Biomechanics associated with Achilles tendinopathy

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Achilles tendinopathy in runners

Prevalence 6 - 10%
Incidence 9-14%
(Lopes 2012; Van Ginckel 2009; Hein 2014)

General population 6%
Elite runners 36-52%
(Kujala 2005)

Runners 30x more likely
Achilles tendinopathy

Why?

Intrinsic factors

Extrinsic factors

Relative load

Footwear
Surface

Distance
Frequency
Speed
Type

Achilles tendinopathy
Intrinsic risk factors

- Central adiposity
- Increased BMI
- Diabetes mellitus
- Genetics
- Exposure to medications
- Biomechanics
- Age?
- Strength knee flexors, PFs
- DF ROM
- Foot posture

(Brukner & Khan 2016)
Biomechanical factors - running

Kinematics

Kinetics

Neuromotor
Biomechanical factors - running

Kinematics
Kinetics
Neuromotor
### Biomechanical factors - running

#### Frontal plane rearfoot kinematics

<table>
<thead>
<tr>
<th>Measure</th>
<th>Controls</th>
<th>Cases</th>
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</thead>
<tbody>
<tr>
<td>Calcaneus - vertical TDA*</td>
<td>25</td>
<td>25</td>
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<tr>
<td>Calcaneus - tibia TDA</td>
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<tr>
<td>Calcaneal at HS (B)</td>
<td>34</td>
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<tr>
<td>Calcaneal at HS (S)</td>
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<tr>
<td>Eversion at HS (B)</td>
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<td>Eversion at HS (S)</td>
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<tr>
<td>Eversion at 10% stance</td>
<td>25</td>
<td>25</td>
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<tr>
<td>Pronation at 10% stance</td>
<td>25</td>
<td>25</td>
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<tr>
<td>Max pronation</td>
<td>25</td>
<td>25</td>
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<tr>
<td>Calcaneal max (B)</td>
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<td>Calcaneal max (S)</td>
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<td>Eversion max (B)</td>
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<tr>
<td>Max eversion</td>
<td>25</td>
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<tr>
<td>AEV max</td>
<td>35</td>
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<tr>
<td>Eversion ROM (B)</td>
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<td>Eversion ROM (S)</td>
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<tr>
<td>Total pronation ROM</td>
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<tr>
<td>Calcaneal ROM (B)</td>
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<tr>
<td>Calcaneal ROM (S)</td>
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<td>AROM ev/in</td>
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<td>AROM in</td>
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<tr>
<td>Total eversion</td>
<td>25</td>
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<tr>
<td>Calcaneus - tibia TOA</td>
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<tr>
<td>Calcaneus - vertical TOA</td>
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<tr>
<td>Initial velocity</td>
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<tr>
<td>Max pronation velocity</td>
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<tr>
<td>AVEL ev</td>
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<td>Time to max eversion</td>
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<td>Time to max pron</td>
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<td>tAEVmax</td>
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<td>Time to max pron velocity</td>
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<td>tAVEL ev</td>
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<td>AVEL in</td>
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<tr>
<td>Greater in controls</td>
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<tr>
<td>Greater in cases</td>
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</tbody>
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4.8° 2.0°
Biomechanical factors - running

Leg muscle activity

[Diagram showing leg muscle activity with various measurements and percentages, indicating differences between controls and cases.]
Biomechanical factors - running

No difference hip kinematics

↓

Knee flexion (foot contact & mid stance)

↑

Kinematics

No difference GRF

←

Kinetics

Neuromotor

Joint moments?

↓

Gluteus medius & rectus femoris
Post-heel strike
Biomechanical factors – proximal considerations

Frontal/transverse plane

Sagittal plane
Design

**Kinematics**
N=19
37 (8) years
1.8 (0.6) m
77.4 (10.2) kg
37.6 (16.4) km

**Kinetics**
N=14
43 (8) years*
1.8 (0.5) m
82.3 (11.1) kg
38.1 (13.2) km
VISA-A 70 (10)

**Neuromotor**

- VISA
- Kinetic (joint moments)
Kinematics

Degrees

Flex / DF
Add / EVN
ER

CTRL
AT

Degrees

Degrees

Degrees

Degrees
Kinetics – Peak

CTRL
AT

Flex / DF
Add / EVN
ER
Kinetics – Impulse

![Diagram showing kinetics and impulse with graphs and data points.]

CTRL AT
Kinetics – Impulse

CTRL

AT
Kinetics - peak

- Flex / DF
- Add / EVN
- ER

CTRL
AT
AT + FO

Nm/Kg

Flex / DF
Add / EVN
ER

CTRL
AT
AT + FO
Kinetics - peak

CTRL
AT
AT + FO

Flex / DF
Add / EVN

Nm/Kg

-1
-0.5
0
0.5
1

-1
-0.5
0
0.5
1

A green check mark indicates that the peak is within the acceptable range.
Kinetics - impulse

Flex / DF | Add / EVN | ER
----------|-----------|------
CTRL      | AT        | AT + FO
Nm.Sec/Kg | Nm.Sec/Kg | Nm.Sec/Kg

CTRL
AT
AT + FO
Kinetics - impulse

CTRL
AT
AT + FO

Flex / DF
Add / EVN
ER

Nm / Kg

Nm.Sec / Kg
Neuromotor

SOL offset 18 (22) ms earlier relative to LG
Neuromotor
Summary of findings – AT vs CONTROL

No difference hip/ankle/knee kinematics
(Creaby 2017; Azevedo 2009)

Delayed & shorter duration GMED, GMAX
Less synchronous triceps surae
(Franetttovich Smith 2014; Wyndow 2013; Azevedo 2009)

Increased hip joint moments
No difference knee/ankle moments
(Creaby 2017; Kim 2015)

Pre-existing?
Compensation?
Biomechanical factors – what evidence?

Cross-sectional vs Prospective

Running biomechanics vs Achilles tendinopathy
Biomechanical factors – what evidence?

Cross-sectional vs Prospective

13 studies
• Kinematics (7)
• Kinetics (7)
• Neuromotor (5)

3 studies
• Kinematics (2)
• Kinetics (2) - PP

14 studies runners
Biomechanical factors – prospective studies

- More laterally directed force at forefoot FF
- More medially directed force distribution MS
- Decreased total displacement of COF (van Ginckel 2009)
- No difference dynamic arch index (Kaufman 1999)
- Ankle DF Eversion (Hein 2014)
- Knee flexion (Hein 2014)

Neuromotor?
Kinetics?
(joint moments)
Take home message

Include proximal assessment

(...in addition to local)
Summary of findings – AT with ORTHOSES

No difference hip kinematics / joint moments / gluteal control
(Boldt 2013)

Reduced impulse & peak eversion moment
(McMillan 2008)
Take home message

Individualised approach

(Arnold 2018; Bishop 2016; Mundermann 2003; Scott 2015)
Neuromotor Control of Gluteal Muscles in Runners with Achilles Tendinopathy

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Hip Biomechanics Are Altered in Male Runners with Achilles Tendinopathy

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Triceps surae activation is altered in male runners with Achilles tendinopathy

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Hip
• No difference (Azevedo 2017; Creaby 2017)

Knee
• Reduced knee flexion (Azevedo 2009)
• Greater knee flexion (Donoghue 2008; Hein 2014)
• No difference (Creaby 2017)

Foot/ankle
• Greater eversion ROM (Hein 2014; Donoghue 2008; Ryan 2009; McCrory 1999; Becker 2017)
• Reduced DF (Hein 2014)
• Greater DF ROM (Donoghue 2008)
• No difference eversion or DF (Creaby 2017)
• **GRF variables**
  - Delay reaching peak forces (McCrory 1999)
  - Increase in braking forces (McCrory 1999)
  - No difference (Azevedo 2009; Baur 2004)

• **Plantar pressures**
  - Laterally directed force distribution beneath forefoot FF (van Ginckel 2009)
  - More medially directed force distribution during midstance (van Ginckel 2009; Baur 2004)
  - Reduced total forward progression of COF (van Ginckel 2009)

• **Joint moments**
  - Reduced peak tibial external rotation moment (Williams 2008)
  - Reduced hip extension moment (Kim 2015)
  - Increased hip adduction & external rotation moment (Creaby 2017)
  - Reduced knee flexion moment (Kim 2015)
Plantar pressures

(Munteanu 2011; Ogbonmwan 2018)

Reduced total forward progression of COF

Laterally directed force distribution beneath forefoot at foot flat

More medially directed force during midstance
Neuromotor

(Munteanu 2011; Ogbonmwan 2018)

↓ Gluteus medius
   Post-heel strike
   (Azevedo 2009)

↓ Rectus femoris
   Post-heel strike
   (Azevedo 2009)

↓ Peroneus longus
   Weight acceptance
   (Baur 2011)

↓ Medial gastrocnemius
   Weight acceptance
   (Baur 2011)

↓ Tibialis anterior
   Pre-heel strike
   (Azevedo 2009)

↓ Gluteus medius & maximus
   Delayed onset
   Reduced duration
   (Franettovich 2014)

↓ Medial gastrocnemius
   Increased duration (Baur 2004)
   Earlier offset of SOL relative to LG
   (Wyndow 2013)

↓ Tibialis anterior
   Delayed onset (Baur 2004)