Achilles tendon rupture: Is full recovery possible? An Orthopedic surgeon’s, a Physical Therapist’s and Biomechanist’s perspective.

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Course Description
This session will review the evidence and current knowledge concerning how to treat patients with Achilles tendon rupture. Achilles tendon rupture occurs to 12-37 per 100,000 people every year, in the general population. Recreational sports activity accounts for 73% of Achilles tendon ruptures, with the highest incidence occurring in individuals aged 30-49. Due to the level of disability following Achilles tendon rupture, many of these patients are unable to return to their prior level of physical activity or sport after injury. The best approach to treating individuals following Achilles tendon rupture is unclear. This session will include a review of the evidence concerning the best treatment approach both from the orthopedic surgeon’s and the physical therapist’s perspective. It will present how an Achilles tendon rupture affects function and how this limits the ability to return to sports. The session will describe what the obstacles are for full recovery with suggestions for how to overcome those.
Course Objectives

1. Interpret the evidence concerning the various types of initial treatment following an Achilles tendon rupture

2. Understand how to progress a patient with an Achilles tendon rupture through the various stages of rehabilitation and develop an individualized treatment program.

3. Identify the various reasons for impairments following an Achilles tendon rupture

4. Recognize how an Achilles tendon rupture can affect the biomechanics of gait.
What’s the evidence behind Surgical or Non-Surgical treatment?
An Orthopedic surgeon’s perspective
Katarina Nilsson Helander MD, PhD
University of Gothenburg
Kungsbacka Hospital, Sweden

Disclosure
Neither I, Katarina Nilsson Helander, nor any family member(s), have any relevant financial relationships to be discussed, directly or indirectly, referred to or illustrated with or without recognition within the presentation.

Epidemiology
• Incidence peak 55/100 000 p
• Incidence rising in the developed world
• Bimodal distribution
• Gender difference
• Increased risk of contralateral rupture
  Aaroen Scand J Med SCI Sports 2004

Etiology
• Multifactorial
  • intrinsic, e.g.
    degeneration, aging, reduced collagen fiber diameter (Sargon 2005), < tendon vascularity, >BMI, gender, GS dysfunction, pes cavus, lateral ankle instability
  • extrinsic factors, e.g.
    sport activities; overuse; repetetive microtrauma, fluoroquinolone antibiotics, corticosteroids

Acute Achilles tendon ruptures Diagnosis
• Clinical
• Medical history
  sudden pain, struck from behind, audibly snap, push of on weightbearing forefoot, extended knee
• Typical palpable gap, mid-substance rupture
• Thompson’s or Simmond’s, calf squeeze test
• Matles test
• Achilles tendon resting angle (ATRA) Carmont 2015, Carmont 2015
“BATTLES OF ACHILLES: The operative vs non-operative treatment debate
Early mobilization techniques have revolutionized both surgical and non-surgical management of Achilles ruptures, but the resulting improved outcomes have ignited a heated discussion among practitioners as to which approach is best”

(Lower Extremity Review May 2012)

Treatment
Surgical or Non-surgical treatment
Never ending debate

RCT

Systematic reviews

Complications

• Non-surgical treatment
  > re-rupture
• Surgical treatment
  infection superficial/deep
  sural nerve disturbance
  scar problems, adhesions
• Surgical and Non-surgical treatment
  tendon lenghtening
  DVT

Surgical treatment

• open
• minimal invasive
• percutaneous

Non-Surgical treatment

• Cast
• Brace Functional/ Heel lifts
• Cast/Brace combined

Non-surgical treatment

- Cast/Brace combined or only Brace,
- total 8 weeks
- Midsubstance rupture
- Treatment start within 72 hours

Early range of motion training and early weight-bearing!
Aspenberger 2007, Kjaer 2009
**Acute Achilles Tendon Rupture**

A Randomized, Controlled Study Comparing Surgical and Nonsurgical Treatments Using Validated Outcome Measures

Katarina Nilsson-Helander, MD, PhD, Karin Grävare Silbernagel, MD, PhD, Aneta Sonwald, MD, PhD, Mary Paterson, MD, PhD, Evi Pafano, MD, PhD, Maryke Ossendorp, MD, PhD.

Department of Orthopaedic Surgery, Institute of Orthopaedic Sciences, Sahlgrenska Academy, University of Gothenburg, Sahlgrenska University Hospital, Gothenburg, Sweden.

Primary outcome re-ruptures, secondary outcome, ATRS, no significant differences between the groups, and functional test in favour for the surgical group after 6 month follow-up.

**Functional tests**

- Drop Jump
- Hopping
- Concentric
- Eccentric
- Heel-rise work test

**RESULT**

Functional tests

<table>
<thead>
<tr>
<th>Test</th>
<th>6-month evaluation</th>
<th>12-month evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surgeon</td>
<td>Nonsurgeon</td>
</tr>
<tr>
<td></td>
<td>m=37</td>
<td>m=40</td>
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<tr>
<td></td>
<td>60±17</td>
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<td>69% (15)</td>
<td>67% (15)</td>
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<td></td>
<td>40±23</td>
<td>40±12</td>
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<td>70% (15)</td>
<td>60±12</td>
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<td>40±12</td>
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<td></td>
<td>60±17</td>
<td>60±17</td>
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<td>5±10</td>
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<tr>
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<td>6±1</td>
<td>6±1</td>
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<tr>
<td></td>
<td>69% (15)</td>
<td>67% (15)</td>
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<tr>
<td></td>
<td>40±23</td>
<td>40±12</td>
</tr>
<tr>
<td></td>
<td>70± (15)</td>
<td>62% (18)</td>
</tr>
<tr>
<td></td>
<td>40±12</td>
<td>40±12</td>
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<td>60±17</td>
<td>60±17</td>
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<td>62% (18)</td>
</tr>
<tr>
<td></td>
<td>40±12</td>
<td>40±12</td>
</tr>
</tbody>
</table>

**FSI, Limb Symmetry Index** (Skadad/Frisk x 100)

Fisher variance 180 (30-360).

At 2 years, no significant differences between the non-surgical and surgical group.

**Operative versus Nonoperative Treatment of Acute Achilles Tendon Ruptures**

A Multicenter Randomized Trial Using Accelerated Functional Rehabilitation

By Eunice Wibik, MD, MS, FRCS, Annette Assendelft, MD, MS, Bjarne Bystrøm, MS, MD, PhD, and Karin Grävare Silbernagel,

Medical University of Gothenburg, Gothenburg, Sweden.

Primary outcome Re-ruptures, Secondary outcome, isokinetic strength, Leppilathi score.

Accelerated rehabilitation avoid severe complications in patients treated non-surgically. Accelerated change of motion together with early weight-bearing seems to be important.
Surgical or Non-surgical treatment

Individual treatment is recommended… how?

Ultrasonography

Could US performed in acute setting predict re-ruptures and outcome?

initial large diastasis between the tendon ends together with non-surgical treatment seems to increase the risk for a re-rupture, as well as inferior functional results according to an ongoing study in Sweden.

> 5 mm initial diastasis cut off point to recommend surgery?

Conclusion

• Individual treatment
• Both Surgical and Non-surgical treatment with immediate weightbearing, and early mobilization could be recommended.
• Surgical treatment are recommended for young patients in high level sports – earlier return to sports.
• Return to sports - functional perspective rather than a time perspective rehabilitation.
Conclusion

• Regardless treatment 10-30% functional deficits persists, the reasons for variation are still unknown, and need to be further evaluated.
• Non-surgical treatment is not recommended >72 hours after initial injury.
• Tendon lengthening should be avoid.
• Predictors may affect outcome, further studies are needed.

• Ultrasonography in acute setting; guidance Surgical or non-surgical treatment, further studies are needed.
• Important to distinguish between mid-substance, proximal, and insertional ruptures (different treatment recommendations).
• Partial ruptures are uncommon (except in patients with tendinopathy)
Achilles tendon rupture
The obstacles and impairments that limit full recovery

Karin Grävare Silbernagel PT, ATC, PhD
Department of Physical Therapy, University of Delaware
Department of Orthopaedics, University of Gothenburg

Rerupture versus Clinical outcome

• Historically the success of treatment after an Achilles tendon has been measured by minimizing the risk of rerupture
• Rerupture risk 2-15% (decreased with early mobilization)
• Majority of the patients have long-term deficits in strength and function regardless of treatment

Disclosure
No conflict of interest

Where are we today?

• What are the obstacles and impairments that limits full recovery?
• What can we recommend today for rehabilitation, especially in the early stage (irrespective of initial treatment)?

Achilles tendon rupture

• Common in middle-aged physically active individuals
• Often rupture during sporting activity (73%)
• The patients’ main goal is initially to return to same sport/activity level
• Patients describe not returning to sport due fear of re-injury

Achilles tendon rupture – fear of re-injury

• At 8 weeks 84% wanted to return to sports
• At 1 year 54% returned, 30% had the ability but not the ambition
• Often comment that “I am not returning to the sport in which I got injured”

Möller et al 2001
Fear of movement – Achilles tendon rupture

Evaluation of relationship between level of kinesiophobia (TSK-SV) and patient-reported outcome 3 months after an Achilles tendon rupture

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation coefficient</th>
<th>P-value</th>
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</thead>
<tbody>
<tr>
<td>Physical activity level</td>
<td>-0.275</td>
<td>0.013</td>
</tr>
<tr>
<td>ATRS</td>
<td>-0.371</td>
<td>0.001</td>
</tr>
<tr>
<td>FAOS - ADL</td>
<td>-0.376</td>
<td>0.001</td>
</tr>
<tr>
<td>FAOS - Sport &amp; Rec</td>
<td>-0.346</td>
<td>0.002</td>
</tr>
<tr>
<td>FAOS - QOL</td>
<td>-0.321</td>
<td>0.003</td>
</tr>
<tr>
<td>EQ - 5D</td>
<td>-0.239</td>
<td>0.032</td>
</tr>
</tbody>
</table>

Can the impairments be fully resolved?

- Gait abnormalities two years after injury (Don et al. 2007)
- Deficits in calf strength of 10-30% (Khan et al. 2004)
- Tendon elongation and disproportionate weakness at end range of plantar flexion (Schepull et al. 2012; Mullaney et al. 2006)
- Deficits in heel-rise endurance of 20-30% (range 0-70%) (Silbernagel et al. 2009)
- Deficit in heel-rise height correlates with degree of tendon elongation (Silbernagel et al. 2012)

Possible reasons for deficits

Calf muscle weakness

- Deficits in strength of 10-30% (Khan et al. 2004)
- Deficits in heel-rise endurance of 20-30% (Silbernagel et al. 2009)
- Only 50% of patients can perform a standing single-leg heel-rise at 3 months (Olsson et al. 2014)
- Pain at 3 months or lower function at 6 months correlates with delayed recovery of calf muscle endurance at 1 year (Bostick et al. 2010)

Tendon elongation

- No side to side difference in healthy individuals
- Mean 3 cm side to side difference after and Achilles tendon rupture
- Varies between 0-5 cm side to side difference

Possible reasons for deficits

Tendon elongation

- The tendon elongates during healing (Mortensen et al. 1992)
- Similar elongation regardless of surgery or not (Schepull et al. 2012)
- Amount of tendon elongation correlates with heel-rise height deficit (Silbernagel et al. 2012)
  - Gait
  - Ability to generate plantar flexion force
  - Correlates with degree of symptoms
Achilles tendon rupture: Impairments and rehabilitation

12/1/15

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Mean difference in heel-rise height is 3 cm at 12 months

<table>
<thead>
<tr>
<th>12 months</th>
<th>Non-surgical</th>
<th>Surgical</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSI mean</td>
<td>77%</td>
<td>81%</td>
</tr>
<tr>
<td>LSI min-max</td>
<td>49-113</td>
<td>47-103</td>
</tr>
</tbody>
</table>

Mean difference in heel-rise height is 3 cm at 12 months

Mechanical properties

Roentgen Stereophotogrammetric Analysis - RSA

Schepull et al SJMSS 2010

Tendon elongation and muscle activity during gait

- The injured Achilles tendon was longer
- The calf muscles ability to contract was not reduced during walking
- During gait, the patients compensate for an elongated Achilles tendon by greater activation of the gastrocnemius muscles to account for the additional tendon slack before motion is produced at the joint

Summary

- Fear of re-injury might affect Return to Play
- Minimizing the occurrence of tendon elongation of great importance
- Tendon elongation causes permanent deficits in ankle plantar flexion power generation and absorption
- Other joints/tendons/muscles might compensate for loss of ankle PF functions
- Full recovery of triceps surae to pre-injury level might not be realistic for all

The rehabilitation – the evidence and clinical application

The rehabilitation

- Some patients recover 100% so it is possible
- The rehabilitation/mobilization is crucial for outcome
- Historically we push the boundaries of rehabilitation in the surgical group first
- Up to this point the same early loading has been equally successful in non-surgical patients in the next step
- Main difficulty is to measure and compare how much do we actually load the Achilles tendon with current treatments
Why early mobilization?

- The tendon needs to be exposed to load during healing to improve tendon structure (Kjaer et al. 2007, Aspenberger 2007)
- Increased physical activity gives larger/stronger tendon callus in shorter time (Andersson et al. 2009)
- Higher physical activity was associated with a more mature tissue repair (Bring et al. 2009)
- Early rehabilitation/mobilization results in decreased risk of rerupture (Nilsson-Helander et al. 2010)
- Early rehabilitation/mobilization results in less tendon elongation (Kangas et al. 2007)

Stages of Rehabilitation

- Early mobilization phase
  - 0-6 or 8 weeks
  - Most recent studies allow weight bearing through the heel in brace (with heel lift)
  - Improved outcome and decreased rerupture rates with this early weight bearing
  - However rarely exercise designed to load the tendon even though loading is needed for healing
  - It is in this phase the rehabilitation has differed between surgical and non-surgical treatments

Early Exercise Protocols

- Started early loading using theraband as resistance in surgically treated group
  - 1-2 weeks
    - AROM up to 15 of PF
    - PF with theraband as resistance and setting heel-rise
  - 3-4 weeks
    - Increased theraband resistance, sitting heel-rise with weight and increased ROM up to 0 degrees
  - 4-5 weeks
    - No brace, started standing heel-rise (2-legs) full AROM

Results – early mobilization

At 3 months

- 50% of the patients were able to perform a one-legged heel-rise
- No difference between surgical or non-surgical group
- Heel-rise ability correlated with fear

At 12 months

- Surgical group higher LSI values in all functional tests (only sig in 2 of the tests)
- Again large variations in both groups (Olsson et al. 2012 and 2013)
Early Exercise Protocols

**Exercises started after 2 weeks**
- Limit amount of DF
- Seated heel-rise
- Theraband
- Foot intrinsics and extrinsics

_Boot with heel lifts (allow full weight-bearing) week 0-6_

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Early Exercise Protocols

**Concerns**
- What muscle is actually used?
- At what stage is the tendon healed enough for loading (in the individual)?
- How do we monitor the load and recovery in order to individualize treatment?

**What guides can I have in the clinic?**
- Achilles Tendon Resting Angle (Carmont et al 2013)
- Seated heel-rise test (Brorsson et al 2015)
- US imaging

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Guides for individualized early treatment?

**Achilles Tendon Resting Angle**
_Carmont et al 2013 Foot and Ankle Surgery_

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Seated heel-rise test with 50% of body weight

- 98% of the patients were able to perform the test at 3 months (standing only 50%)
- Has to be able to perform at least >20 reps before enough strength to perform single-leg standing heel-rise (Specificity 98%)

_Brorsson et al 2015_

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Rehabilitation Exercise

**Early rehabilitation phase**

6-11 weeks
- This is when the patient starts to walk without brace
- Starting to strengthen the calf muscles
- If the patient is allowed to walk it is safe to perform double-leg heel-rise
- Remember that the speed of loading affects the tendon load
- The greatest risk for rerupture is during this phase

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<table>
<thead>
<tr>
<th>Early rehabilitation phase (6-11 weeks)</th>
<th>Visil for physical therapy 2-3 times a week and home exercises daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercises programme:</td>
<td></td>
</tr>
<tr>
<td>Exercise bike</td>
<td></td>
</tr>
<tr>
<td>Ankle strengthening using a resistance band or cable machine</td>
<td></td>
</tr>
<tr>
<td>Sitting heel-rise with external load (25-50% of body weight)</td>
<td></td>
</tr>
<tr>
<td>Standing heel-rise progressing from two legs to one leg</td>
<td></td>
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<tr>
<td>Goal training</td>
<td></td>
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<tr>
<td>Balance exercises</td>
<td></td>
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<tr>
<td>Leg presses</td>
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<tr>
<td>Leg extensions</td>
<td></td>
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<tr>
<td>Leg curls</td>
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<tr>
<td>Foot exercises</td>
<td></td>
</tr>
</tbody>
</table>

Department of Physical Therapy

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Late rehabilitation phase

Week 12-15

- Goal is to slowly progress to running and jumping
- Continue to progress by increasing external load and speed of movement
- Go from 2-leg jump to 1-leg jump
- Functional evaluations are important to determine if appropriate to starting a running and jumping program

Return to sports phase

Table 2. Criteria for starting a running progression programme

<table>
<thead>
<tr>
<th>Criteria for starting a running progression programme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Must be 12 weeks post injury, able to perform 90% of available height at the height of the injured side.</td>
</tr>
<tr>
<td>If the patient is not able to perform the heel-raise criteria at weeks 14-15, they can begin the running progression if they are able to raise at least 70% of their bodyweight during a single heel-rise.</td>
</tr>
</tbody>
</table>

What do we know about Return to Play after an Achilles tendon rupture?

- Recommendations in the literature to return to running and jumping in non-contact sports week 16-24
- Preliminary results from a systematic review
  - Of 102 articles only 20% reported on return to play
  - The weighted percentage of subjects who returned to play was 73%
  - No consistent return to play definition
  - Often a return to activity reported but not symptomatic state
  - Similar rates between surgical and non-surgical treatment range 29-87%

The effect of Achilles tendon rupture on sports performance

American Football Players - NFL

- Average age 29 y/o (older than the average age 26.5 y/o)
- 32% (10/31) of the players never returned to the professional level
- A 50% reduction in performance
  (Parekh et al 2009)

Basketball Players - NBA

- Average age 29.7 y/o (same as average age)
- 39% (7/18) of the players never returned to the professional level
- Significant decrease in playing time and performance
  (Amin et al 2013)
Summary

- Time to focus treatment on achieving full functional recovery not just on avoiding reruptures and infections
- Current research indicates that the rehabilitation during the first 3 months are of great importance for outcome
- Continued research needed for:
  - Determining how much the patient is loading the calf and Achilles tendon with the exercises
  - Determining the ideal loading conditions/Exercises for the early phase
- Develop outcome measures that can be used early in the rehabilitation to help with individualizing the treatment

References


References
Achilles tendon ruptures: Biomechanics perspective

Richard Willy, PhD, PT, OCS
Assistant Professor of Physical Therapy
Department of East Carolina University
Greenville, NC USA

The presenter has no financial relationships or product endorsements to disclose

Outline

1. Achilles and Triceps surae: Functional anatomy
2. Tissue biomechanics
3. Biomechanical challenges post-ATR
4. Movement patterns post-ATR:
   a. Walking
   b. Running
5. Biomechanical considerations for ATR rehabilitation

Disclosures

I have no disclosures or conflicts of interest

Functional anatomy

ATR effect: Tendon stiffness and elasticity

Gastrocnemius/soleus musculature

ATR: Achilles tendon rupture

Healthy Achilles tendon

Mean elasticity: 291.91 ± 4.38 kPa

MVIC elongation

SVIC elongation

ATR: Achilles tendon rupture

Healthy Achilles tendon

Mean elasticity: 56.46 ± 68.59 kPa

MVIC elongation

SVIC elongation

ATR: Achilles tendon rupture

Physiological CSA

Soleus 64%
M Gastroc: 25%
L Gastroc: 12%

Muscle volume

Soleus 52%
M Gastroc: 32%
L Gastroc: 16%

East Carolina University
**Force or excursion?**

Albracht 2008, Wickiewicz 1983 Adapted from Lieber 2002

<table>
<thead>
<tr>
<th>Fiber length (mm)</th>
<th>Cross-sectional area (mm²)</th>
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</thead>
<tbody>
<tr>
<td>20</td>
<td>3000</td>
</tr>
<tr>
<td>80</td>
<td>2000</td>
</tr>
<tr>
<td>140</td>
<td>0</td>
</tr>
<tr>
<td>180</td>
<td>0</td>
</tr>
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</table>

Increasing excursion

Increasing force

FDL  POP  FHL
Post Tib  RF  BF  Ant Tib
POD  FDL  FHL
Ext Hal longus  Semitendinosus

**Functional ROM:**

50° PF → 20° DF

Ascending length-tension curve

Typical elongation: 10-15%

Mortensen 1992, Suydam 2011

Active insufficiency: 10-12%

Maganaris 2002

**Medial Gastrocnemius**

Functional ROM: 50° PF → 20° DF

Ascending length-tension curve

Typical elongation: 10-15%

Mortensen 1992, Suydam 2011

Active insufficiency: 10-12%

Maganaris 2002

**ATR: Strength and work deficits**

Effects of ankle position on isometric force

LSI Isokinetic Plantarflexor work

Plantarflexion ang. velocity during running: 230 deg/sec

**Calculation of tissue loading**

ATR limb: Gait kinematics

Tengman and Riad, 2013

2-5 years post Achilles tendon rupture
**ATR healing: effect on gait kinematics**

3-6 mo’s post ATR: DF
12-24 mo’s post ATR: DF

5-9 years post ATR: Greater ABD
Hopping: 66% greater toe out, $p=0.03$, $d=0.50$
Reduced AT torsional tension??

**Reduced ankle power**

Tengman and Riad, 2013

16.6% deficit in concentric work

Reduced pressure under forefoot, Increased heel pressure

Costa 2005

**Effect on gastroc/soleus muscle activity**

Suydam 2015

Suydam 2015

Relationship with AT length+

Contributing factors: more compliant tendon with greater hysteresis
Don 2007, McNair 2013

Greater neural drive required to develop sufficient muscular force

**Ankle power & Achilles force during running**

Suydam 2015

18.9% Concentric power deficit, $p<0.001$, $d=0.61$

**Coordination strategies post-ATR**

Support moment distribution during walking

Hip
Support Moment
$p=0.82$, $d=0.07$

Knee
Support Moment
$p=0.009^*$, $d=0.46$

Ankle
Support Moment
$p=0.001^*$, $d=0.51$

Unpublished data, SAABS

**Proximal consequences?**

SAABS Preliminary data here
Greater energy storing demand, greater proximal load

SAABS Preliminary data here

ATR: Rehabilitation considerations

- Loss of mechanical properties with disuse Reeves 2005
- Tendon responds to loading Aspdenberg 2007
- Assists with collagen fiber alignment Bring 2007
- Contralateral limb considerations Arøen 2004
- Strengthening: consider endrange (shortened) Maquirriain 2011
- Mechanical loading:
  - Increases collagen synthesis Kjaer 2009
  - Increases tendon CSA
- Strength training Milgrom 2014
- 22% greater; Chronic endurance running Magnusson 2003
  - Not apparent with short-term running Hansen 2003

Effect of strengthening on tendon qualities

ATR: less stiffness and greater tendon hysteresis Wang 2013

Potential for strengthening?

14 Wks of resistance training

- 65% inc in PT stiffness
- 22% reduction in hysteresis Reeves 2003
- Longer for CSA gains Magnusson 2008
- Strengthening will not reduce tendon length! Kuwanda 1999

Focus: Strengthening with focus on CSA gains & energy storage McNair 2013.

Treadmill or overground?

Willy et al., In review

<table>
<thead>
<tr>
<th>Sex</th>
<th>Running volume (km/week)</th>
<th>Age (yrs)</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>37.1 (27.4)</td>
<td>24.6 (4.6)</td>
<td>23.1 (2.5)</td>
</tr>
<tr>
<td>Female</td>
<td>36.3 (27.2)</td>
<td>22.8 (2.2)</td>
<td>21.2 (2.7)</td>
</tr>
</tbody>
</table>

Treadmill of Overground: Achilles injuries

Willy et al., In review

Treadmill:
Greater Peak Achilles force
p=0.003, d=0.50

Greater Achilles loading rate
p=0.0004, d=0.61

Case study:

24 year old male, 15 months post ATR, percutaneous repair

Running: Ankle power

Focus: Strengthening with focus on CSA gains & energy storage McNair 2013.
Shoe prescription

Current shoes:
- Brooks Adrenaline™ 6 mm heel-toe drop
- Pearl Izumi M2™ 12 mm heel-toe drop
- Altra impulse™ 0 mm heel-toe drop

Shift Gastroc/soleus complex to more optimal length-tension range

Take home points

- ATR affects the entire Gastroc/soleus/Achilles complex
  - Tendon elongation
  - Restricts crossbridge formation
- Largest limitations: fast and endrange plantarflexion
- Affects ability to absorb and generate ankle power
- Proximal effects. Risk unknown.
- Rehab: little to change length of tendon
- Focus on stretch-shorten strengthening
- Potential role for chronic endurance training

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