# Assessment Diagnosis and Treatment of Musculoskeletal (MSK) Foot and Ankle Problems

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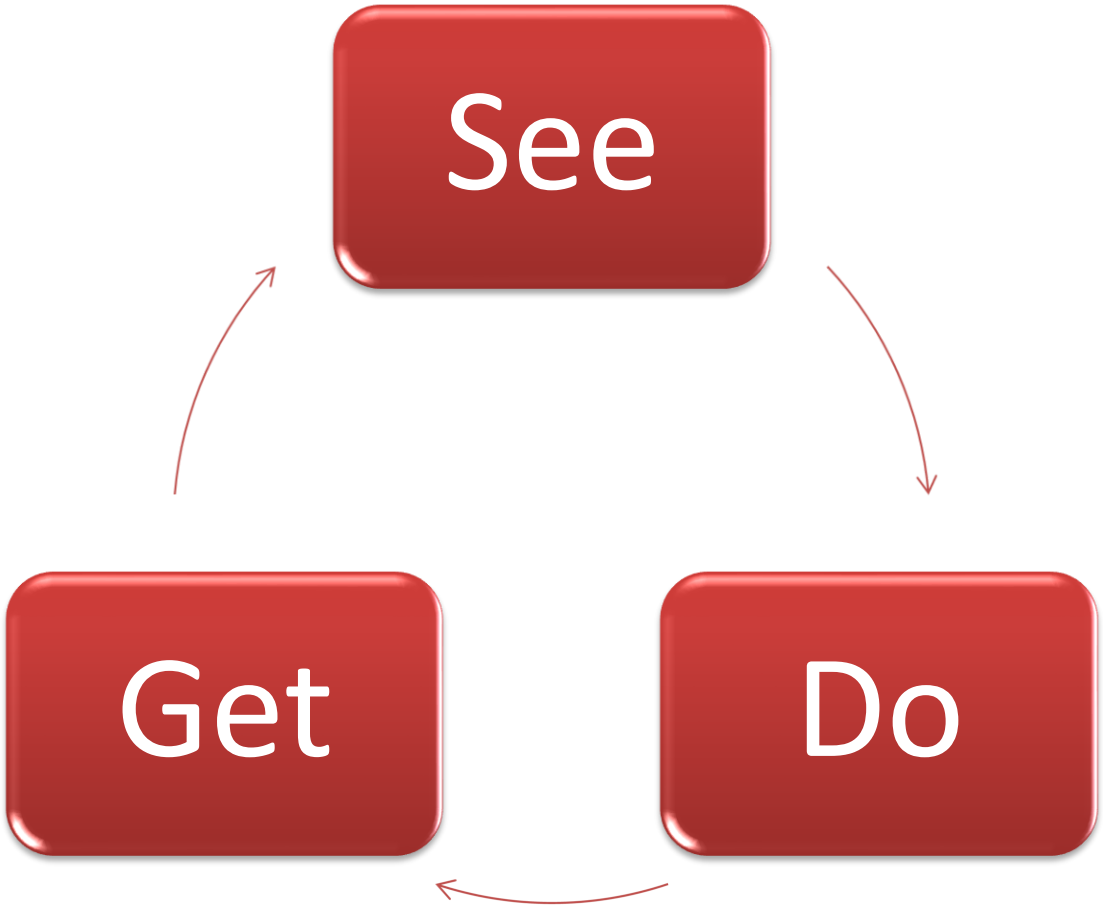
# Problem Solving



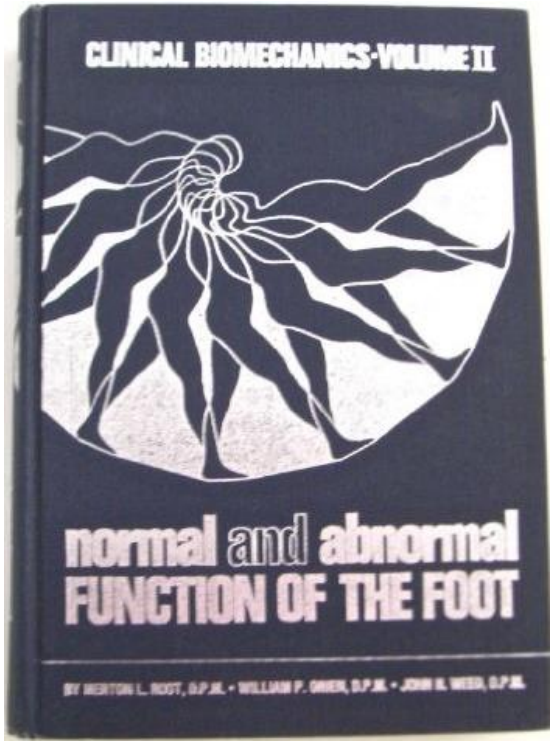
# What do foot orthoses do?

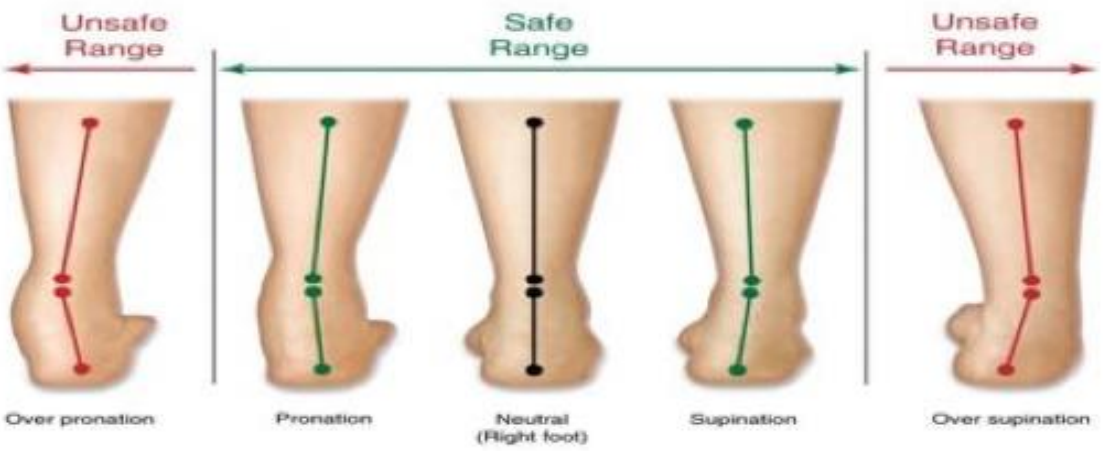
- “Correct the foot to neutral alignment”
- “Prevent excess pronation”
- “Correct spinal deformity”
- “Correct cranial and atlas malalignment”
- “Improve vascular supply”
- “Heal arthritis”
- “Reduce wrinkles”
- “Improve sex life”

# Merton Root, John Weed, William Orien, (1977)

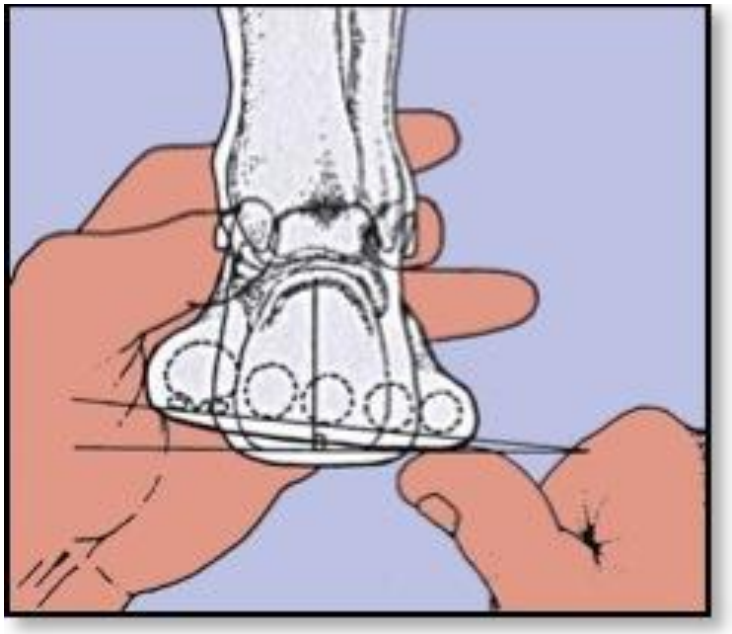
Proposed that all feet which did not meet the criteria for “normal” displayed structural deficits and were therefore “abnormal”.

Developed a classification system based on the concept that subtalar joint neutral was the best foot position for gait.



# Subtalar neutral



# What is wrong with this concept?

1. Insoles can be used to improve alignment
2. There is a universally “optimal” foot alignment
3. “Non-optimal” foot alignment predisposes injury
4. Defining the term “excess pronation”

# Problem number 1:
# Can insoles change foot alignment?

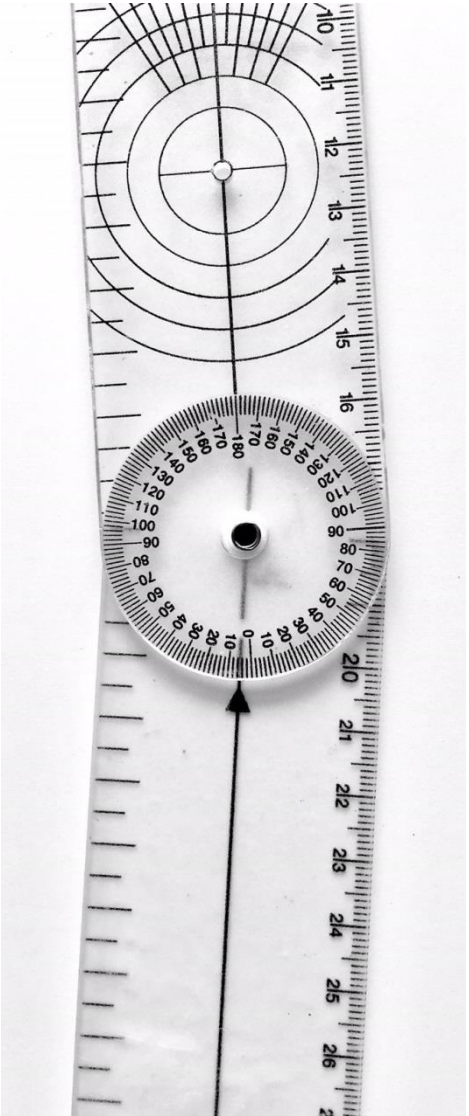
- Stacoffa et al, 2000. Found an average 1-3 degree eversion reduction when running with use of a 20 degree posterior medial inclined orthosis when running.

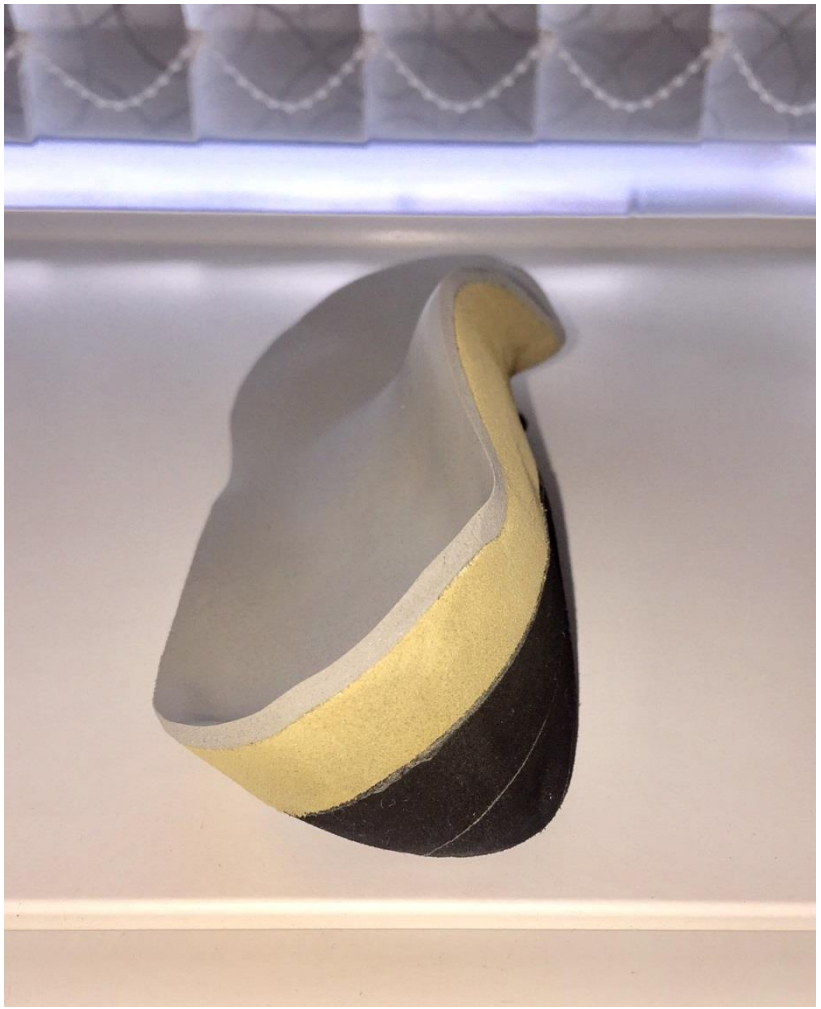
- Telfer et al, 2013. Found an average 0.26 degree decrease in eversion per 2 degree medial heel wedging when walking.

- Mills et al, 2009 and Cheung et al, 2011 systematic reviews and meta-analyses, show on average a 2.1 - 2.2 degree reduction in eversion with the use of foot orthoses. Some studies actually show an increase to calcaneal eversion with the use of such orthoses

- **Subject specific responses!**

# Problem number 1:
# Can insoles change foot alignment?





# Problem number 2 & 3:
# Is foot alignment related to injury?

- Buchanan et al, 2005. Found that 92% of asymptomatic individuals had a forefoot varus.

- Jarvis et al, 2017. Found 100% of asymptomatic participants presented with a forefoot deformity as defined by Root et al.

- Neal et al, 2014. Systematic review and meta-analysis, show no relationship between foot type and the likelihood of developing **any** foot or ankle pathology, bone stress reaction or non-specific lower limb overuse injury.

  The only strong correlation exists between pronated foot posture and medial tibial stress syndrome.

# Problem number 2 & 3:
# Is foot alignment related to injury?

Can insoles be used for prevention of foot ankle ankle injury?

- Bonanno 2016, systematic review and meta-analysis – contoured foot orthoses are not found to prevent the likelihood of developing any soft tissue injury.
- “Shock absorbing” insoles are not effective for the prevention of any type of injury.
- Contoured foot orthoses provide a 41% reduction in lower limb stress fracture in runners only.
- Bonanno 2017, RCT, prefabricated Foot Orthoses reduced injury in Navy recruits by 38%

# Problem number 4:
# What is “excess pronation” and why is it so bad?

# Jan Bruckner, “Variations in the Human Subtalar Joint” (1987)

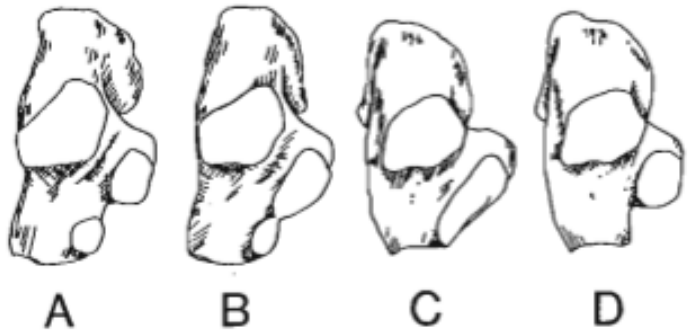



Fig. 3. *Superior view of right calcanei depicting variations in subtalar joint facet number: A, three-facet configuration; B, transitional two-facet configuration; C, simple two-facet configuration; D, special two-facet configuration.*

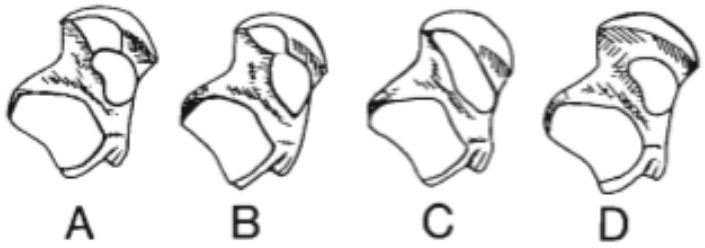



Fig. 4. *Inferior views of right tali depicting variations in subtalar joint facet number: A, three-facet configuration; B, transitional two-facet configuration; C, simple two-facet configuration; D, special two-facet configuration.*

# Thomas McPoil and Gary Hunt (1995)

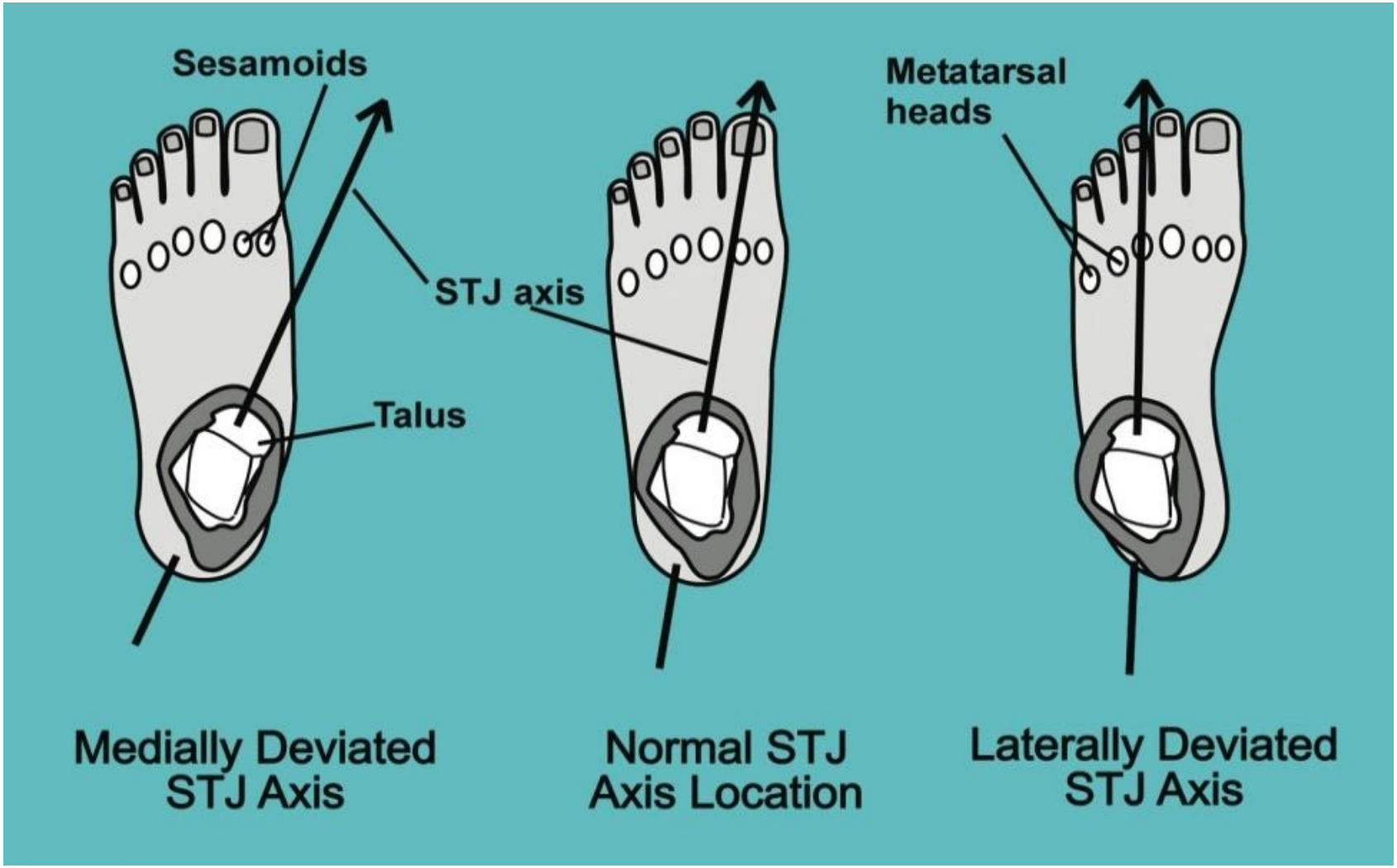
"Tissue stress" first proposed as a model for treatment of the foot with mechanical therapy

Abnormal movement will increase the strain in some tissues

Prolonged strain can lead to plastic deformation

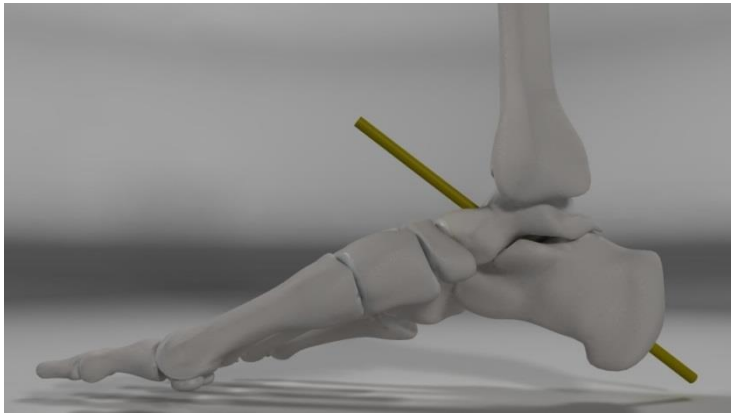
Outlined issues with the reliability of subtalar neutral theory

# Dr Kevin Kirby – SALRE theory (2001)

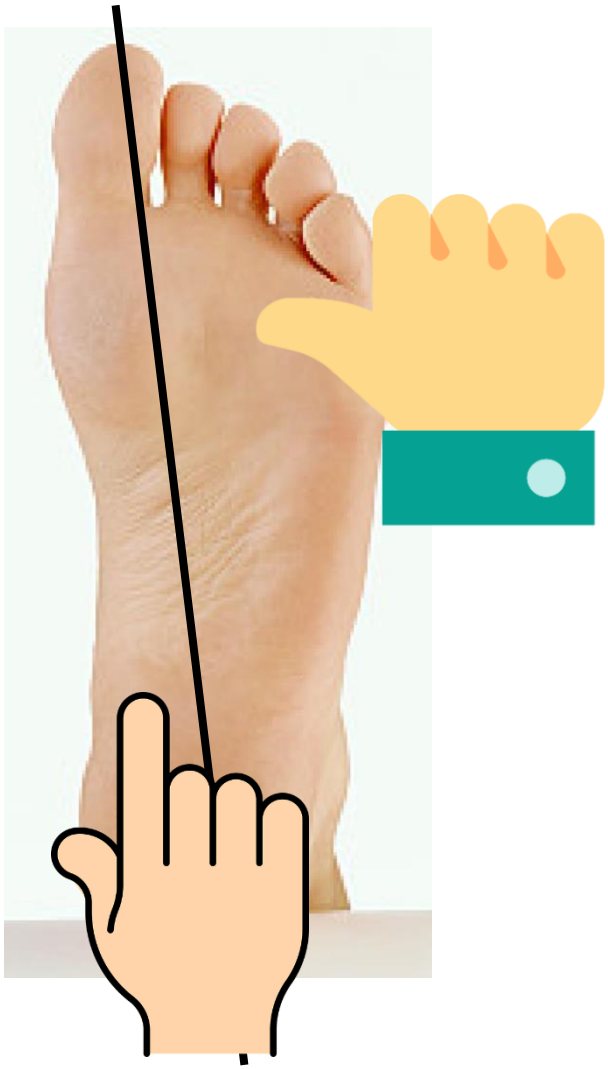


# STJ Axis Location

- Joint Axis is center of rotation for a joint
- Axis determines ROM
- ROM Determines Axis
- Axis varies according to bony geometry
- STJ axis average location is 16 degrees in transverse plane and 42 degrees in the sagittal plane



# NWB STJ Axis Location Assessment



- Vertical Forces Applied medially to STJ axis will generate a supination moment

# NWB STJ Axis Location Assessment

- Vertical Forces Applied laterally to STJ axis will generate a pronation moment
- Forces applied to axis will not supinate or pronate foot
- Find and mark 2 points on plantar surface of foot to determine axis

# Subtalar Joint Axis Location W/B Assessment

- Stand patient barefoot
- Palpate talus while supinating and pronating foot
- Mark centre of talus head when patient in relaxed stance position
- Transpose mark to posterolateral heel to approximate STJ axis location

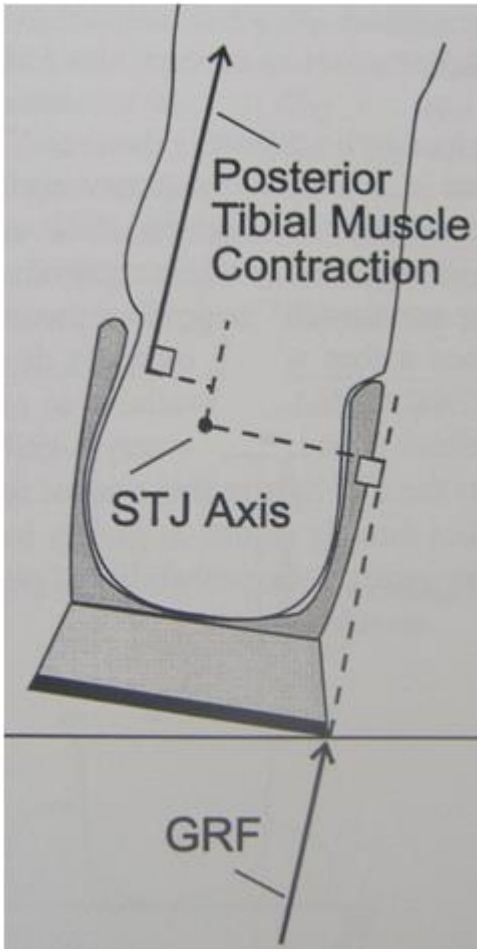
# Effects of Medially Deviated STJ Axis

Transverse plane 16 degrees medial of midline

Axis Location Changes from patient to patient

Change in axis-location will require change in orthotic specification

Palpation technique developed in 1987



# Orthoses and tissue stress

- Garbalosa et al, 2016 – EMG found reduced muscle activity in the tibialis posterior with the use of “full contact” foot orthoses
- Moisan et al, 2016 - EMG found that insoles with a lateral forefoot wedge decreased amplitude and activity of the peroneus longus muscle during mid-stance/terminal stance. Insoles decreased amplitude and activity of the tibialis anterior muscle at initial contact.
- Murley and Bird, 2006 - Peroneus longus maximum EMG amplitude increased significantly with the use of a 15° inverted orthosis
- Murley et al, 2010 – Tibialis posterior amplitude significantly decreased with the use of custom inverted and prefabricated insoles
- Kogler et al, 1999 – Significant decrease in plantar fascia strain with the use of lateral forefoot wedging

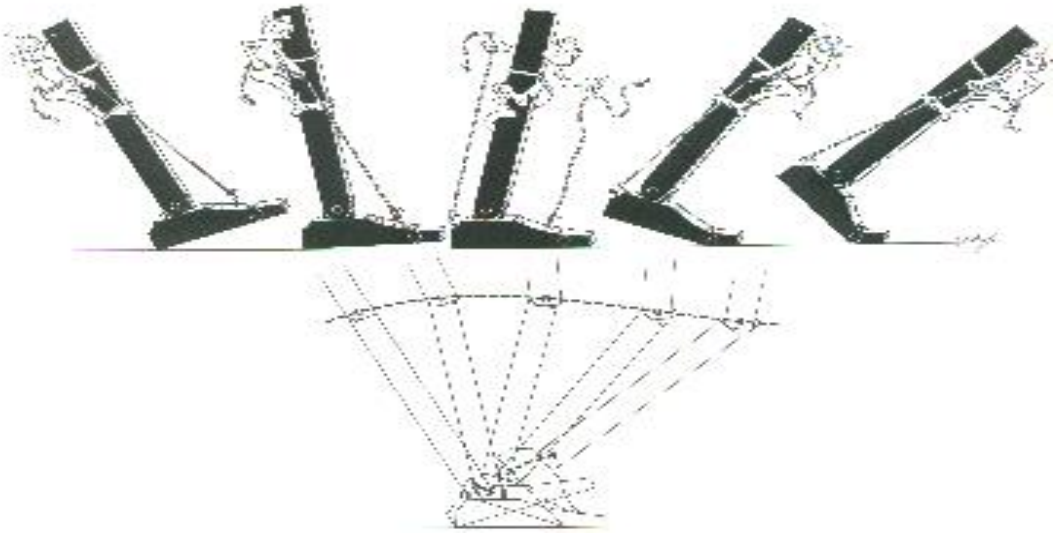
# Chris Nester, “Invasive in vivo measurement of rear, mid and forefoot function motion during walking” (2008)

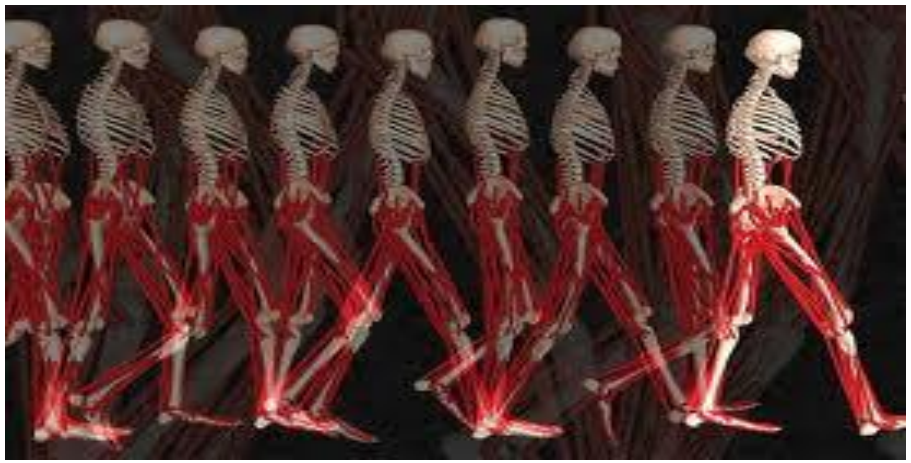
Pioneering investigation of joint kinematics in live and cadaveric subjects - walking and running

**Table 1 Mean total ranges of motion (ROM) and standard deviations of motion about selected joints in the sagittal, frontal and transverse planes during walking. Data from six healthy, male subjects. From Lundgren et al., 2008.**

| plane | calc-tib | | calc-tal | | nav-tal | | cub-calc | | cub-nav | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ROM [°] | SD | ROM [°] | SD | ROM [°] | SD | ROM [°] | SD | ROM [°] | SD |
| **sag** | 17.0 | 2.1 | 6.8 | 1.4 | 8.4 | 1.1 | 9.7 | 5.2 | 7.2 | 2.4 |
| **front** | 11.3 | 3.5 | 9.8 | 1.8 | 14.9 | 6.1 | 11.3 | 3.9 | 8.8 | 4.4 |
| **trans** | 7.3 | 2.4 | 7.5 | 2.0 | 16.3 | 6.5 | 8.1 | 2.0 | 8.9 | 4.3 |

# Howard J. Dananberg, “Sagittal Plane Biomechanics” (2000)





# Sagittal Plane Biomechanics

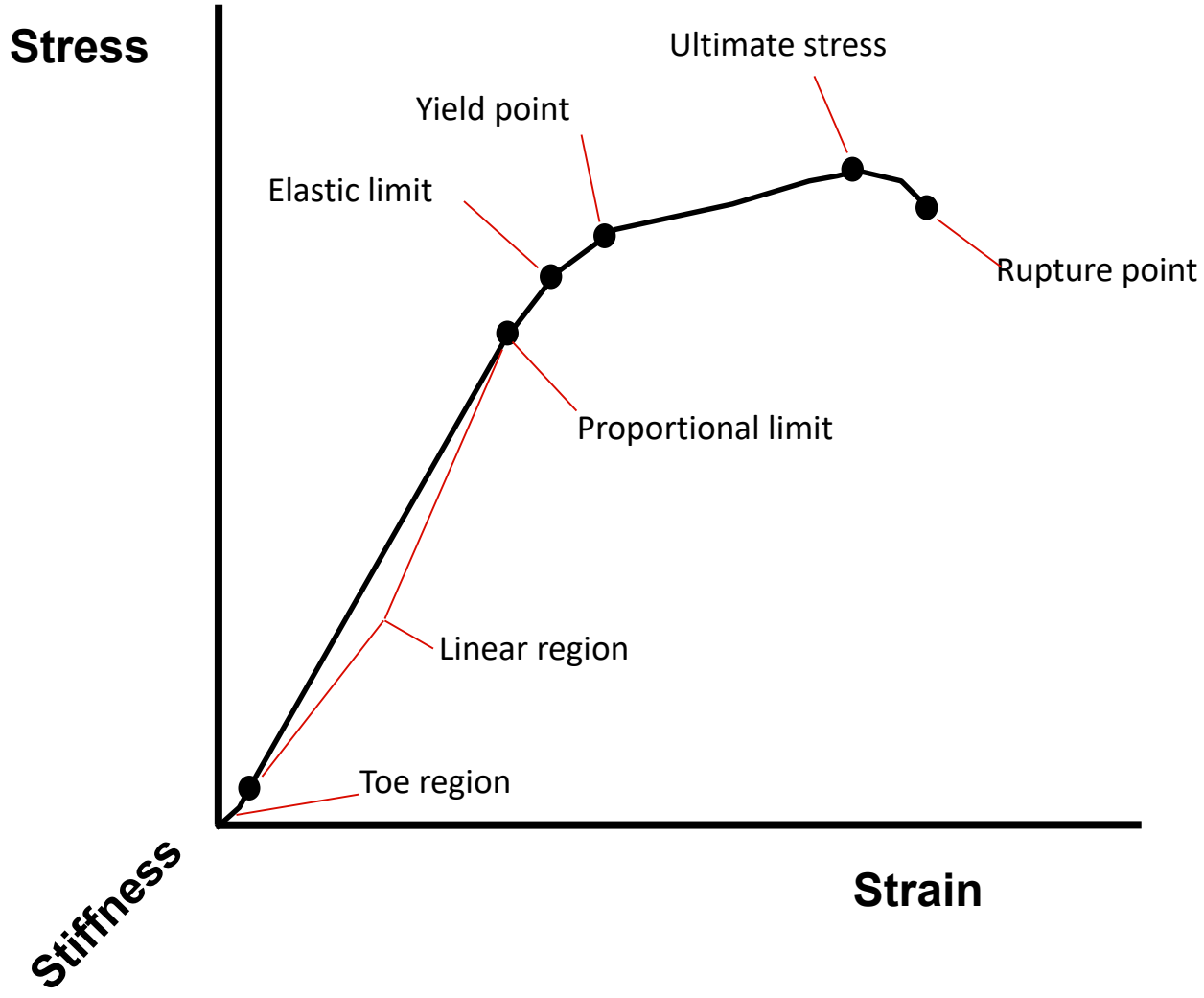
**Enemies of Foot & Ankle Function!!!!!!**

- Reduced Ankle Dorsiflexion
- Forefoot Equinus
- MTP dorsiflexion stiffness (structural or function)

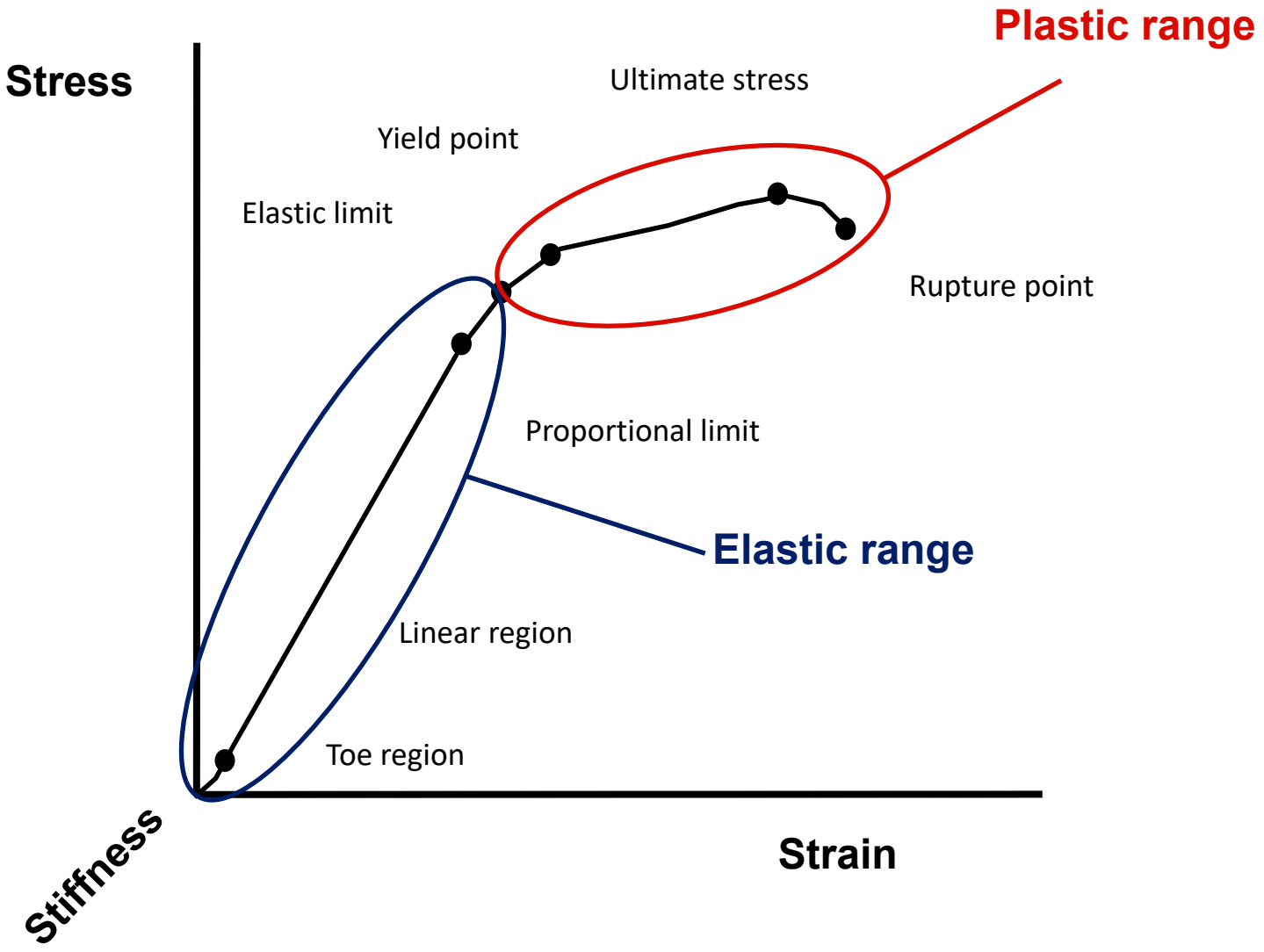
****All of the above significantly change load rate and load duration****

# So what?

# Material load testing machine stress/strain curve



# Material load testing machine stress/strain curve



# Zone of optimal stress (ZOOS)

- Two options to prevent tissues from functioning outside of their zone of optimal stress:

  [1] reduce the stress
  [2] increase the ZOOS

# Old Thinking/Theory

- Focus on Alignment
- Sub-Talar Neutral
- PRONATION
- Mal-alignment is predictive of injury

"Foot orthotics work by re-aligning feet and the kinetic chain"

# New Thinking/Evidence

- Pronation is a movement not a diagnosis
- Alignment not important in predicting injury or prescribing an Orthotic
- Orthoses reduce stress on soft tissues/joints by changing the way feet are loaded and move

Without insoles

With insoles

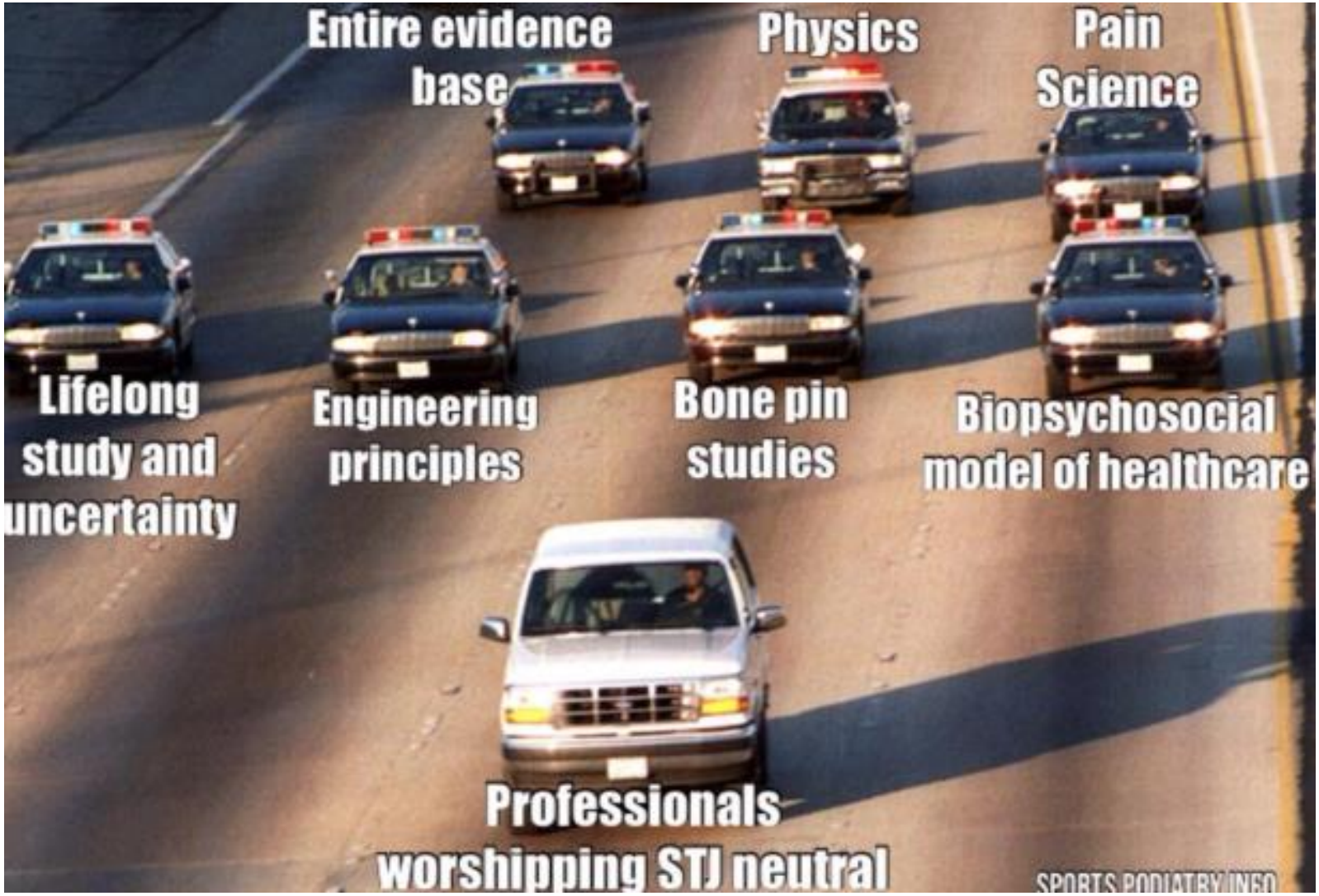
# Padawan vs Jedi!!!!!

# New Thinking

- Orthoses are a clinical tool (and may not be needed permanently)
- Orthoses on their own can potentially cause intrinsic muscle weakness
- Orthoses should be used in combination with strengthening/load management/stretching programmes
- As pain resolves remove orthoses gradually (if possible)

# Biomechanical objectives of orthotic intervention

- Make the complex simple
- Identify tissues under increased strain
- Apply forces to reduce pathologic loading forces to those tissues
- Maximise sagittal plane biomechanical function
- Load Management Strategy
- Don’t forget 1st Line Interventions……


Entire evidence base
Physics
Pain Science
Lifelong study and uncertainty
Engineering principles
Bone pin studies
Biopsychosocial model of healthcare
Professionals worshipping STJ neutral
SPORTS PODIATRY INFO

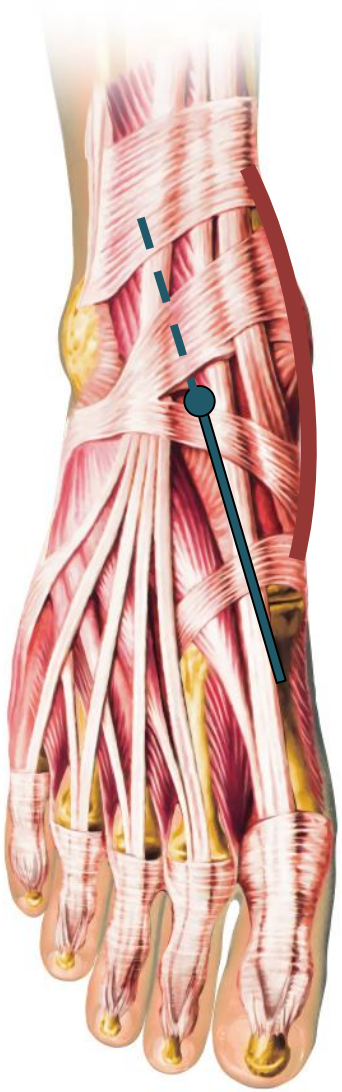
Relationship between foot pain, muscle strength and muscle size: a systematic review

Latey et al, 2017

Foot orthoses for plantar heel pain: a systematic review and meta-analysis
Whittaker et al, 2018

# Combined intervention

# Strengthening – Tibialis Posterior

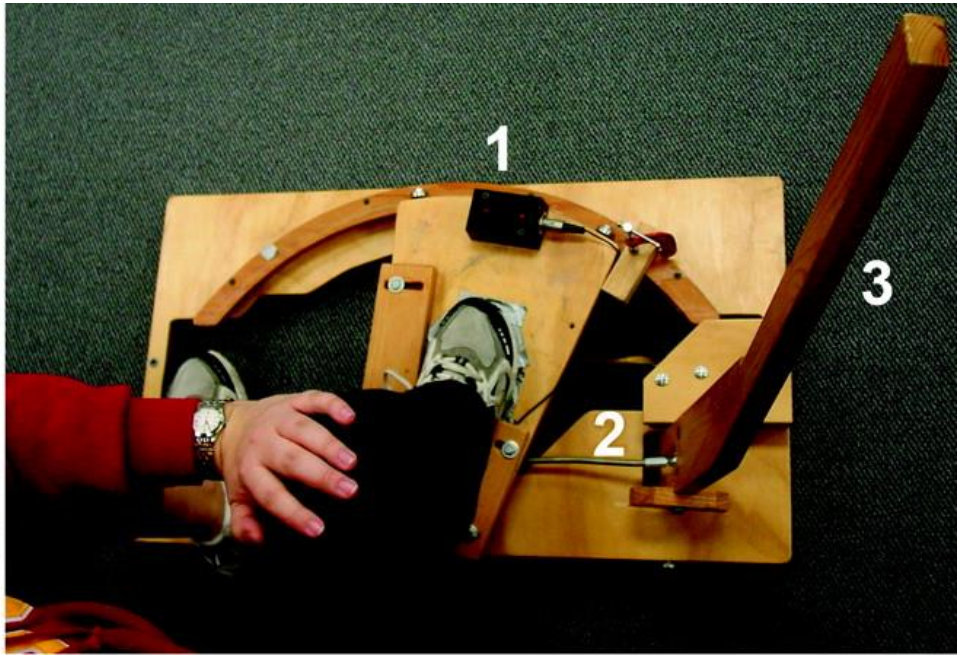


A 10-week twice daily, progressive eccentric tendon loading, calf stretching program with orthoses was implemented with ten, early stage tibialis posterior tendinopathy subjects.

<u>6 Month follow up:</u>
Reduction in functional foot index for pain ($p<0.05$)
Reduction in functional foot index for disability ($p< 0.05$)
Increase in number of single heel raises ($P=0.041$)

(Kulig et al., 2009a)

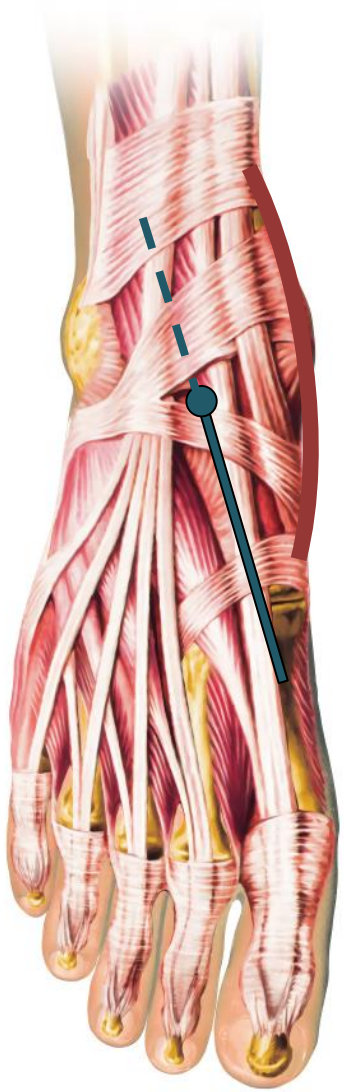
# Strengthening – Tibialis Posterior

# Strengthening – Tibialis Posterior

Alternatives?!

# Strengthening – Tibialis Posterior



49 subjects with Grade 1 to 3 TPTD. Randomly assigned to home-based rehabilitation (21 cases) or center-based rehabilitation (28 cases).

(Bek et al., 2012)

<u>3 week follow up:</u>

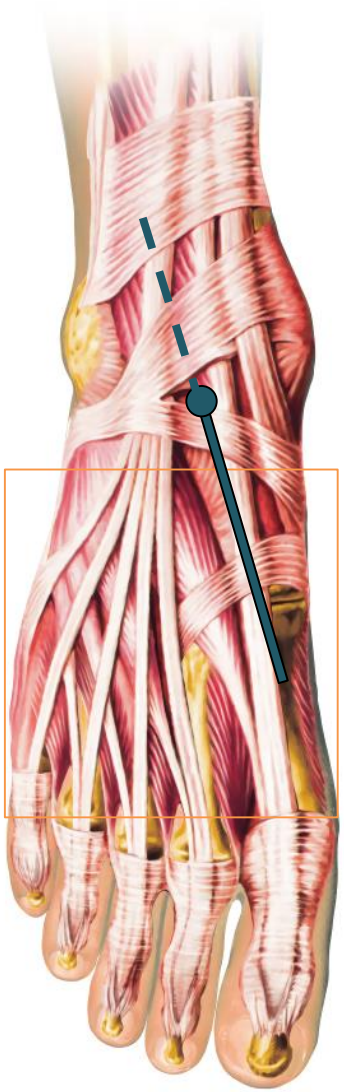
Centre based rehabilitation: Reduction in pain, first MTP joint angle, forefoot abduction angle, functional foot index scores and foot and ankle muscle strengths ($p < 0.05$)

**Table 5.** Intergroup comparison of parameters measured after treatment.

| | z | p |
|---|---|---|
| Pain intensity | -0.014 | 0.989 |
| 1st metatarsophalangeal articular angle | -0.112 | 0.911 |
| Subtalar articular angle | -0.187 | 0.851 |
| Forefoot abduction angle | -0.620 | 0.535 |
| Foot function index | -1.500 | 0.134 |
| Tibialis posterior strength | -2.330* | 0.020* |
| Gastrocnemius strength | -0.549 | 0.583 |
| Gastrocnemius-soleus strength | -1.373 | 0.170 |
| Tibialis anterior strength | -1.397 | 0.162 |
| Peroneus longus strength | -3.329 | 0.001 |
| Peroneus brevis strength | -1.569 | 0.117 |
| Extensor digitorum communis strength | -0.389 | 0-697 |

*p<0.05

# Strengthening – Plantar intrinsics

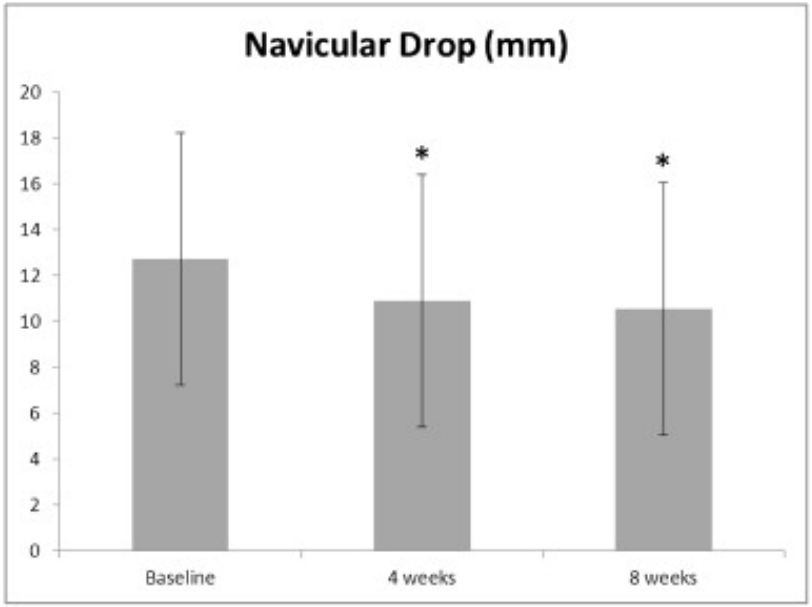


21 subjects performed sets of 75 repetitions of isotonic flexion contractions of the intrinsic foot muscles against a 4.55 kg weight on a custom pulley system. Navicular drop was measured before and directly after.

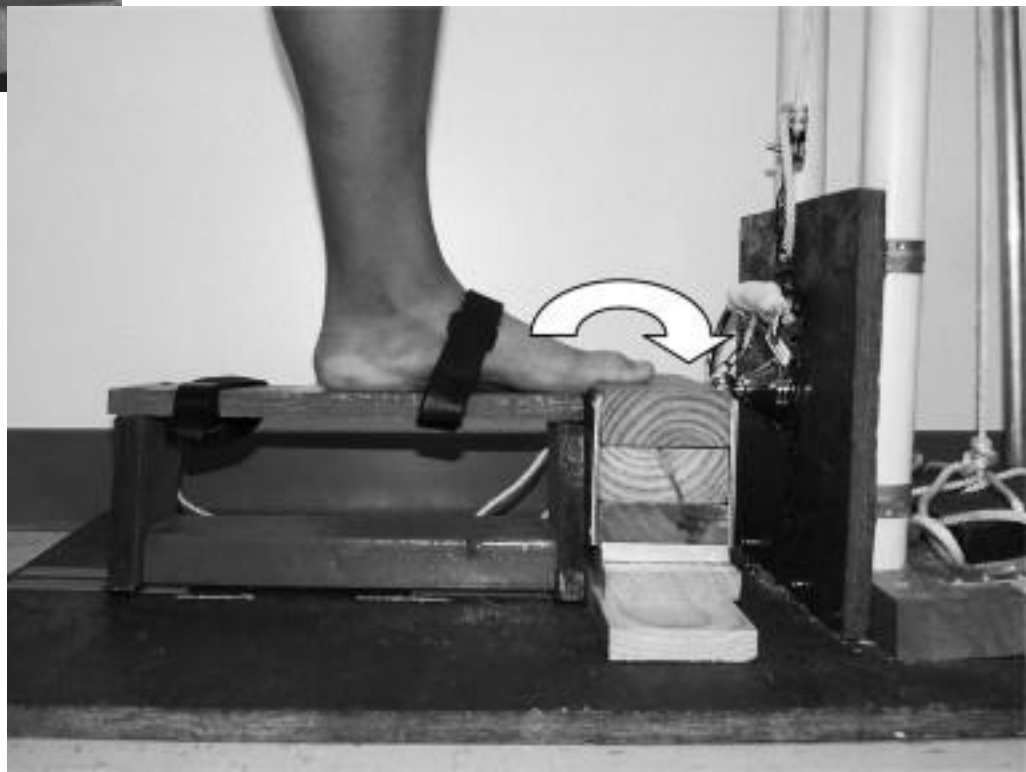
Results: 10.0 ± 3.8 mm of navicular drop at baseline and 11.8 ± 3.8 mm after fatigue ($p < 0.0005$) (Headlee et al., 2008)

21 subjects undertook 4 weeks of progressive intrinsic muscle training. (Mulligan et al., 2013)

Results:
Navicular drop decreased by a mean of 1.8 mm at 4 weeks and 2.2 mm at 8 weeks ($p < 0.05$)



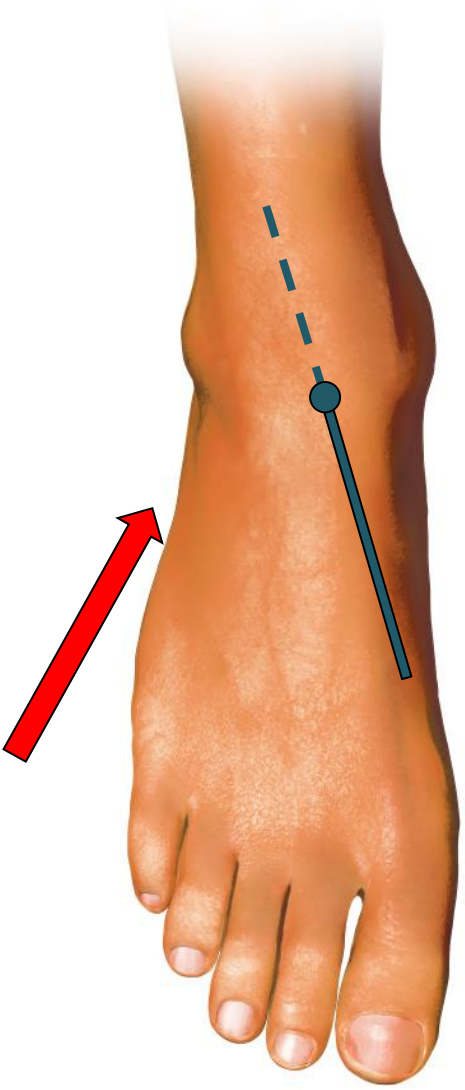

* $p < 0.05$



(Headlee et al, 2008)

Alternatives?!

# Combined intervention

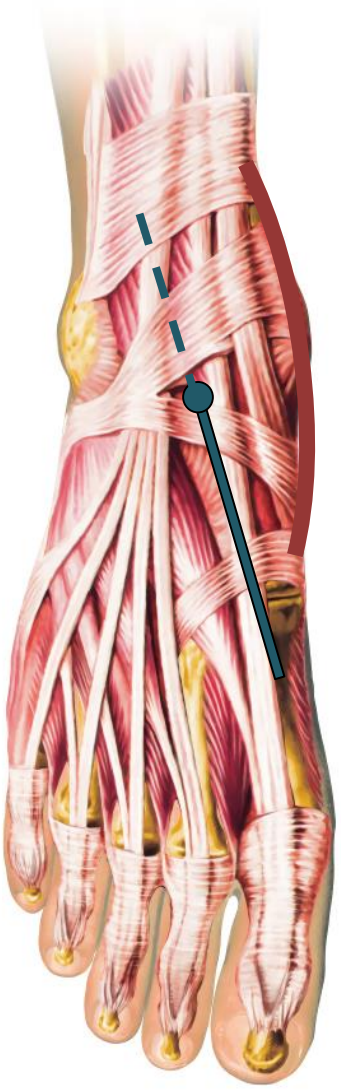


36 participants with stage I or II TPTD were randomly assigned to complete a 12-week program of:
**(1)** orthoses wear and stretching;
**(2)** orthoses wear, stretching, and concentric progressive resistive exercise, or;
**(3)** orthoses wear, stretching, and eccentric progressive resistive exercise.

(Kulig et al., 2009b)

Foot Functional Index scores (total, pain, and disability) decreased in all groups after the intervention. Pain after the 5-minute walk test reduced signficantly in all groups.

**Group (3)** demonstrated the most improvement in each subcategory
**Group (1)** demonstrated the least improvement.



Alternatives?!

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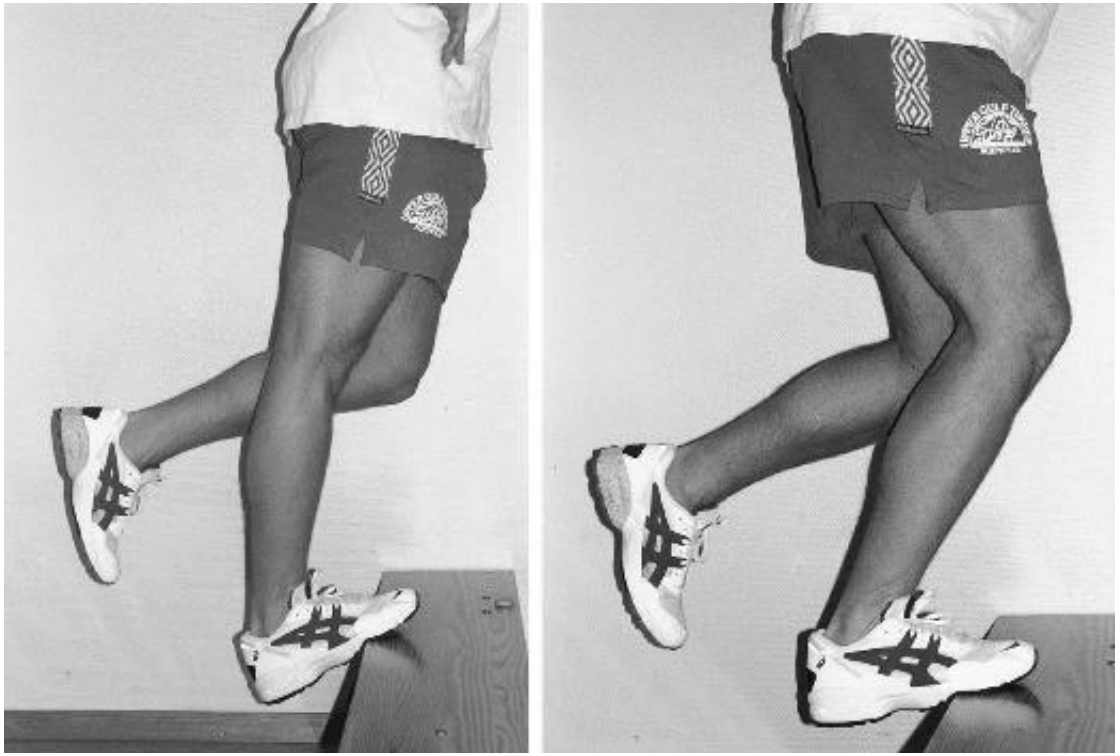
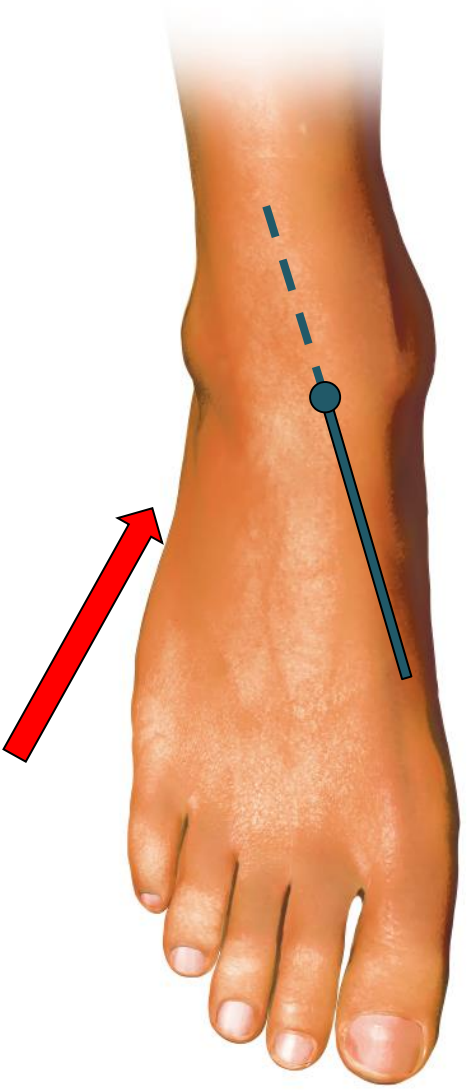


Heel drop.  Changes the mechanical stiffness of the Achilles tendon and specifically the gastrocnemius, (Leung et al 2017)

Increased range of motion is achived likely due to improved stretch tollerance rather than tendon or muscular lengthening (Konrad, 2014)

# Combined intervention

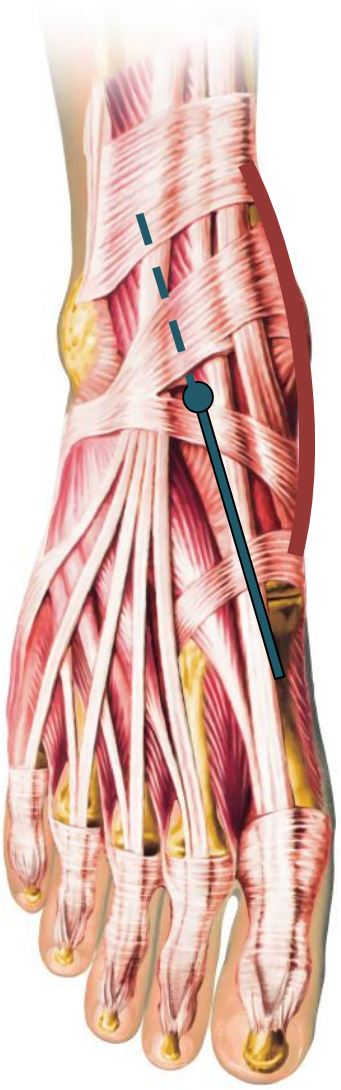


39 participants with stage II TPTD randomly assigned to 12 week regime of (1) orthosis with stretching (2) orthosis with stretching and strengthening. Outcome measures FFI and Short MSK Function Assessment at 6 and 12 week follow up. (Houck et al., 2015)

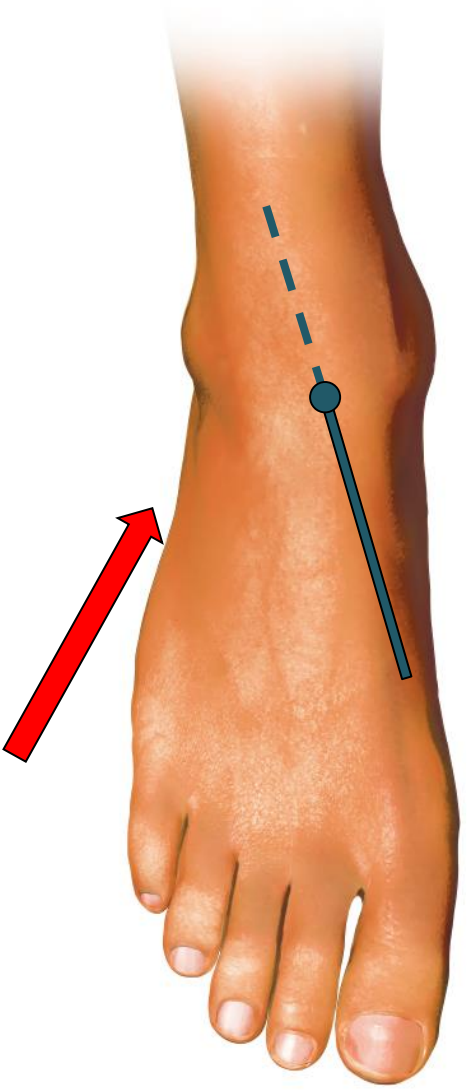
<u>Results:</u>

Significant improvement in pain and function for both groups throughout the 12-week trial period.

Minimal differences between the treatment groups.



# Combined intervention

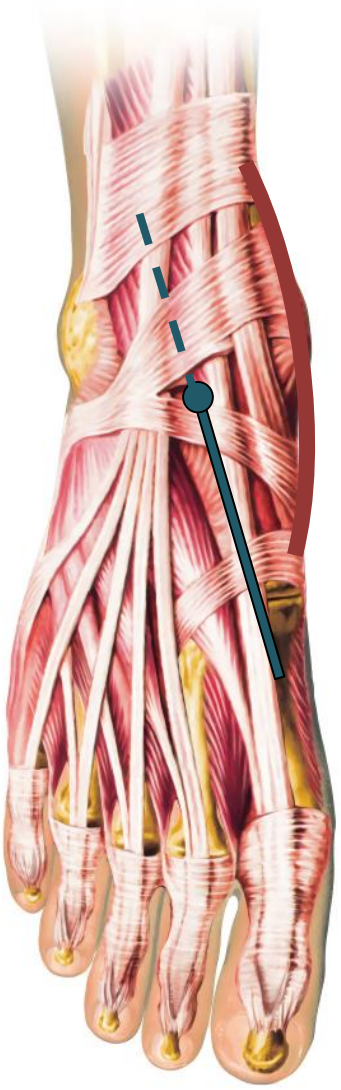


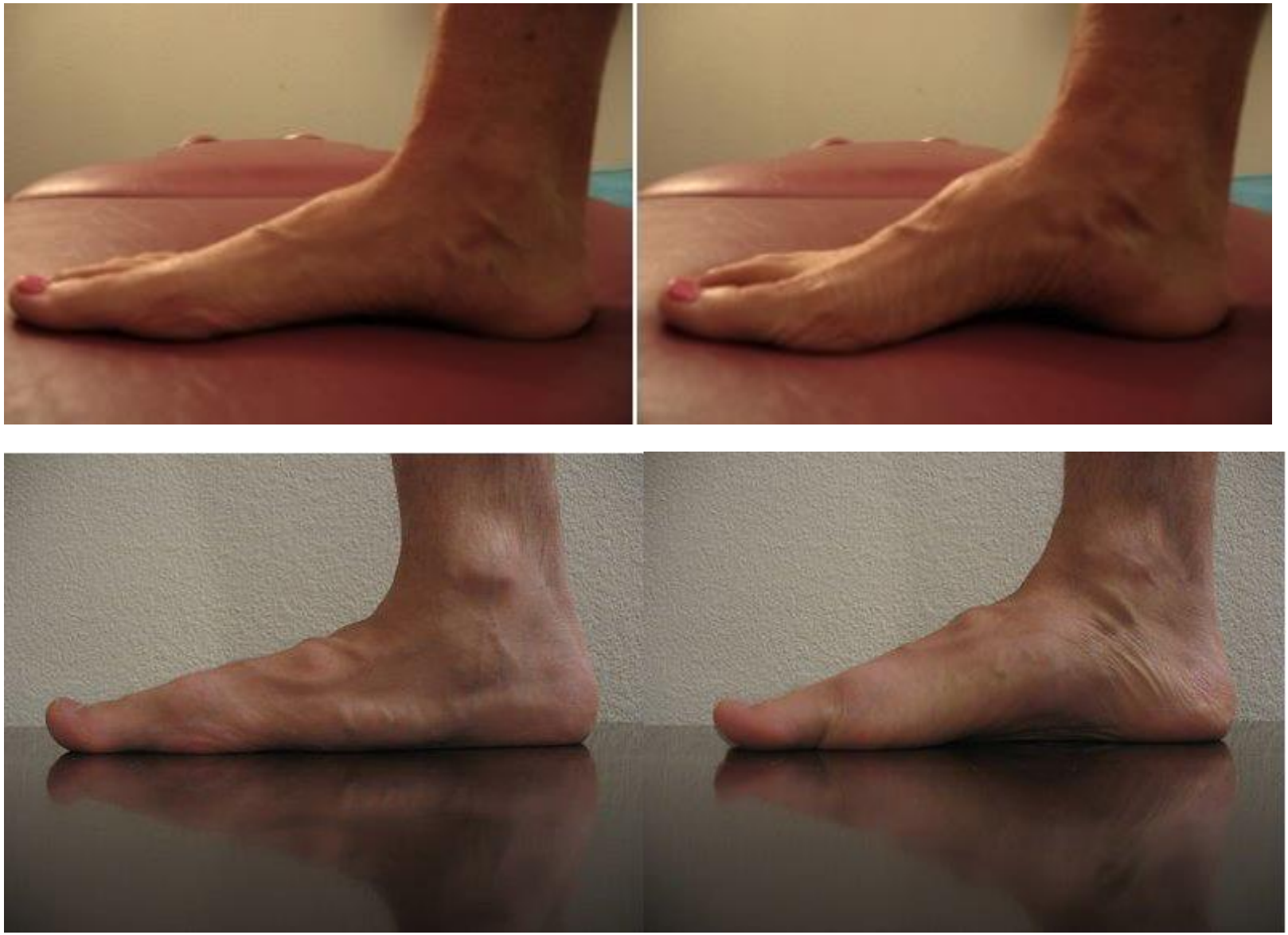
28 subjects with mobile pes planus were randomly assigned to insole treatment alone, or combined insoles and Intrinsic muscle strengthening. (Jung et al 2011a)

<u>Results:</u>

cross sectional muscle area and strength significantly improved in both groups (P<0.00), but significantly greater improvements were found in the combined therapy group compared with the insole only group (P=0.008)

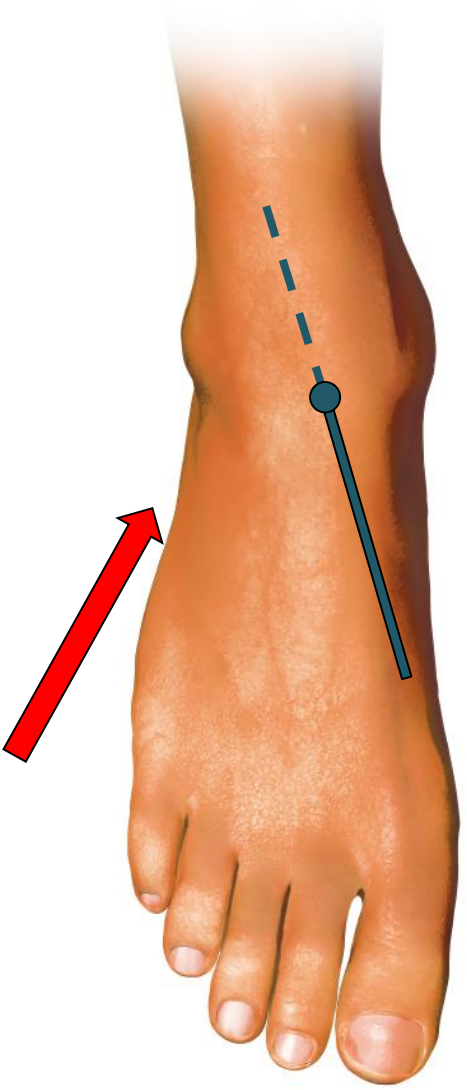
Systematic review by Ashford et al in 2016 concurred with these findings





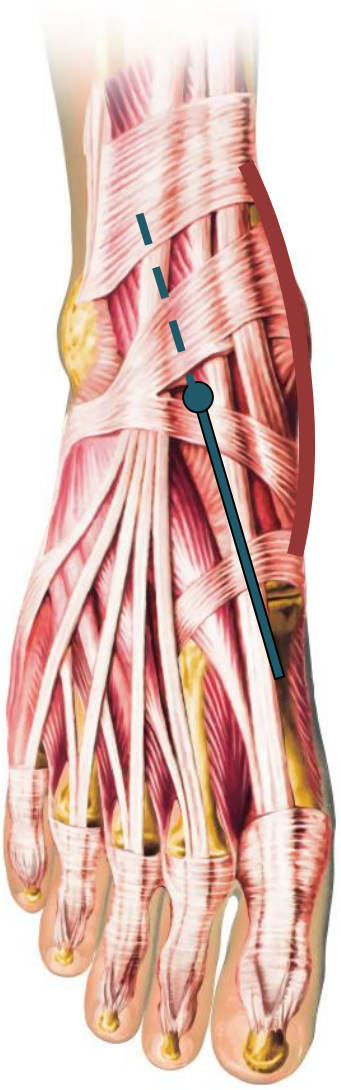
Alternatives?!

# Combined intervention

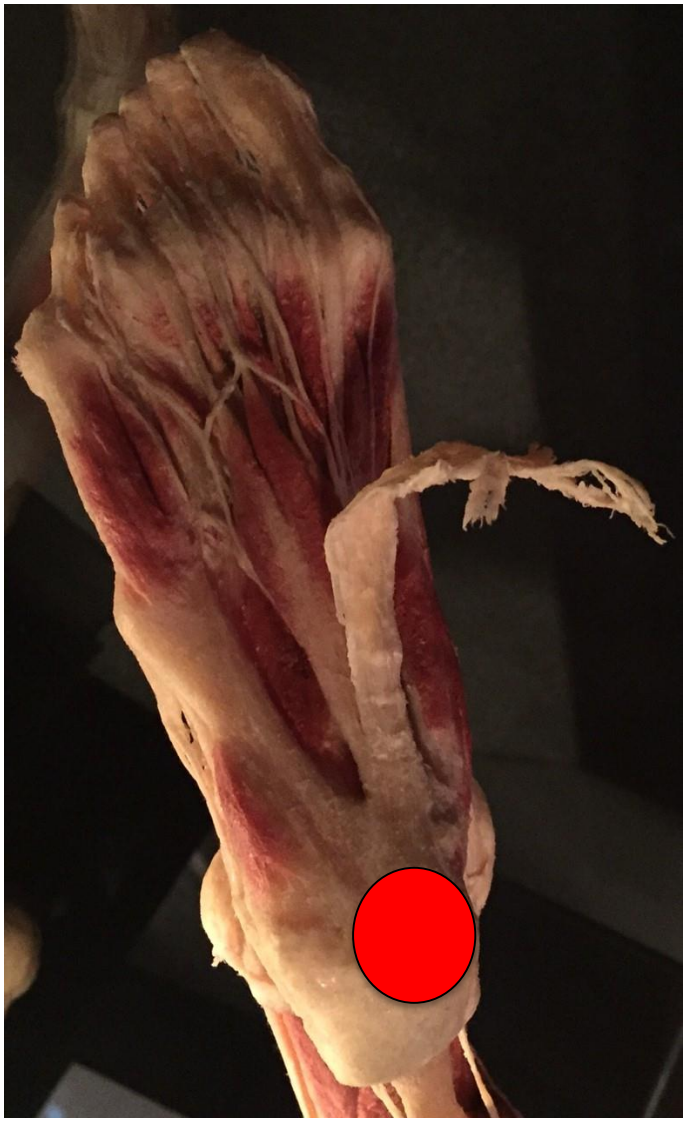


EMG studies compared short foot exercises and toe curl exercises in single leg stance. The former produced significantly greater muscle activation (73.2% vs 17.5%) (Jung et al 2011b)

EMG study comparing ankle positions while performing the short foot exercise found siginficantly higher amplitude in a plantigrade or dorsiflexed ankle position (Yoon et al 2017)



# Plantar heel pain – treatment regimes



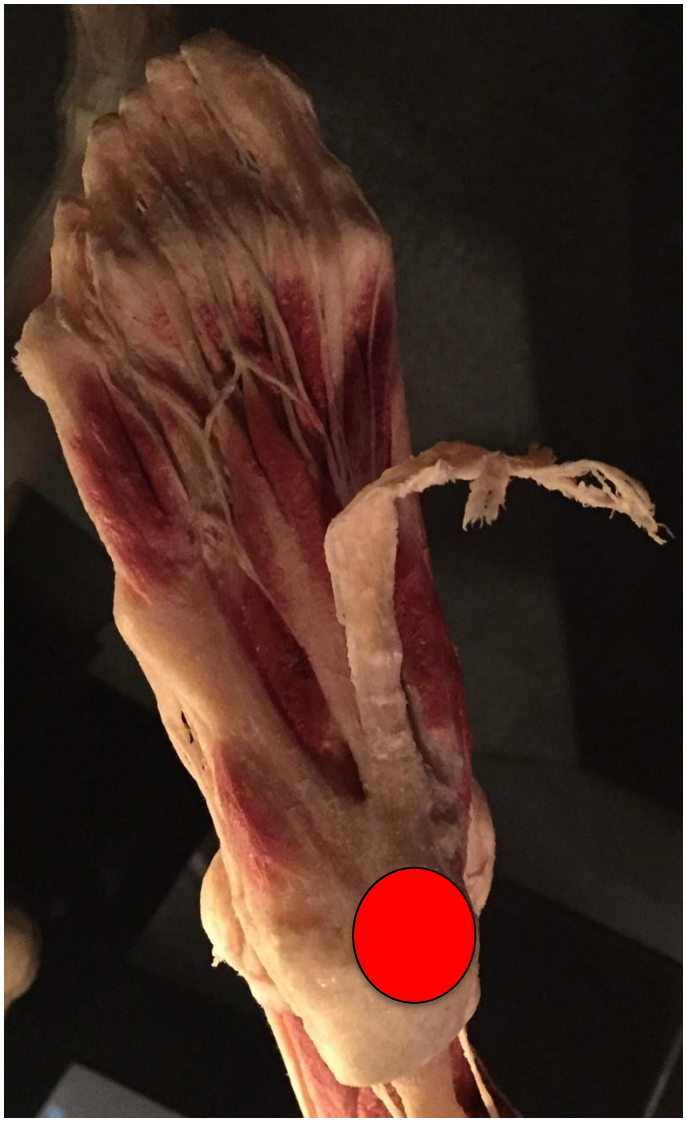
Foot orthoses for plantar heel pain: a systematic review and meta-analysis (Whittaker et al, 2018)

Outcomes: Unreliable results for long term improvements with orthotic intervention. Suggestive of short term improvements but inconclusive

Three randomised controlled trials have demonstrated the effectiveness of a plantar fascia stretching (Rompe et al 2010, DiGiovanni et al. 2006, DiGiovanni 2003)
And systematic review concurrence (Fraser et al 2017)

Alternatives?!

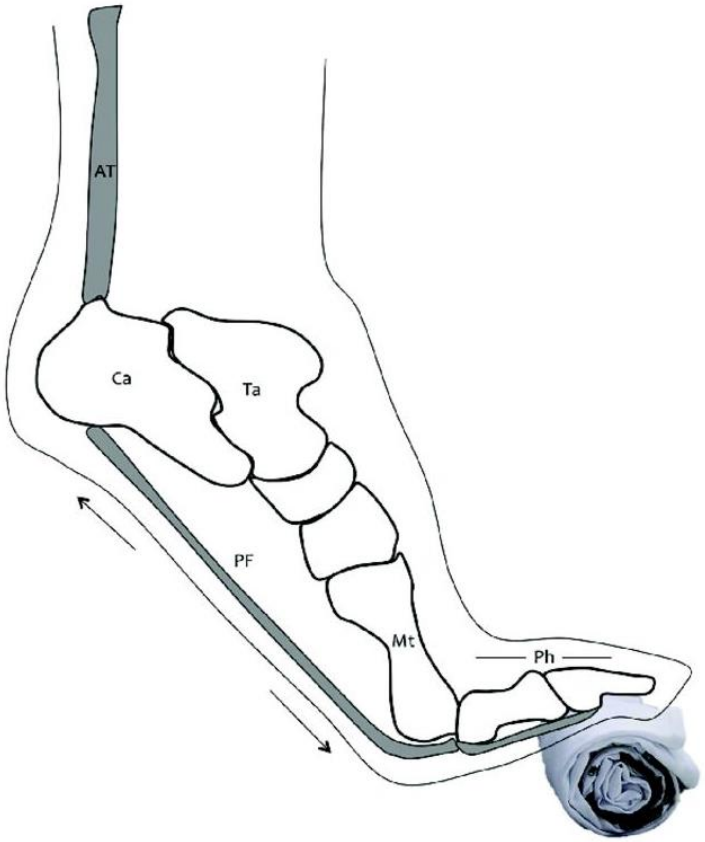
# Plantar heel pain – treatment regimes

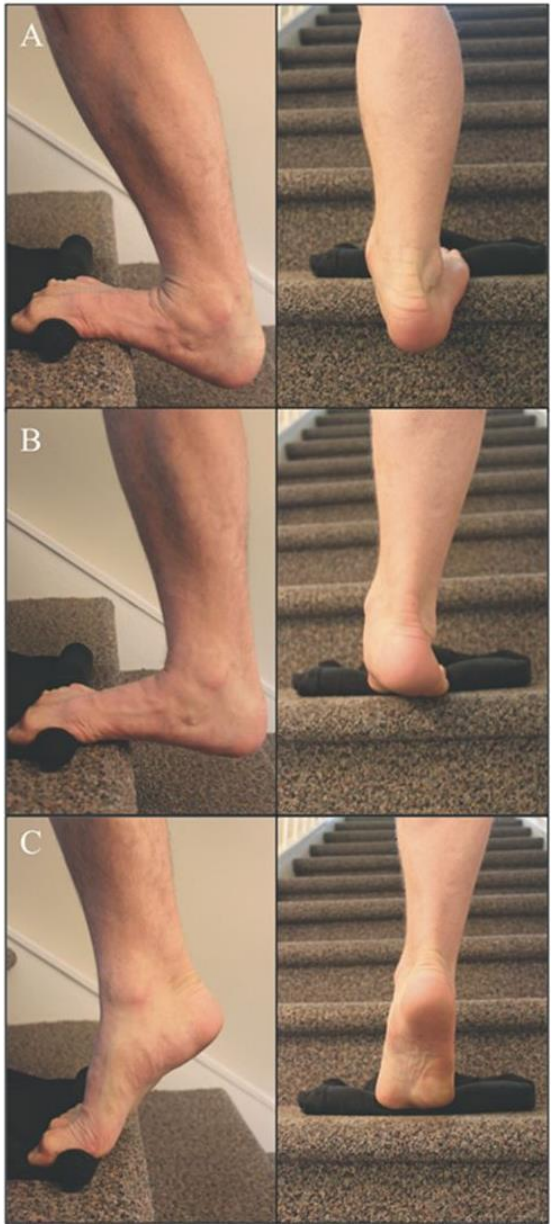


Rathleff et al 2014 – high load strengthening vs stretching RCT.
Results: Greater reduction in symptoms using a high load strengthening intervention at the primary study endpoint (3 months) in comparison to stretching interventions.

Huffer et al 2017 - systematic review of RCTs found the above to be the only significant outcome for strengthening programmes for plantar heel pain

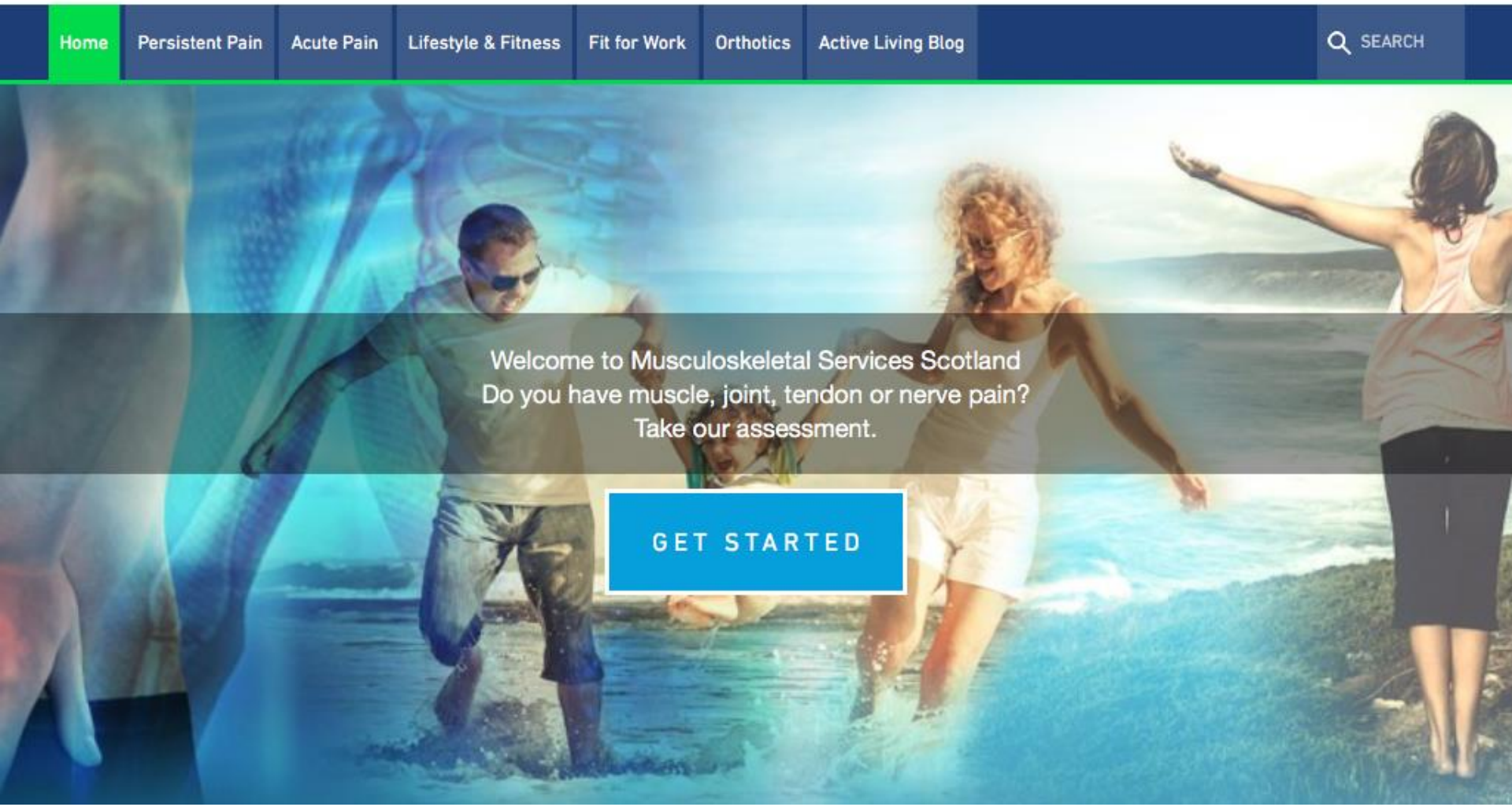
Alternatives?!




(Carutun et al, 2018)

# Methods of delivering exercise prescription?



## DIFFERENTIAL DIAGNOSIS:

# FOREFOOT

# PLANTAR PLATE DYSFUNCTION (aka pre-dislocation syndrome)

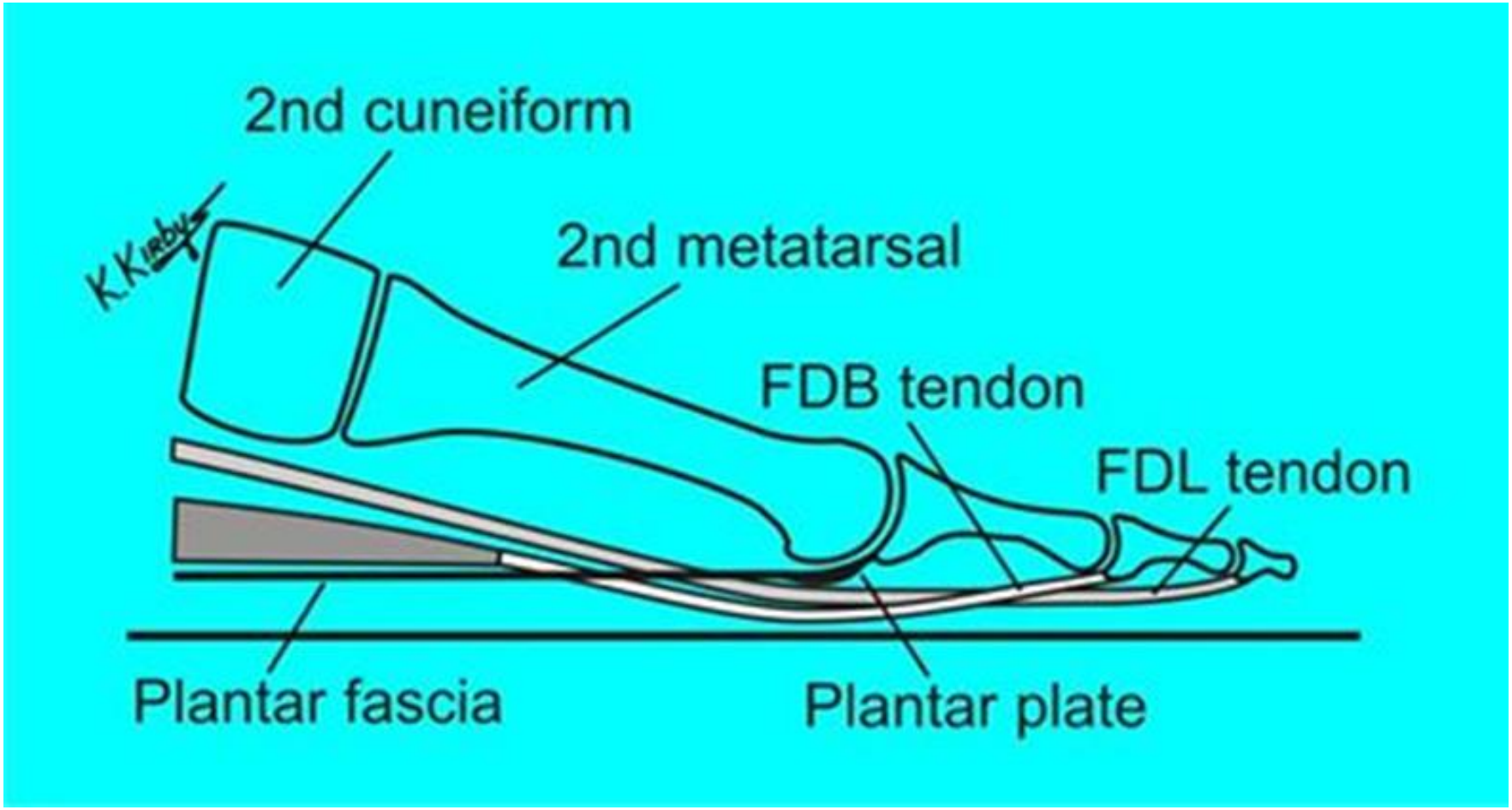
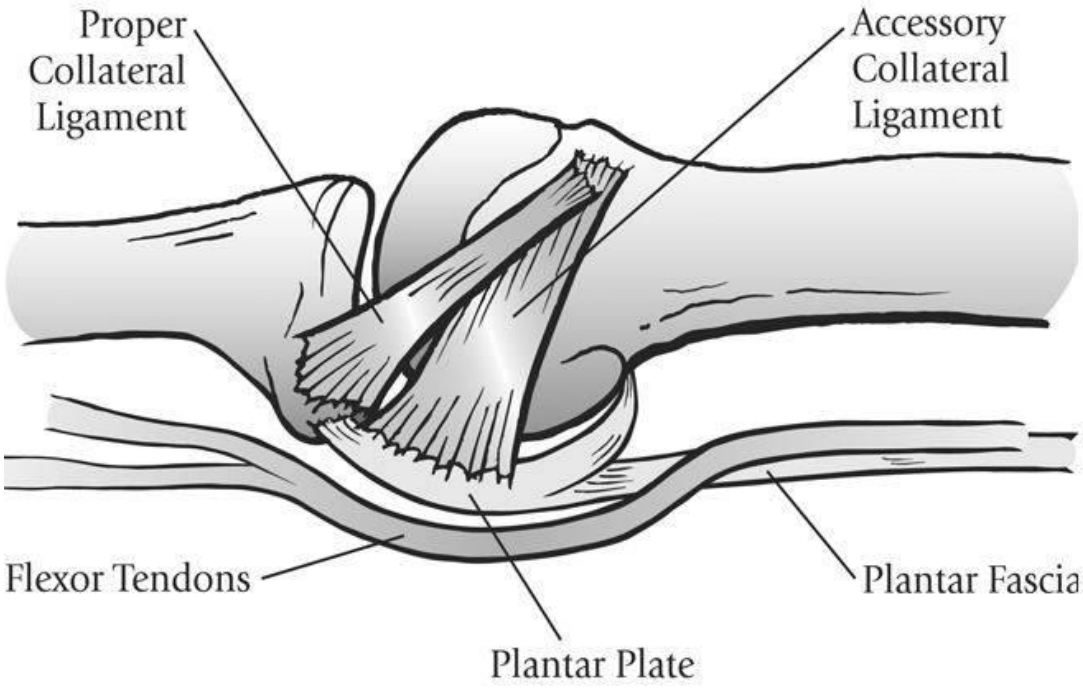
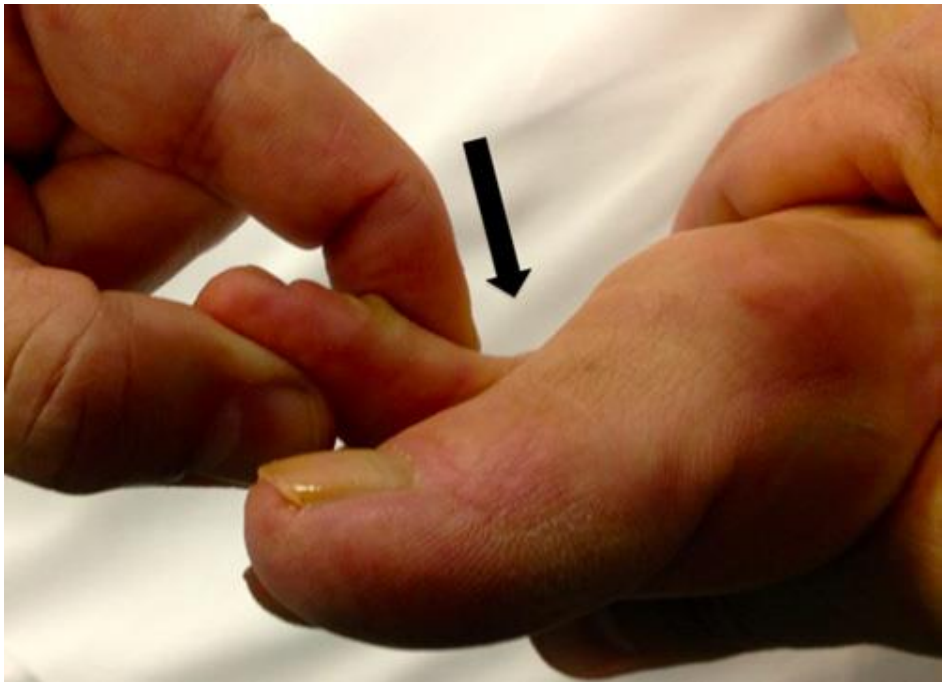



Image with thanks to Dr Kevin Kirby

# Plantar Plate Anatomy

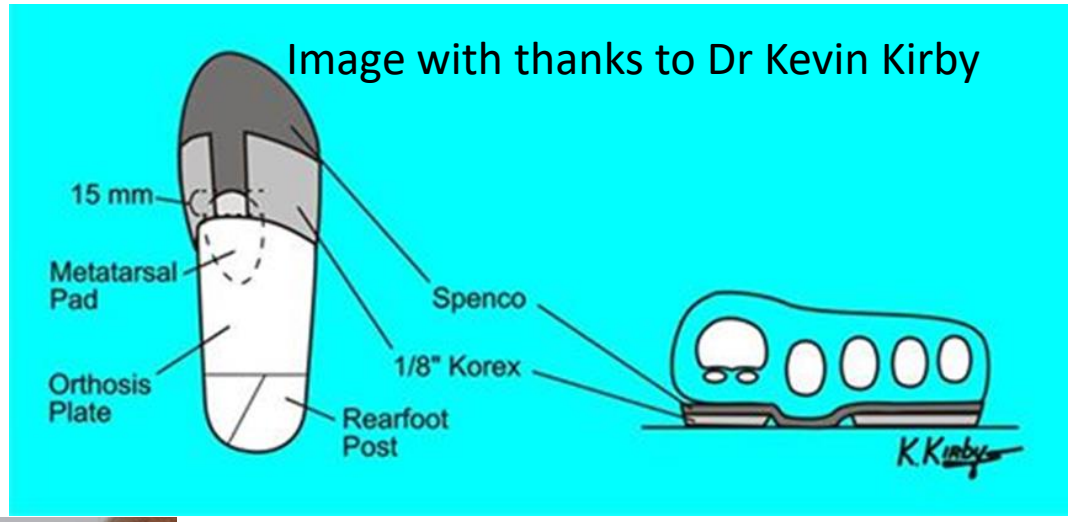


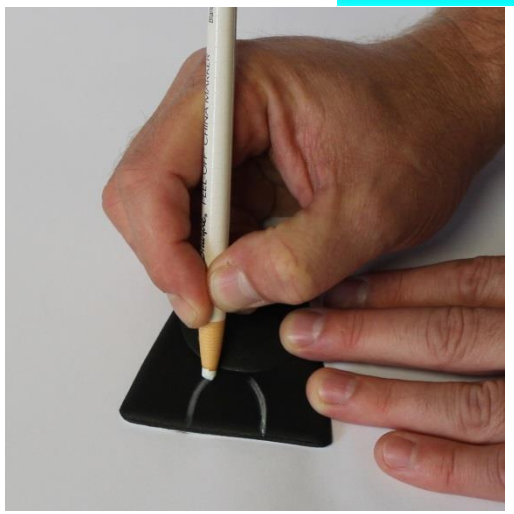
# Plantar Plate Provocation Test



- Dorsiflex toe 30 degrees
- Apply dorsal force to distract toe away from metatarsal (Distraction)
- Palpate MTH and plantar plate for pain
- Distraction may indicate tear/rupture

# PLANTAR PLATE ORTHOTIC TREATMENT



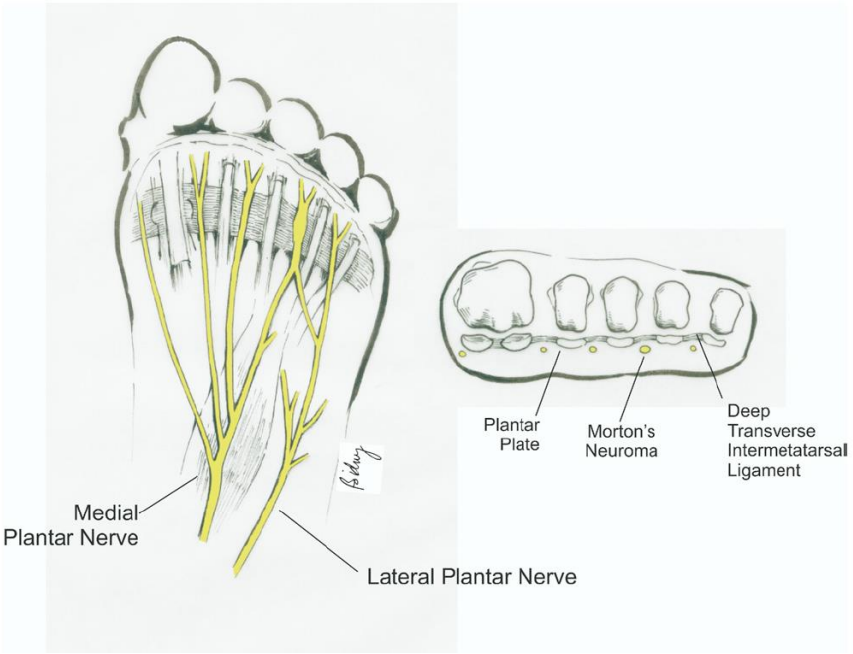



# Plantar Plate Strapping

# MORTON'S NEUROMA

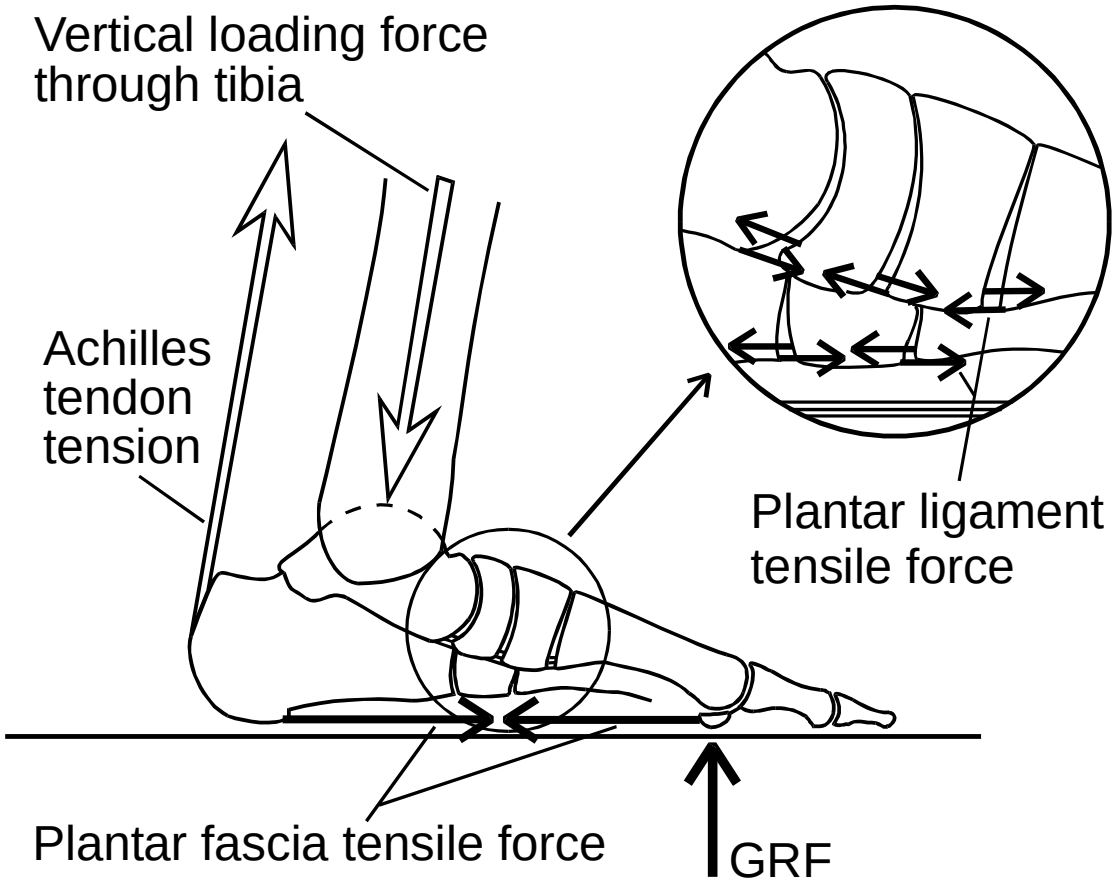
**Causes**

- Irritation of distal medial plantar nerve
- Tight footwear
- Abnormal metatarsal length
- Forefoot hypermobility
- Functional Hallux Limitus/Abductory Twist
- Most commonly occurs in patients in 30's



# Neuroma Mechanism of Injury?

# Resistance to forefoot loading



# MORTON'S NEUROMA

**Pain**

- Sharp/shooting pain between MTH's shooting into toes
- Pins and Needles in web space
- Numbness
- Some patients may describe increasing pressure leading to explosive sharp pain

# MORTON'S NEUROMA

**Investigations**

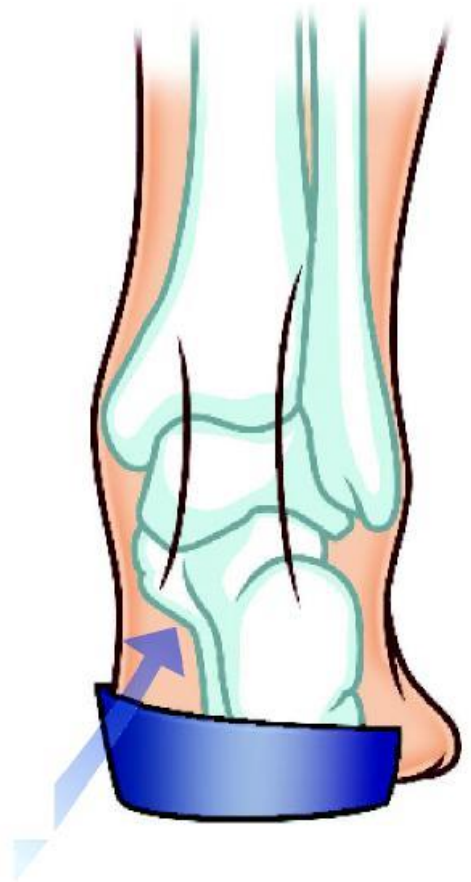
- Mulder's click
- Ultrasound
- MRI

**Treatment Objectives**

- Wider footwear
- Improve biomechanics
- Stabilise hypermobility with orthotic
- Reduce tension & Compression on nerve

# Summary

- Orthotists are ideally positioned to effectively treat vast majority of foot & ankle conditions
- Foot Orthoses reduce pain
- Foot Orthoses prevent degenerate changes
- Be systematic and keep it simple!



Nothing is impossible, we just haven’t figured out how to do it all yet……