

# Foot Core and Footwear Applications to Runners



# Disclosure

I have nothing to disclose

# The Problem

Foot Pain is a huge problem in the US  
87% of individuals have foot pain in their life  
Annual prevalence up to 36% - 10% disabling pain  
*Canca-Sanchez et al, 2024*

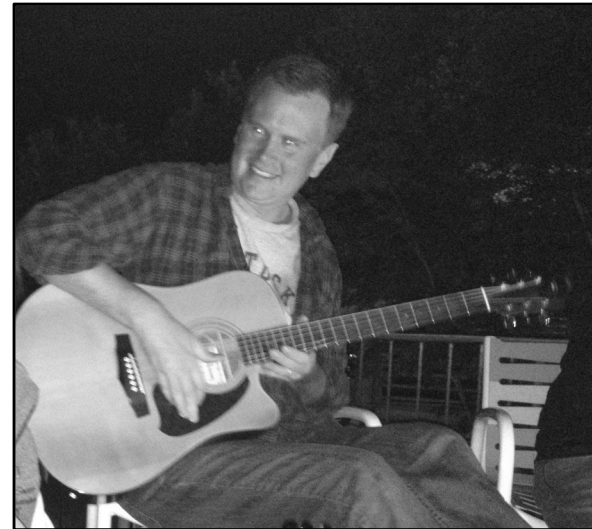
When your foot hurts.....you don't function well!



Unfortunately, our feet, **and preserving their overall health**, are often ignored

# The Foot Core Concept

International Foot and Ankle Symposium, 2012





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## Heel Pain—Plantar Fasciitis:

*Clinical Practice Guidelines  
Linked to the International Classification  
of Functioning, Disability, and Health  
from the Orthopaedic Section of the  
American Physical Therapy Association*

Recommend: Modalities, Manual Therapy, Stretching,  
Taping, Orthotic Devices, Night Splints

No recommendations regarding strengthening

Every other Practice Guideline (knee, ankle, etc)  
recommend strengthening

**Need for awareness of the importance of foot strength  
for normal foot function**

# The Foot Core Concept



Pat McKeon



Jay Hertel



Irene Davis



Dennis Bramble

## The foot core system: a new paradigm for understanding intrinsic foot muscle function

Patrick O McKeon,<sup>1</sup> Jay Hertel,<sup>2</sup> Dennis Bramble,<sup>3</sup> Irene Davis<sup>4</sup>

### ABSTRACT

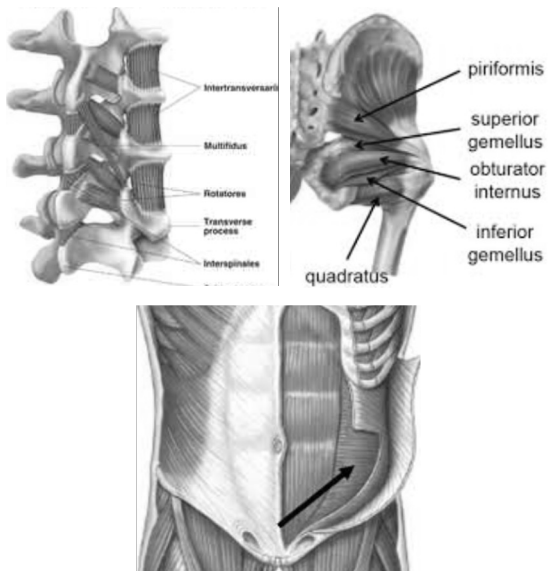
The foot is a complex structure with many articulations and multiple degrees of freedom that play an important role in static posture and dynamic activities. The evolutionary development of the arch of the foot was

and global movers such as latissimus dorsi.<sup>2</sup> The local stabilisers have small cross-sectional areas and small moment arms. Therefore, they do not produce large rotational moments at the respective joints that they cross. However, they do act to increase intersegmen-

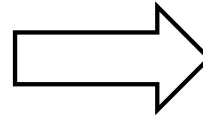
*BJSM, 2015*

# Lumbo-Pelvic Core Stability

## Lumbopelvic Core Muscles



Malfunction



Small X-sectional areas and small moment arms-are Stabilizes and not prime movers

Hip ADD and IR  
Contralateral Pelvic Drop  
Anterior Pelvic Tilt

# Proposing there is an analogy in the foot

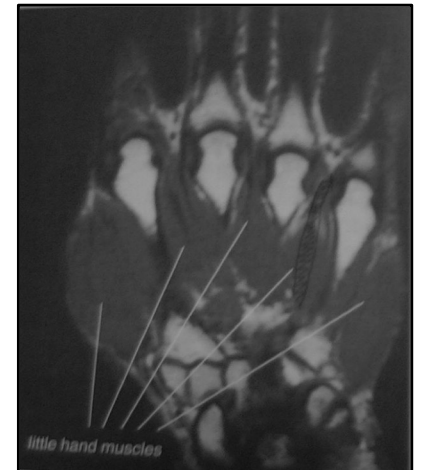


## **Intrinsic Foot Muscles**

Small X-sectional areas

Short moment arms

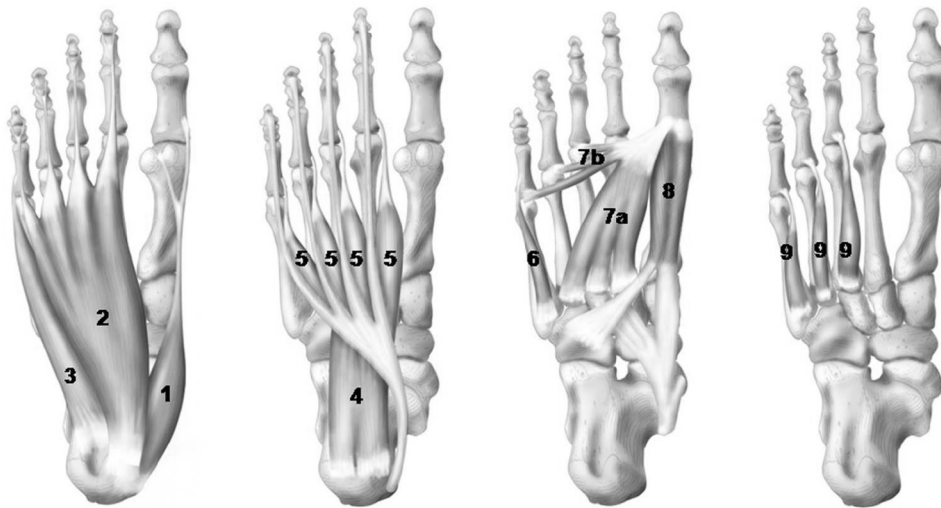
Stabilizers vs prime movers



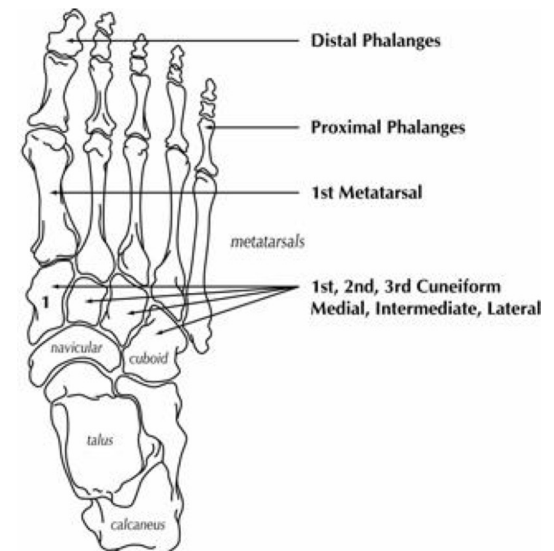
You need foot stability (intrinsic) for proper foot mobility (prime movers) and proper function

**Importance of foot strength highly underappreciated**

# Well-Designed Feet



10 arch muscles in 4 layers  
originate and insert in the foot

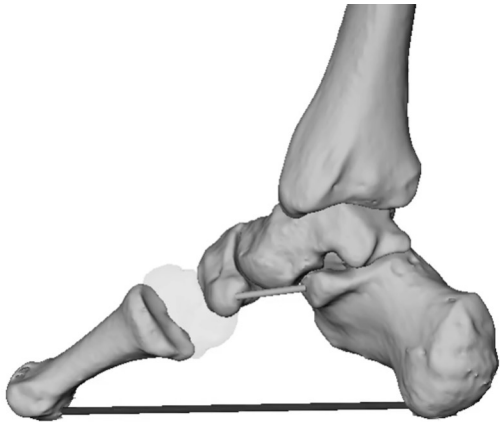


28 bones, 33 jts with  
6 dof of movement

Base of Support, Rigid Lever, Mobile Adapter, Spring

# Normal Foot Function

4 layers of intrinsic arch muscles



Control the deformation  
with each footstrike

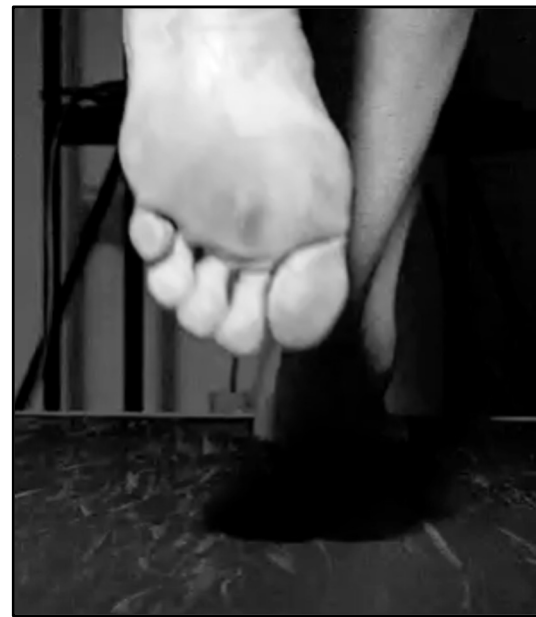


Maintain arch during full  
loading

# Normal Foot Function



Natural foot splaying



Strong, supportive arch

Therefore .....



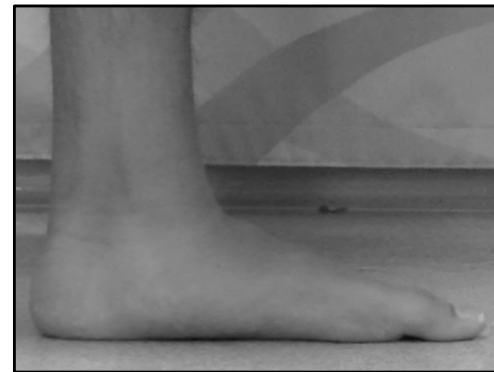
Left to its own  
devices, the human  
foot is well-suited  
for walking and  
running locomotion

.....so why do we have so many foot and lower extremity injuries?



# Mismatch Theory of Evolution

Environment changing faster than our bodies can adapt  
We are not living the lives our bodies evolved for: Food, Air, Activity level  
Cause of many of the illnesses today: Diabetes, Obesity, CV disease  
Extends to Musculoskeletal Problems



deconditioned  
feet

Perhaps we are not running the way our bodies were adapted to

Pes Planus is associated with foot pain  
*Canca-Sanchez et al, 2024*

# Arches degrade under load

Quiet Stance



Midsupport  
of Running

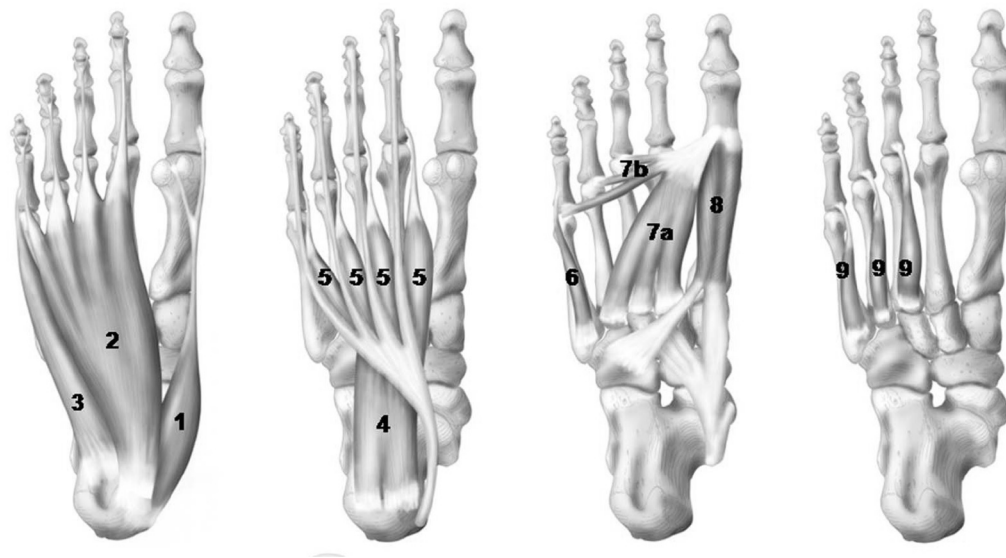


Increased downward  
arch deformation



Excessive medial  
arch deformation

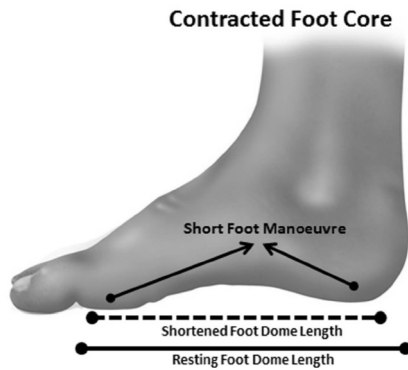
# Plantar Intrinsic Muscles



Important stabilizers of the foot

.....But how do we strengthen them?

# Foot Core Exercises



Doming  
(Short foot ex)  
Stiffen toes,  
draw ball of foot back  
to heel  
'squeeze your arches'



Long toe flexors



Dorsal and plantar interossei



Toga!

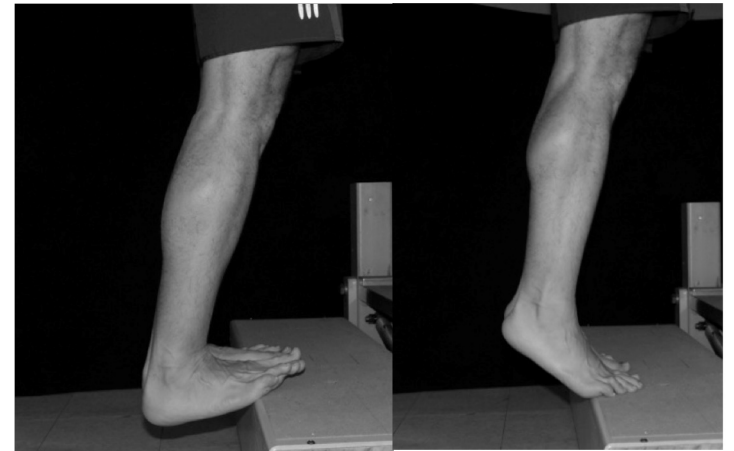
# Foot Core Training – Calf muscles



Calf-Achilles  
Plantar Fascia  
Plantar Muscles =  
1 Functional Unit



2 feet, then 1 foot  
30 SL heel rises and 45 sec holds  
Progress with weight



Off Step  
(unless insertional  
Achilles tendinitis)

Don't forget soleus muscle – repeat with knees flexed

# Foot Core Training – Functional Exercises



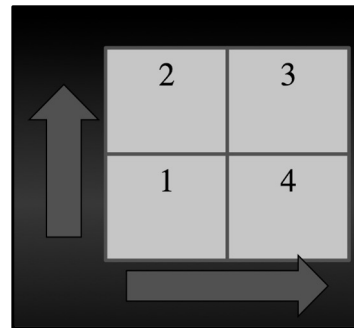
Active Standing



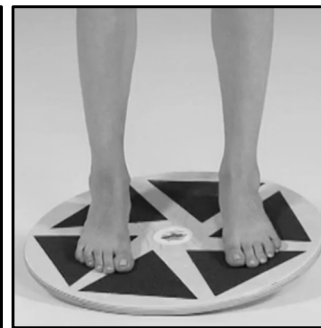
Doming and Hopping



Balance activities



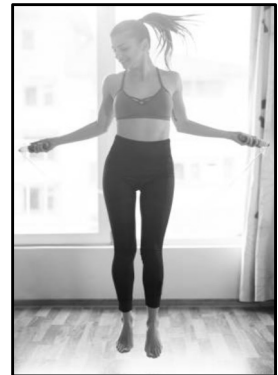
Single leg  
square jumps



Unstable  
surfaces

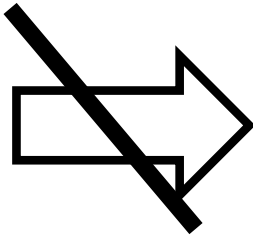


Leaping



Jump rope

# Does Footwear Matter?

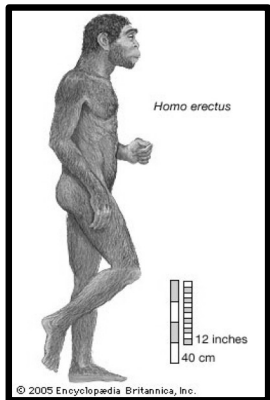


**Cushion?**



**Support?**

# Historical Look at Footwear



2 Million  
yrs ago



10,000  
yrs ago



cushioned/  
supportive  
shoes are  
actually the  
trend!



1970



2020



2,000,000 yrs

50 yrs

**99.9975%**  
evolutionary history in bare  
feet/primitive shoes

50 yrs  
2,000,000 yrs

**0.0025%**  
time in  
cushioned/supportive



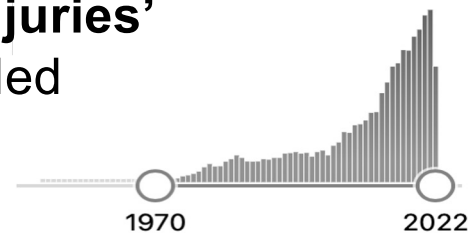
# A Little Bit of History

Jeff Johnson – Nike 1965-1983

**50-60's** Ran in thin-soled canvas shoes on hard surfaces  
Well-trained - reports that injuries were rare back then

**70's** Running Boom – more inexperienced runners – beginning of cushioned shoes (Cortez)

**'Running injuries'**  
PubMed

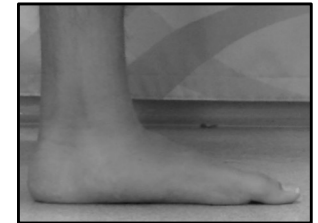


Early 80's Nike invites Drs. Steve Subotnik, Harry Hlavick, Dennis Vixie - prominent sports DPMs. They encouraged more elevated heel, motion control and cushioning

so.....Rather than conditioning the runner to the activity, they  
they adapted the shoe to the unconditioned runner,

*Davis, 2014*

# Problem with Modern Footwear: Support



## Effect of 12 wks of orthotic use on CSA of the arch ms.

	Muscle	Group	BL	12-W
CSA (cm <sup>2</sup> )	FDB	Control	2.19 (0.46)	2.23 (0.49)
		Orthotic	2.09 (0.50)	1.89 (0.46) *
	Abd DM	Control	1.30 (0.27)	1.31 (0.27)
		Orthotic	1.23 (0.10)	1.02 (0.09) *
	Abd H	Control	1.82 (0.46)	1.81 (0.21)
		Orthotic	1.38 (0.51)	1.14 (0.38) *

Muscles in orthotic group significantly decreased ( $p < 0.001$ ) in size (between 10-17%) in just 12 weeks!

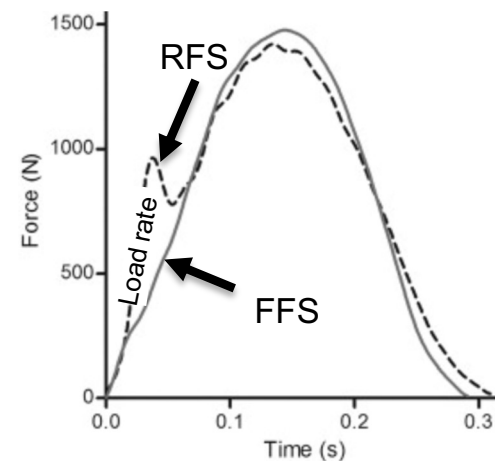
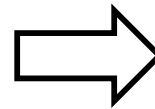
*Protopapas et al, 2018*

**Chronic support weakens feet (Mismatch)**

# Problem with Modern Footwear: Cushioning



Promotes a RFS pattern

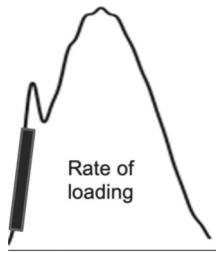


Induces an abrupt impact force  
Slope of the impact peak = Load rate

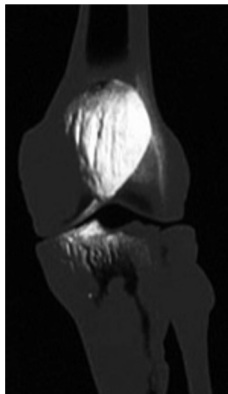
**1000 footstrikes/mile – if 20 mpw = 1,000,000 footstrikes (impacts)/year**

**Are these impacts a Mismatch?**

# Increased Load Rates and Injuries



Patellofemoral Pain



*Johnson et al, 2021*

Plantar Fasciitis



*Pohl et al, 2009*

Hamstring tendinitis



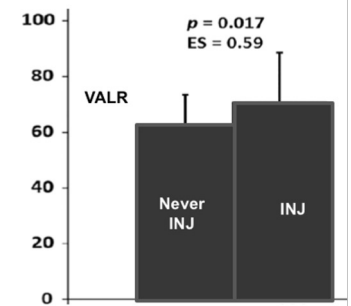
*Johnson et al, 2019*

Tibial Stress Fractures



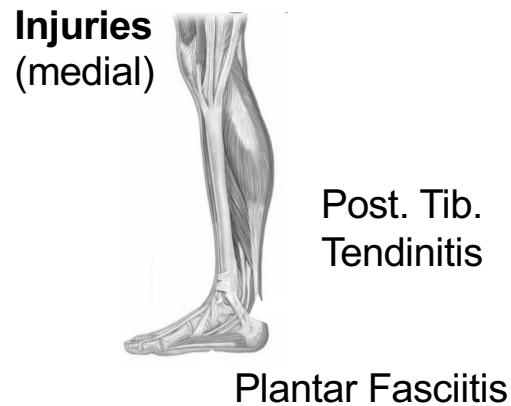
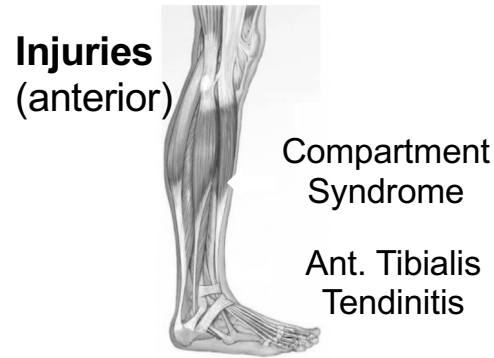
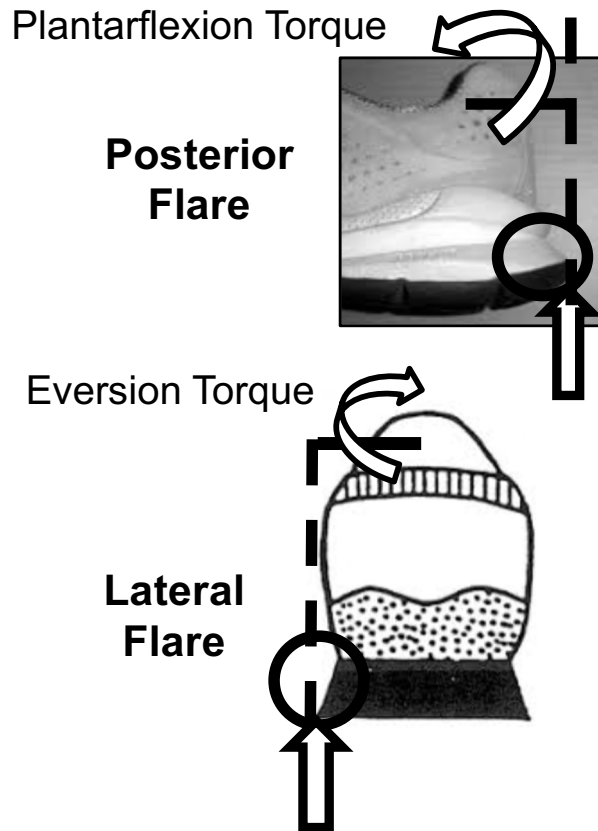
*Milner et al, 2006, Zadpoor et al, 2010*

Injuries as a Group



*Davis et al, 2010*

# Problem with Modern Footwear - Flares



(No Flares)

Conventional shoes increase foot (knee and hip) torques (mismatch?) *Kerrigan et al, 2009*

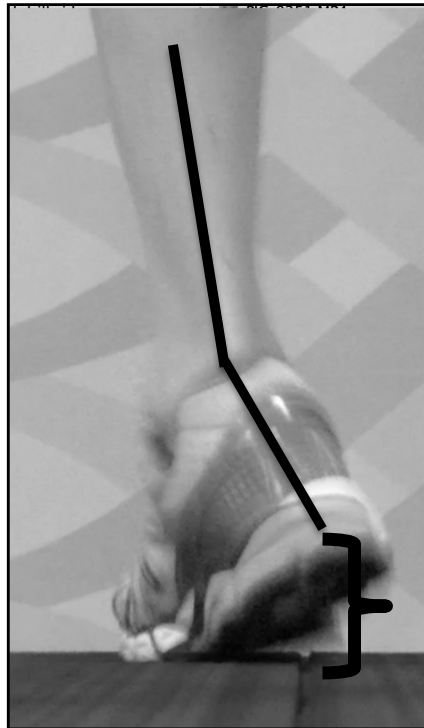
## Effect of Lateral Flares on FFS



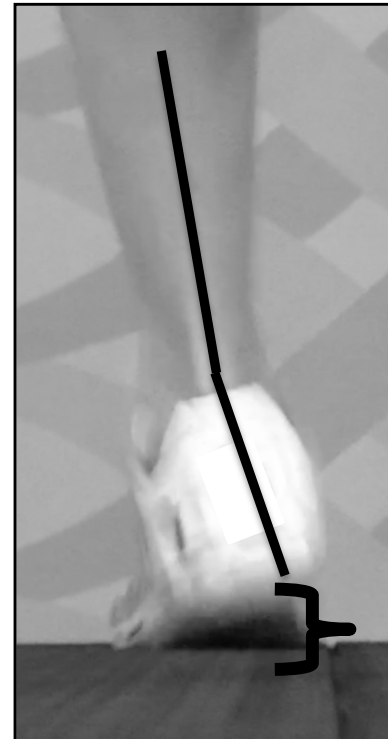
Increased **Inversion** and **Plantarflexion** at FS  
Greater foot excursions/velocities

## Effect of Lateral Flares on FFS

F Runner  
transitioned to a  
FFS in her shoes  
Developed Achillies  
tendinitis and  
Peroneal Tendinitis



Incr. Plantarflexion and  
inversion at FS



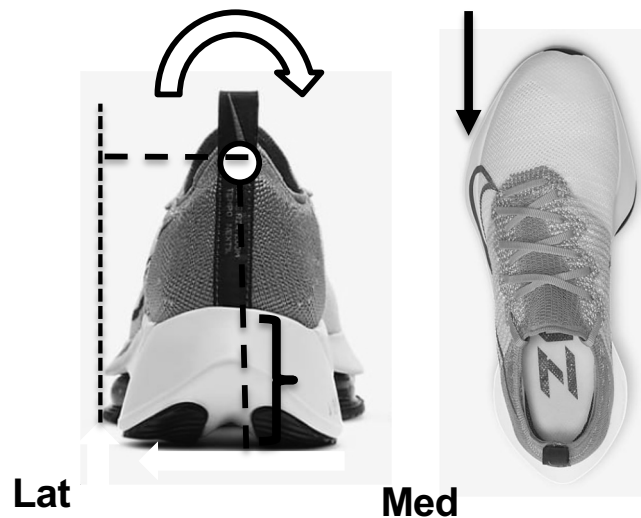
Reduced

# Shoe Anatomy Influences Foot Mechanics

## Advanced Footwear Technology (AFT)

Effect of Sole thickness

Effect of Forefoot flare



**Ouch!**

Case Series of 5 runners with navicular BSIs recently transitioned to AFT shoes  
*Tenforde et al. 2023*



# Footwear Affects Footstrike

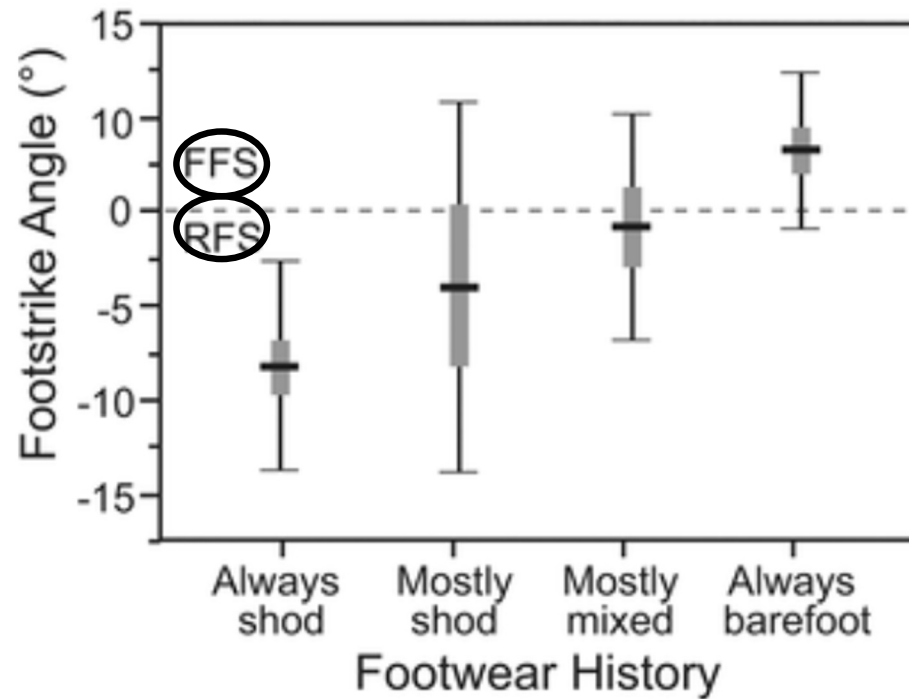


Why 95% conventionally shod runners are RFS *Lieberman et al, 2010*

# Footwear Affects Footstrike



Eldoret Region of Kenya



*Lieberman et al, 2015*

The more time spent in footwear, the greater tendency to RFS

# Minimal Footwear: A Proxy for Barefoot

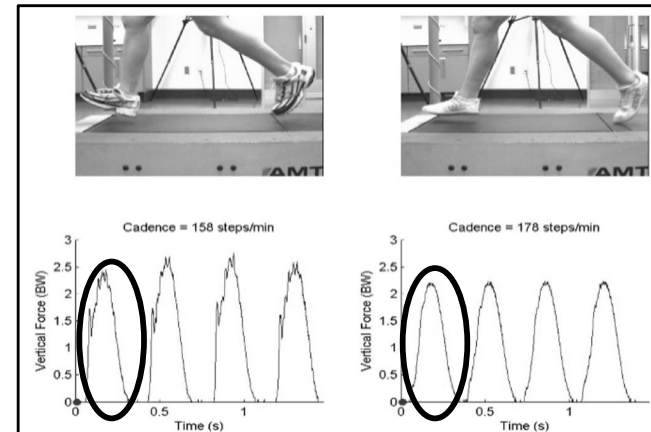


No motion control  
No cushioning

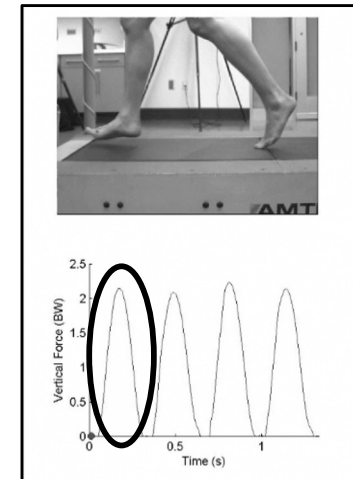
Zero drop  
No arch support  
No midsole



Shoes of Ron Hill – won  
Boston Marathon 1970



Minimal  
similar to BF



# Benefits of Minimal Footwear: Strength

## 8-week RCT (Walkers)

US – Cross Sectional Areas

Flexor Digitorum Brevis    Flexor Hallicus Brevis  
Abductor Hallicus        Quadratus Plantae



Con



Foot Ex



Min shoes

no increase

similar sig. increase

*Ridge et al, 2019*

Suggests that min shoe use is just as efficacious as foot ex!

## 6-month RCT (Runners)

MRI – Volume of intrinsic foot ms

3 wks Calf Ex

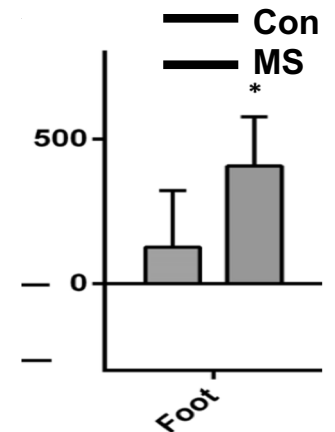


Con



Min shoes

*Chen et al, 2019*



MS: Increased foot muscle volume

Every study has found strengthening of foot muscles with minimal shoe use

*Miller et al, 2014, Johnson et al, 2016  
Brueggemann et al, 2005*

Those randomized to a Foot Core strengthening program had a 2.4 lower rate of running injuries compared to the Control group  
*Taddei et al, 2020*

# Benefits of Minimal Footwear      Achilles Tendon

## Habituated Footwear

*Histen et al, 2016*



Minimal shoe

Achilles tendon:

13.5% larger CSA

37% lower elongation

90.5% greater Stiffness

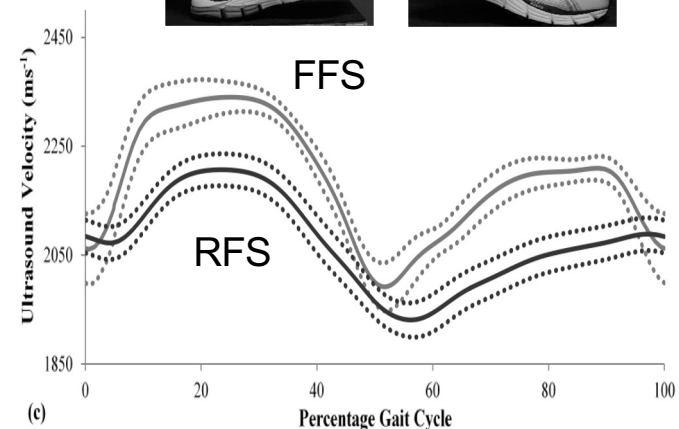
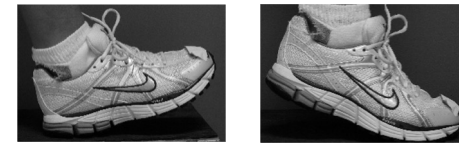
Than Habituated Traditional Shoe

**Min Footwear:  
larger, stiffer tendons**

52% Lifetime incidence of AT in runners (95% RFS)

## Habituated Strike Pattern

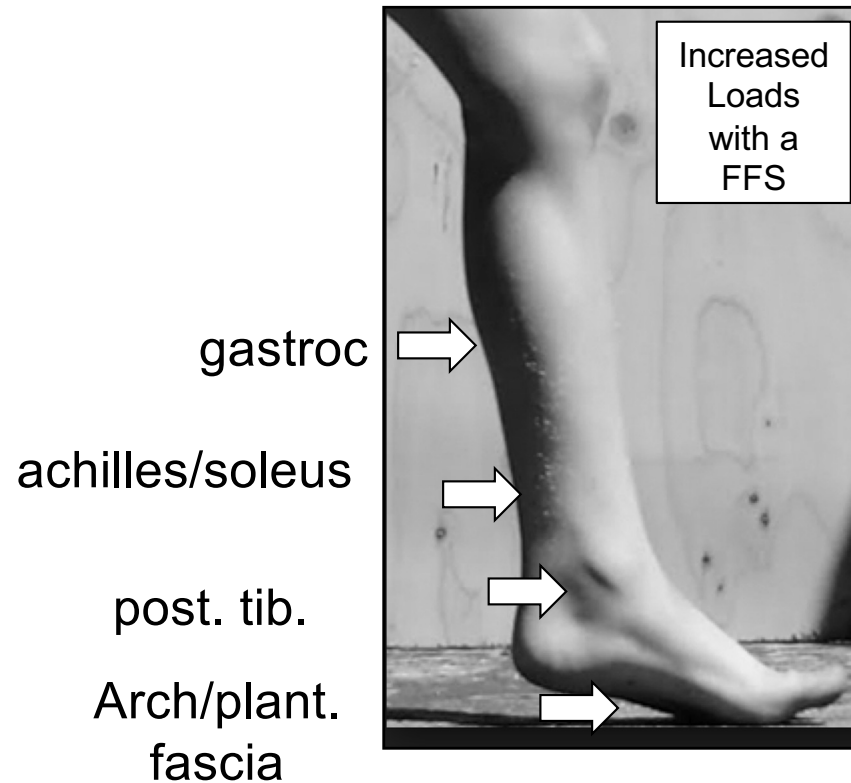
*Wearing et al, 2018*



**Forefoot strike pattern:  
Stiffer tendons**

*Mafulli, 2003*

# Need to Adapt (Esp. for Running)



Strengthen:  
Extrinsic muscles  
Intrinsic muscles

**Progress slowly!**

## Take Home Message



Our feet are not passive structures that need support and cushioning.

**Strong feet are Healthy Feet**

Thank You





# 8 week strengthening program

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Double leg heel raises - flat	3 sets of 10	3 sets of 20	3 sets of 30					
Double leg heel - off step			3 sets of 10	3 sets of 20	3 sets of 30			
Single leg heel raises - flat				3 sets of 10	3 sets of 20	3 sets of 30		
Single leg heel raises – off step					3 sets of 10	3 sets of 20	3 sets of 30	
Towel curls	3 sets of 10	3 sets of 20	3 sets of 30	3 sets of 30				
Toe Spread/Squeeze	3 sets of 10	3 sets of 20	3 sets of 30	3 sets of 30				
Doming	3 sets of 10	3 sets of 20	3 sets of 30	3 sets of 30				
Doming Hopping in place		3 sets of 10	3 sets of 20					
Doming Hopping Square			3 sets of 10 forward and back	3 sets of 20 forward and back	3 sets of 10 side to side	3 sets of 20 side to side	3 sets of 10 diagonal and back	3 sets of 20 diagonal and back
Doming Hopping off Step -2 ft					3 sets 10	3 sets of 20		
Doming Hopping off Step -1 ft							3 sets of 10	3 sets of 20

# Transition Plan for Healthy Runners

Level	A	Walk 30 mins
	B	Walk 9 mins and jog 1 min (x3)
	C	Rest
	D	Walk 8 mins and jog 2 mins (x3)
	E	Walk 7 mins and jog 3 mins (x3)
	F	Rest
	G	Walk 6 mins and jog 4 mins (x3)
	H	Walk 5 mins and jog 5 mins (x3)
	I	Rest
	J	Walk 4 mins and jog 6 mins (x3)
	K	Walk 3 mins and jog 7 mins (x3)
	L	Rest
	M	Walk 2 mins and jog 8 mins (x3)
	N	Walk 1 mins and jog 9 mins (x3)
	O	Rest

Then progress to Running 30 min in a row and run every other day

Keeping speed constant, increase the distance by 10%/week

Once you are up to desired mileage, gradually increase speed, add hills and tempo runs

