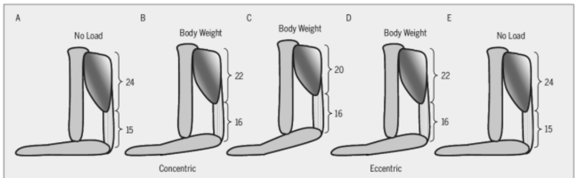


FIGURE 1. Schematic illustration of concentric and eccentric muscle contraction about the ankle joint. Numbers illustrate lengths (not to scale). (A) During concentric heel rise, the tendon and muscle are initially relaxed. (B) As muscle shortens, force is generated, causing the tendon to lengthen until sufficient force has been reached and the heel begins to rise. (C) While muscle shortens further, the heel continues to rise under approximately constant force and, due to the constant load, the length of tendon also remains constant. (D) In the eccentric phase, the heel drops as muscle lengthens, still at approximately constant force, and consequently tendon retains its length. (E) Finally, the muscle lengthens as it is relaxed and tendon shortens because load is removed. Note that across the schematics, tendon length is determined by the amount of load carried independent of muscle length.

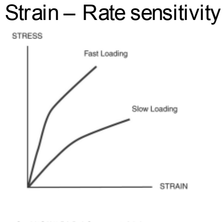
Couppe' et al 2015

Tendon tissue

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

Response of Healthy tendons to Load

- Acute increase in blood flow and collagen synthesis (Langberg et al 1999, 2001)
- Long-term effect – tissue hypertrophy and altered material properties (Kongsgaard et al 2009,2010)
- Tendon cells respond to mechanical stimuli in form of strain (Kalson et al 2011, Moerch et al 2013, Wang 2006)
- Cell-culture experiment suggests increased response with increased strain – but might be an upper limit (Lavagnino et al 2003, Yang et al 2004, Joshi et al 2008)

Response of Healthy tendons to Load

- 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
- Speed and/or duration (Gauvin et al 2011)
  - Cellular level indicates dynamic load superior to static
- 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)
- **In summary tendon is responsive to loading and will respond more strongly to greater loads although there is likely an optimum beyond which load becomes detrimental**

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)
- An increase in tendon vibration at high frequencies with eccentric loading which was not found with concentric loading **however** modulation quite small compared to the total load (Rees et al 2008, Henriksen et al 2009)
- Motor unit activation may differ and may produce difference in load distribution and shear – not likely in patellar tendon (Henriksen et al 2009, Hebert-Losier et at 2012, Reid et al 2012)

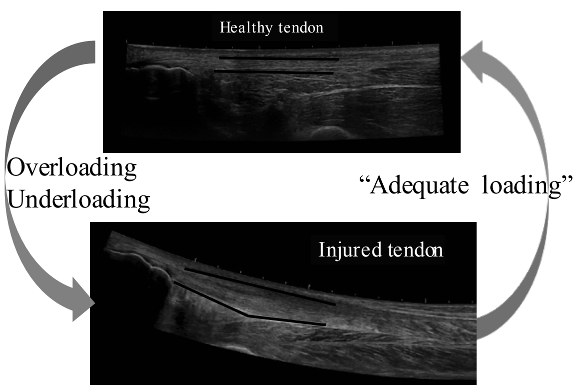
Exercise – Concentric compared to Eccentric loading

- 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**

The benefit of eccentric exercise in tendinopathy

My perspective

- Good evidence that benefit with eccentric exercise
- The first studies came at the same time we went from tenditinis to tendinopathy
- Started to allow pain with exercise which allowed for loading
- IN SUMMARY IT IS THE LOADING THAT IS OF IMPORTANCE



Exercise – Concentric compared to Eccentric loading

- Deficits in both concentric and eccentric strength (Silbernagel et al 2006)
- Address other impairments and symptoms
- Time to focus on **adjusting loading dosage** to the specific tendon/injury and individual patient not focusing on muscle contraction type

Just "handing out" an eccentric exercise program is not appropriate

Exercise for tendon injury

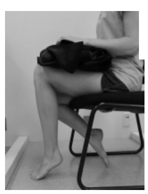
The goal of the exercise treatment

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

Type of exercise

Muscle contraction

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



Beyer et al 2015

Exercise - Treat tendon injury and functional deficits

Scand J Med Sci Sports 2001: 11: 197–206
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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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Accepted for publication 15 December 20

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

A Randomized Controlled Study

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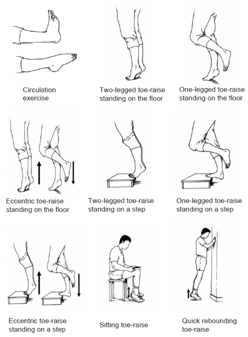
From the †Lundberg Laboratory of Orthopaedic Research, Department of Orthopaedics, Göteborg University, Sahlgrenska University Hospital, Göteborg, Sweden, and ‡SportRehab–Physical Therapy & Sports Medicine Clinic, Göteborg, Sweden

2nd European Conference of Sports Rehabilitation

Exercise – Comprehensive treatment protocol



Exercise program

- Concentric and eccentric loading
- Divided into 4 phases
- Increasing speed of movement

Heavy slow resistance training

Scand J Med Sci Sports 2009: 19: 790–802
doi: 10.1111/j.1600-0838.2009.00949.x

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Corticosteroid injections, eccentric decline squat training and heavy slow resistance training in patellar tendinopathy

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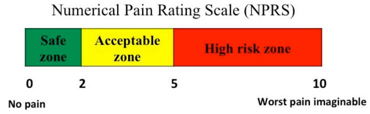
Slow eccentric-concentric contractions in HSR
Pain was acceptable

Exercise – Pain monitoring model

PAIN-MONITORING MODEL

Numerical Pain Rating Scale (NPRS)



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

Has been evaluated in two randomized trials with good outcome

The protective mechanism of pain

Training Diary

Name:______________________________
Physical Therapist:________________________
Startdate:____________________________

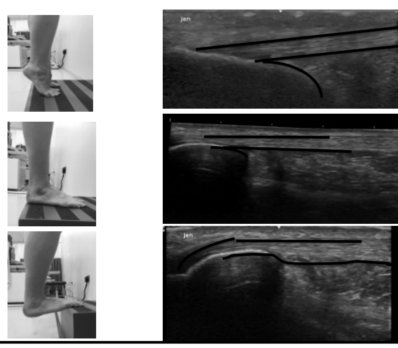
Week #____	Home exercises	Physical activity	Comments
Day 1			
Day 2			

Achilles tendon insertional considerations

Standing plantar flexion

Standing neutral

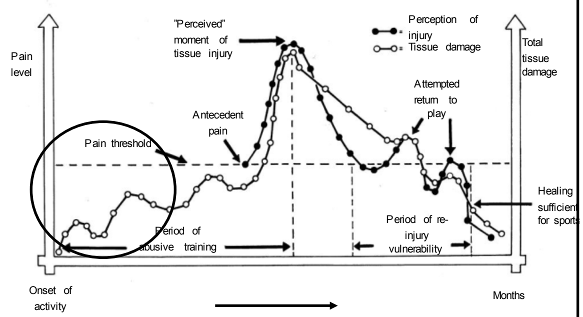
Standing dorsiflexion



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

Tendinopathy and Sports



Schematic illustration of pain and tissue damage in oversue tendinopathy (Leadbetter 1992)

The problem starts before the "injury"

- Insidious onset – listen to early symptoms indications
- Training errors contributing in 60-80% of those with Achilles tendinopathy (Järvinen et al. 2005, Kvist 1991)
- Greater mileage and running years in injured runners (Haglund-Åkerlind et al. 1993)

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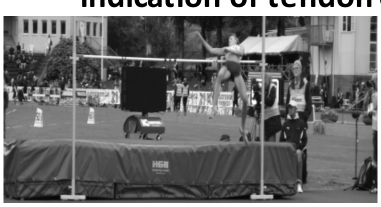
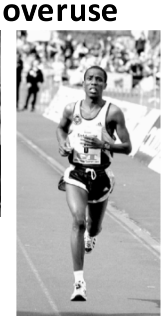
Change in performance could be early indication of tendon overuse





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

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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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[CLINICAL COMMENTARY]

KARIN GRÄVARE SILBERNAGEL, PT, ATC, PhD[1] • KAY M. CROSSLEY, BAppSc (Physio), PhD[2]

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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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

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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

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Progression of tendon load

- Return to play is gradual progression in load
- Load on a tendon can be increased by ↑ load or speed of movement
- Walking loads the Achilles tendon 3.5 x body weight
- Achilles tendon loaded 6-12 x body weight with running
- Increased speed of running increases the load

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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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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

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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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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Take home message

- Full recovery of tendon "function" important for performance and does not directly relate to symptoms
- Treat minor symptoms of tendinopathy early with "load control" instead of ignoring
- Consider changes in sports performance as a possible sign of tendon overuse
- Use the Return to Play program as a model to individualize for each patient

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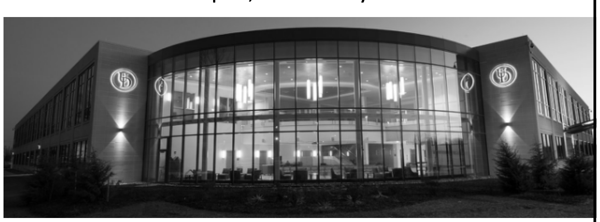

Thank you!

Treatment options for tendinopathy: What is the evidence

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Treatment options

- Deep friction massage
- Ultrasound
- Low level laser therapy
- Nitric oxide
- Injection therapies
  - Corticosteroids
  - Platelet-rich plasma
  - Sclerosing therapy
- Shock-wave therapy
- Eccentric exercise

Deep friction massage

- Mostly used in combination with other treatments such as exercise and ultrasound
- Often described to relieve pain and/or release scar tissue
- Cohrane review only found two randomized trials and concluded no consistent benefit (Brosseau et al 2002)

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Ultrasound

- In animal studies ultrasound has been found to enhance tendon healing
  (Jackson et al 1991, Enwemeka 1989)
- A few clinical studies showing positive results
- Systematic reviews and meta-analyses have failed to show that active ultrasound is more effective then placebo (Brosseau et al 2001, Robertson et al 2001)

3

Low-level laser therapy

- Indications for reducing inflammation, increasing collagen synthesis and angiogenesis
  (Bjordal et al 2008, Reddy et al 1998, Salate 2005)
- Mostly in the animal model
- Systematic review indicate conflicting results with 10 high quality studies showing negative results and 10 showing positive results (Tumilty et al 2010)
- Difficulty comparing studies due to various application techniques and dosages
- May be beneficial as adjunct eccentric exercise

4

Nitric oxide

- Nitric oxide (NO) is a small free radical generated by a family of enzymes, the nitric oxide synthases (NOSs)
- In animal models when additional NO is added, tendon healing is enhanced
- 3 RCTs have reported that NO delivered via a transdermal patch enhances the subjective and objective recovery of patients
- Side effect - sever headache
- Results not better then exercise
- Most studies from one group

Andres et al 2008

(Andres et al 2008, Yuan et al 2003, Paoloni et al 2004, 2007)

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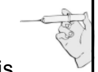
Corticosteroid injections



- Used to decrease inflammation due to tendinitis
- Today we know rarely inflammatory condition
- Adverse effects such as tendon ruptures reported in the literature
- May have initial pain relief
- Has been shown to have positive short term results
- Worse then other treatment options in the intermediate and long terms
- Effects might vary depending on site of tendinopathy

(Coombes et al Systematic review in the Lancet 2010)

Platelet-rich plasma injections - PRP

- Blood with high levels of platelets (Foster et al 2009)
- Platelets contain growth factors important for healing
- Positive results on animal studies
- Systematic review regarding use in tendinopathy found only three studies with adequate methodology and none of these found positive effect (de Vos et al 2010)
- Systematic review concerning use for patellar tendinopathy concluded PRP was safe but not better than other treatments (Liddle and Rodríguez-Merchán 2014)
- Recommendation from International Olympic Committee Consensus meeting is to proceed with caution in the use of PRP in athletic sporting injuries. (Engebretsen et al 2010)

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Shock-wave therapy

- Used to give pain relief and to promote tendon healing
- The underlying mechanism is not clear
- Published trials vary greatly in intensity, frequency and duration
- Best results for calcific tendinopathy (Andres et al 2008, Rompe et al 1998)
- In the elbow not better then control (Andres et al 2008, Haake et al 2002)
- For Achilles tendinopathy is was better then just rest but equal to eccentric exercise (Rompe et al 2007)
- Another study reported shock-wave not better then sham shock wave (Costa et al 2005)
- Possibly better for insertional problems

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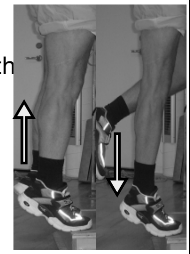
Exercise – Eccentric exercise

- Systematic reviews indicate that exercise (eccentric) have the most evidence of effectiveness (Kingma et al 2007,Magnussen et al 2009, Woodley et al 2007)
- No adverse effects
- Side effects are improved strength and function
- Initial treatment but takes 3-6 months



Summary

- Be careful with new treatments prior to having results from randomized clinical trials
- The treatment effects may vary depending on the site of the tendinopathy
- Avoid corticosteroids
- Exercise most evidence and recommended as first treatment
- All treatments recommend exercise as well
- Shock wave therapy might be beneficial
- Injection therapies need to be further studied
- Be aware of side effects
- Tendon injuries take time to heal need to remember there is no quick fix
- Expect 3-6 months for achieving full healing

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Thank you!

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Kinesiophobia
- in relation to achillestendinopathy

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Learning Objectives

– After this session, you will be able to:

- Identify the relevance of kinesiophobia in relation to achilles tendinopathy
- Understand the treatment principles of reducing kinesiophobia

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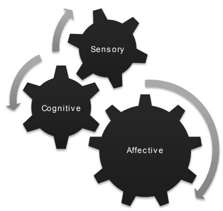
Pain



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Specific fear

What do patients with achillestendinopathy fear the most?

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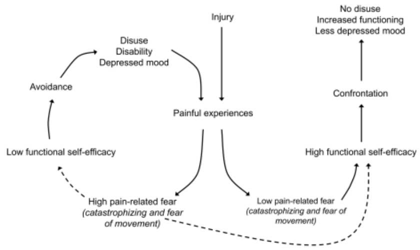
Terminology

Pain-related fear	Fear of movement	Kinesiophobia
Asmundson* et al, 1996 Incorporates fear of pai fear of injury, fear of physical activity and so forth.	Vlaeyen et al, 1995 a specific fear of movement and physical activity that is (wrongfully) assumed to cause reinjury.	Kori et al, 1990 an excessive, irrational, and debilitating fear of physical movement and activity resulting from a feeling of vulnerability to painful injury or reinjury

The cognitive- behavioral fear-avoidance model with the mediating role of self-efficacy



The fear-avoidance model with the mediating role of self-efficacy. Vlaeyen et al., 1995; Woby et al, 2007

What do we need to understand?

- How can we identify fear at an early stage?
- What can we do about it?

What measure to choose?

Constructs	Pain-related fear	Fear-avoidance beliefs	Fear of movement	Kinesiophobia
Conceptual Definitions	Incorporates fear of pain, fear of injury, fear of physical activity and so forth [15]	There is no original definition to be found neither in the article by Lethem et al.[12] nor by Waddell et al.[16]	A specific fear of movement and physical activity that is (wrongfully) assumed to cause reinjury [14]	An excessive, irrational, and debilitating fear of physical movement and activity resulting from a feeling of vulnerability to painful injury or reinjury [13]
Identified Instruments	Fear of Pain Questionnaire (FPQ) Pain Anxiety Symptoms Scale (PASS)	Fear-Avoidance Beliefs Questionnaire (FABQ) Fear-Avoidance of Pain Questionnaire (FAPQ)	No one identified	Tampa Scale for Kinesiophobia (TSK)

Measures

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Review Article

Pain-Related Fear: A Critical Review of the Related Measures

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Objectives: In regards to pain-related fear, this study aimed to: (1) identify existing measures and review their measurement properties, and (2) identify the optimum measure for specific constructs of fear-avoidance, pain-related fear, fear of movement, and kinesiophobia. *Design*: Systematic literature search for instruments designed to measure fear of pain in patients with persistent musculoskeletal pain. Psychometric properties were evaluated by adjusted Wind criteria. *Results*: Five questionnaires *(Fear-Avoidance Beliefs Questionnaire (FABQ), Fear-Avoidance of Pain Scale (FAPS), Fear of Pain Questionnaire (FPQ), Pain and Anxiety Symptoms Scale (PASS), and the Tampa Scale for Kinesiophobia (TSK))* were included in the review. The main findings were that for most questionnaires, there was no underlying conceptual model to support the questionnaire's construct. Psychometric properties were evaluated by diverse methods, which complicated comparisons of different versions of the same questionnaires. Construct validity and responsiveness was generally not supported and/or untested. *Conclusion*: The weak construct validity implies that no measure can currently identify who is fearful. The lack of evidence for responsiveness restricts the current use of the instruments to identify clinically relevant change from treatment. Finally, more theoretically driven research is needed to support the construct and thus the measurement of pain-related fear.

1. Introduction

Over the last decennia, fear of pain and/or injury has become an integral part of our understanding in the explanation of disability in patients with persistent musculoskeletal pain [1]. Pain-related fear has been identified in the general population [2] as well as in various patients' groups with persistent musculoskeletal pain [3–9]. Subsequently, treatment strategies have been developed to reduce fear and disability in patients with low back pain [10, 11], as well as neuropathic pain [4]. In the clinical setting fear is acknowledged as an important aspect in patients' disability which needs to be addressed to achieve successful outcome. Although the role of fear in pain-related disability seems thus well established, consensus concerning proper assessment and interpretation of fear in relation to pain is currently still lacking.

One of the reasons for this is the fact that fear in relation to pain has been described with a variety of conceptual definitions among which pain-related fear, fear-avoidance beliefs, fear of movement, and kinesiophobia are the most commonly used. These are, however, constructs rather than a disorder or other pathological state in and of itself. The relationship between fear and pain was first described by Lethem et al. 1982 in *"the fear-avoidance model of exaggerated pain perception"* [12], in which fear and pain were both presented as associated with behaviour through avoidance learning. Almost a decade later, Kori et al. presented their thoughts about *kinesiophobia* [13].

Things to consider when you select a measure:

- What do you want to measure?
- What do you want to use it for (Screening, assessment, evaluation)
- Its quality

Responsiveness - How can I use the responses in clinical practice?

- Patients improving >8 scores *(Smallest detectable change)* on the Tampa Scale for kinesiophobia are likely to increase their physical ability (Lüning-Bergsten et al, 2012)

The prevalence of kinesiophobia – overuse conditions

Available online at www.sciencedirect.com
ScienceDirect

Kinesiophobia among physiological overusers with musculoskeletal pain

Mari Lundberg *, Jorma Styf

Achilles tendinopathy

- Dr Silbernagel has found a negative correlation between kinesiophobia and heel-rise work recovery at five years follow-up *(Grävare-Silbernagel et al, 2010).*

Achilles tendon rupture

- Nicklas Olsson and his co-workers found a negative correlation between kinesiophobia and functioning 12 weeks after an Achilles tendon rupture (Olsson et al 2012).

What to do about fear?

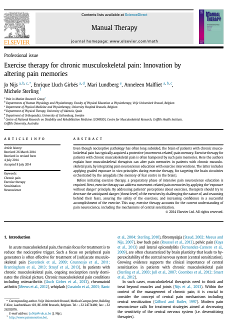
Exposure-based Treatment of Chronic Pain

Cognitive operational principles

based on extinction of Pavlovian conditioning

cognitive process, fear is activated and catastrophic expectations are challenged and disconfirmed

Principles - Applied in Physical Therapy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Professional issue

Exercise therapy for chronic musculoskeletal pain: Innovation by altering pain memories

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ABSTRACT

Even though nociceptive pathology has often long subsided, the brain of patients with chronic musculoskeletal pain has typically acquired a protective (movement-related) pain memory. Exercise therapy for patients with chronic musculoskeletal pain is often hampered by such pain memories. Here the authors explain how musculoskeletal therapists can alter pain memories in patients with chronic musculoskeletal pain, by integrating pain neuroscience education with exercise interventions. The latter includes applying graded exposure in vivo principles during exercise therapy, for targeting the brain circuitries orchestrated by the amygdala (the memory of fear centre in the brain).

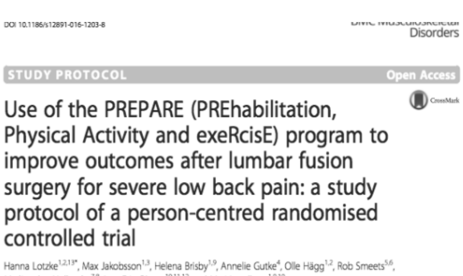
Before initiating exercise therapy, a preparatory phase of intensive pain neuroscience education is required. Next, exercise therapy can address movement-related pain memories by applying the 'exposure without danger' principle. By addressing patients' perceptions about exercises, therapists should try to decrease the anticipated danger (threat level) of the exercises by challenging the nature of, and reasoning

A **preparatory phase** of intensive pain neuroscience education

Exercise therapy can address movement-related pain memories by **applying the 'exposure without danger**' principle

Therapists should try to decrease the anticipated danger (threat level) of the exercises by challenging the nature of, and reasoning behind their fears, assuring the safety of the exercises, and increasing confidence in a successful accomplishment of the exercise

Principles applied in various context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STUDY PROTOCOL Open Access

Use of the PREPARE (PREhabilitation, Physical Activity and exeRcisE) program to improve outcomes after lumbar fusion surgery for severe low back pain: a study protocol of a person-centred randomised controlled trial

Hanna Lotzke[1,2,13*], Max Jakobsson[1,3], Helena Brisby[1,9], Annelie Gutke[4], Olle Hägg[1,2], Rob Smeets[5,6], Marlies den Hollander[7,8], Lars-Eric Olsson[10,11,12] and Mari Lundberg[1,9,10]

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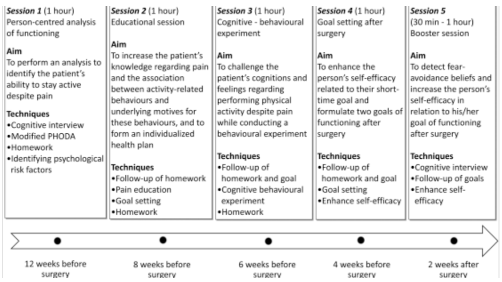
Example of intervention – CBT - based



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