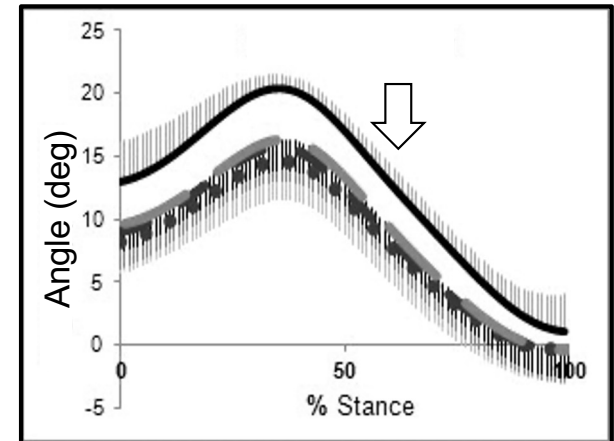
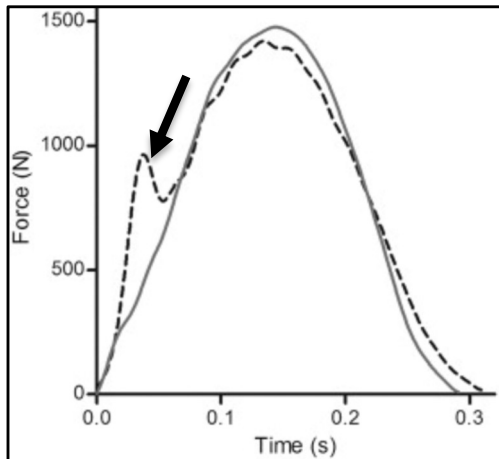


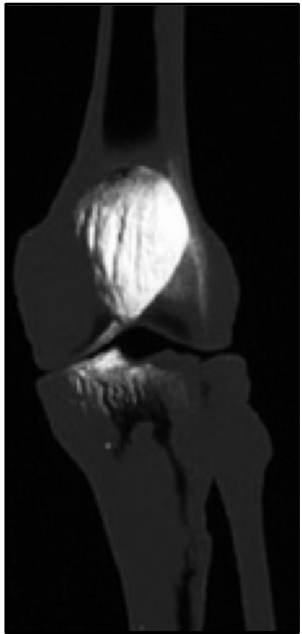
# Biomechanical Approach to Patellofemoral Pain



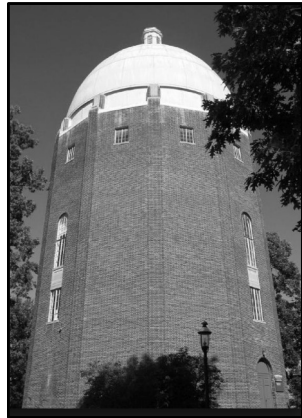
# Disclosure

I have nothing to disclose

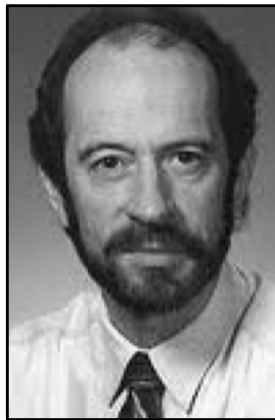
# A Little Bit of History



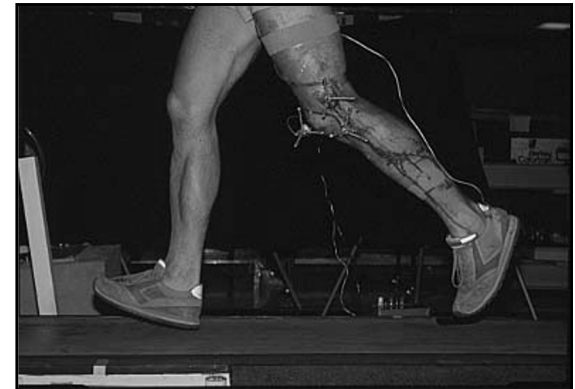
Patellofemoral  
pain



1985

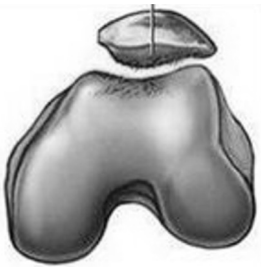


Dr. Peter  
Cavanagh



Left me unsatisfied and I have been studying it ever since!

# Patellofemoral Pain

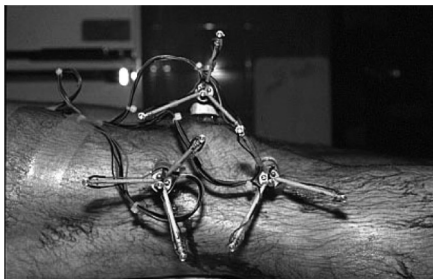


## Epidemiology

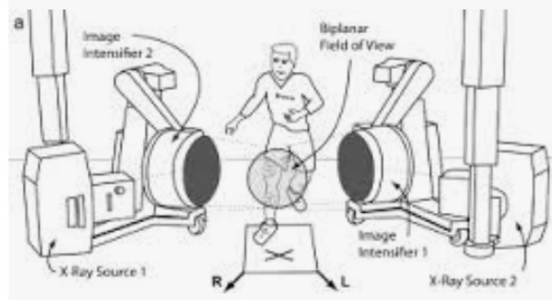
22.7% general population  
Most common knee injury  
Most common running injury  
Females 2X> Males

## Mechanical Etiology

Cannot measure using skin markers



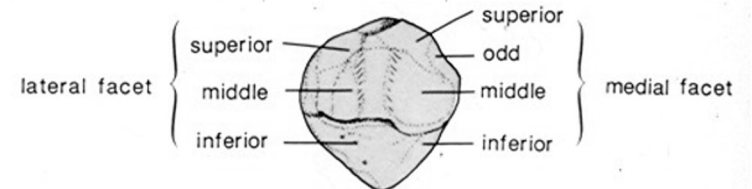
Intracortical Pins



Biplanar  
Videoradiography

## Patellar Anatomy

Largest sesmoid bone  
Thickest cartilage of the body:  
high loads  
Complex surface (7 facets)



Otherwise, you have to infer  
patellofemoral motion from hip  
and knee motion

# Genesis of the International PF Research Retreats



Kay Crossley, PhD, PT (AUS)  
Chris Powers, PhD, PT (US)  
Irene Davis, PhD, PT (US)  
Erik Vitvrouw, PhD, PT (Belgium)  
Jenny McConnell, MS, PT (AUS)

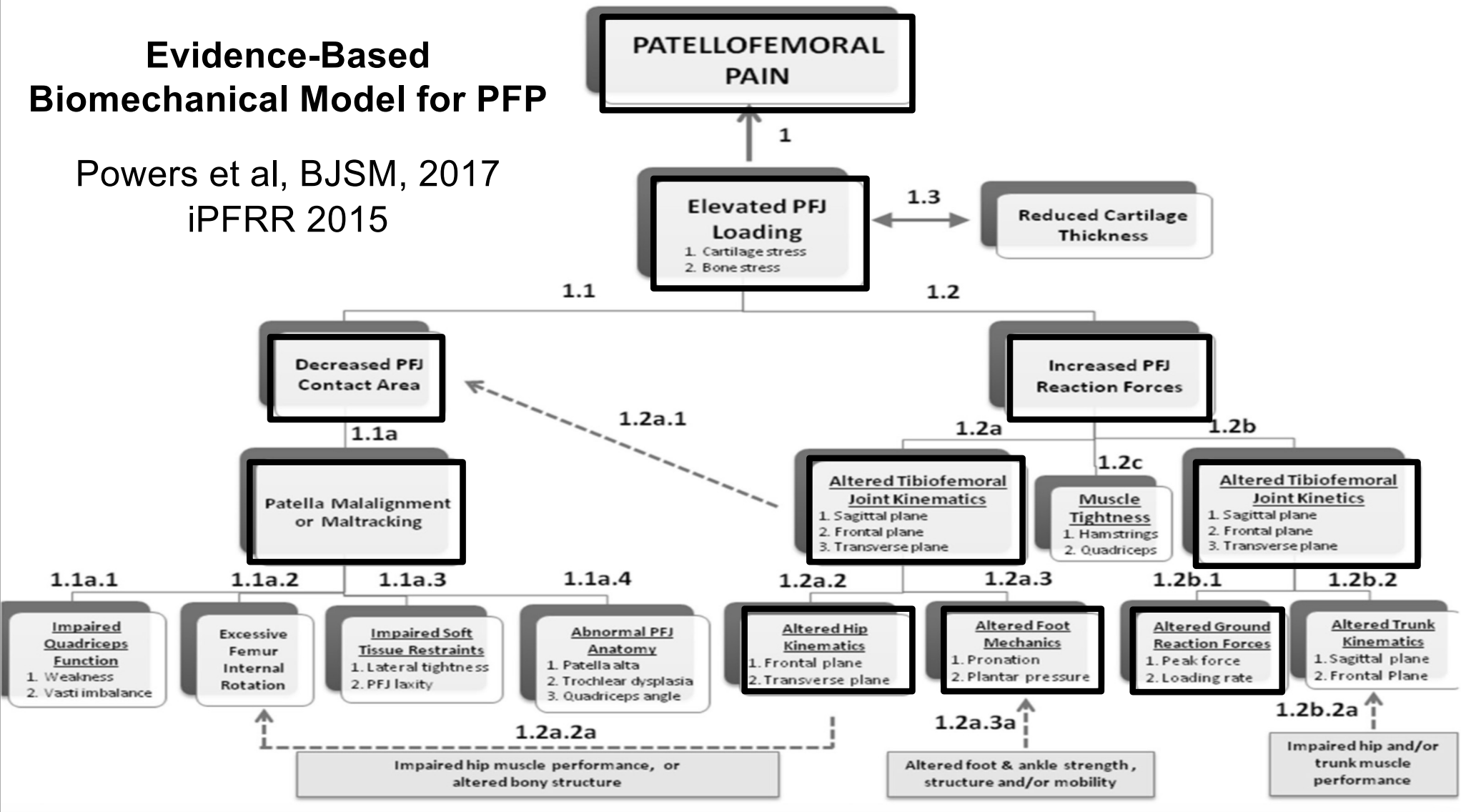
## **Purpose**

To bring together scientists and clinicians from around the world who are conducting research aimed at understanding the factors that contribute to the development and, consequently, the treatment of PFP

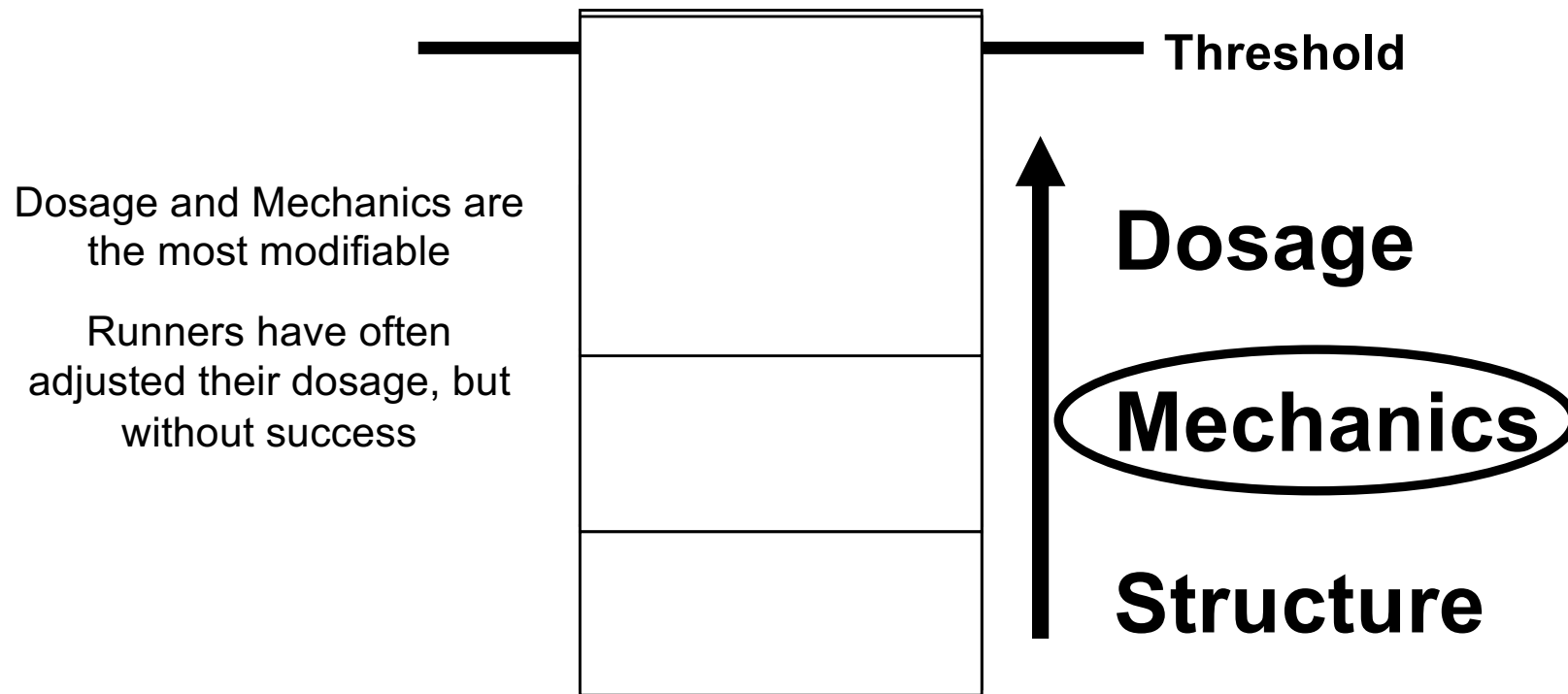
Meeting held every 2 yrs and it typically attracts about 50 international scientists

# Evidence-Based Biomechanical Model for PFP

Powers et al, BJSM, 2017  
iPFRR 2015



# INJURY



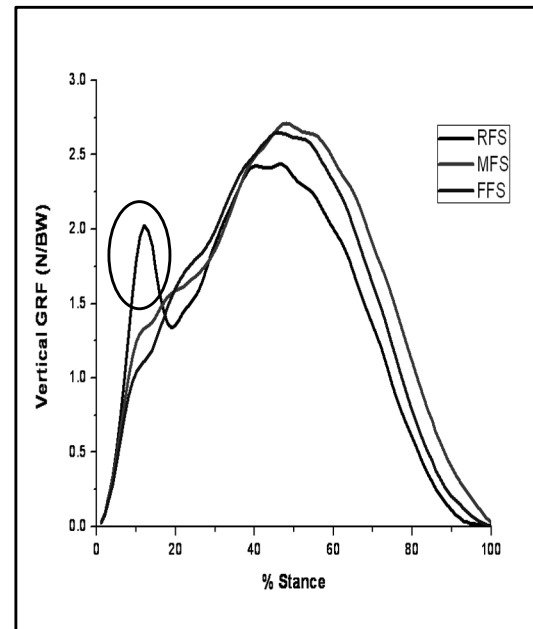
# Mechanics



# Mechanics



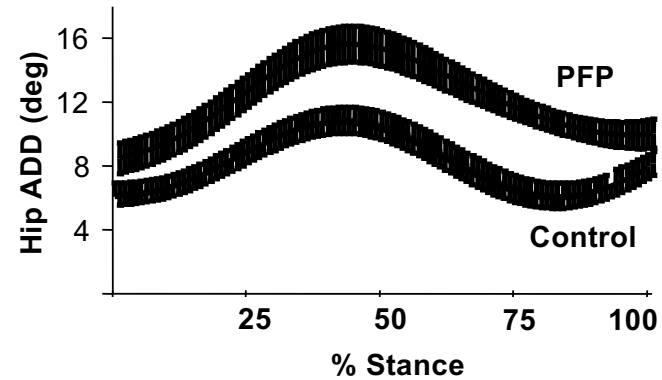
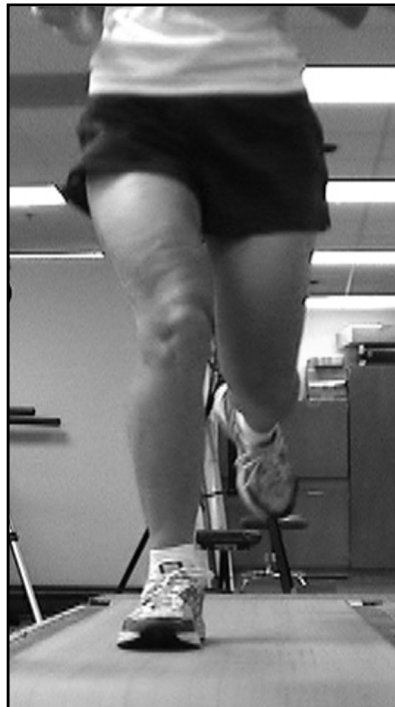
Alignment



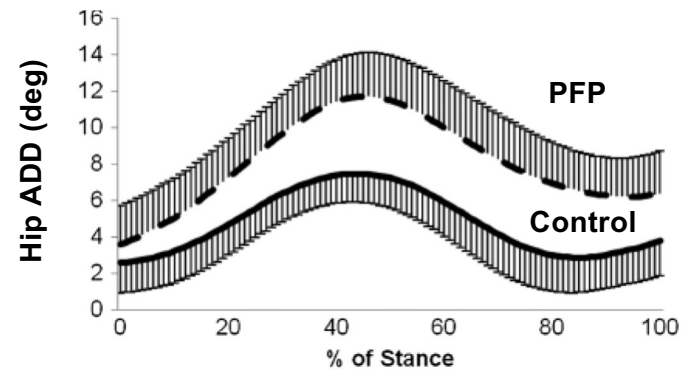
Loading

Goal: Well-Aligned, Soft Landings

# Alignment: Hip Adduction and PFP



**Cross-  
Sectional  
Study**

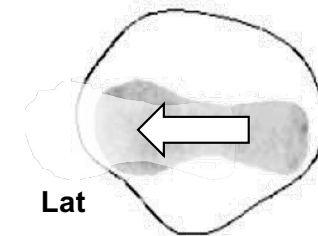
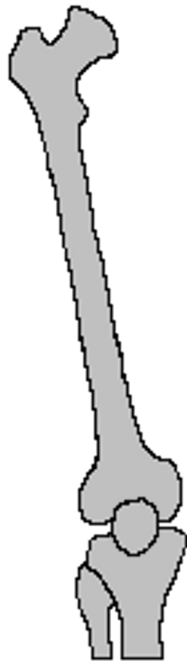


**Prospective  
Study**

*Willson et al, 2008*  
*Noehren et al, 2013*

# Effect of Hip Adduction on PFJ Mechanics

Hip ADD/valgus



**Cadaveric Studies**

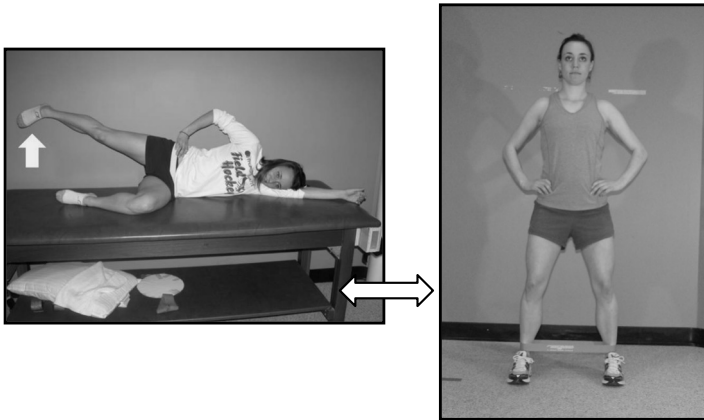
*Huberti and Hayes, 1984; Lee et al., 2003; Besier et al., 2008*

# Traditional Approach - Strengthening

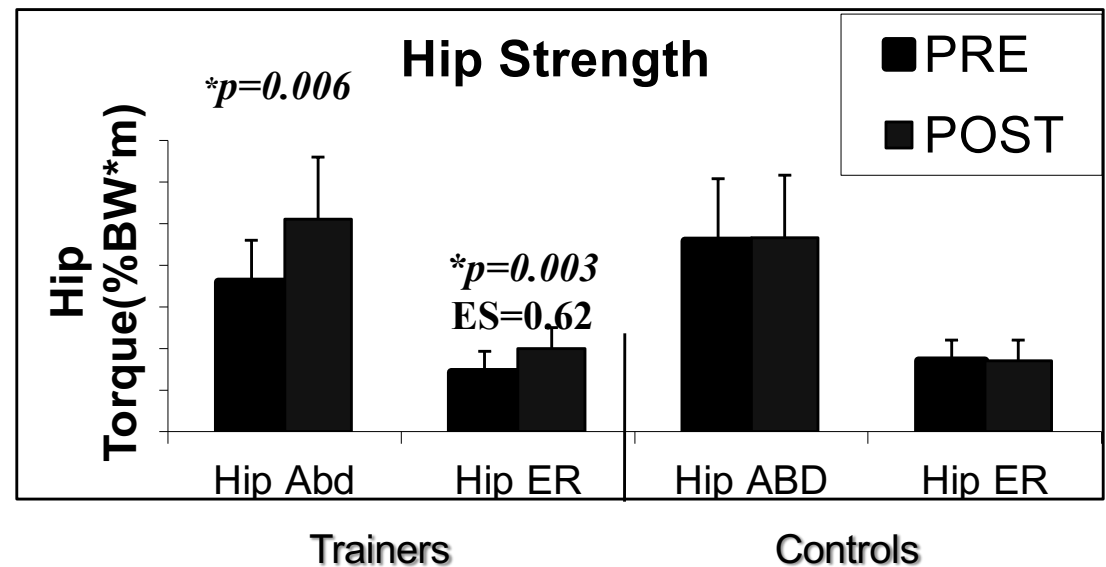
5 yrs post-strengthening for PFP, 80% had pain, 74% had to reduce physical activity  
*Blond et al, 1997*

**Underlying cause unaddressed**

## Effect of Strengthening on Mechanics

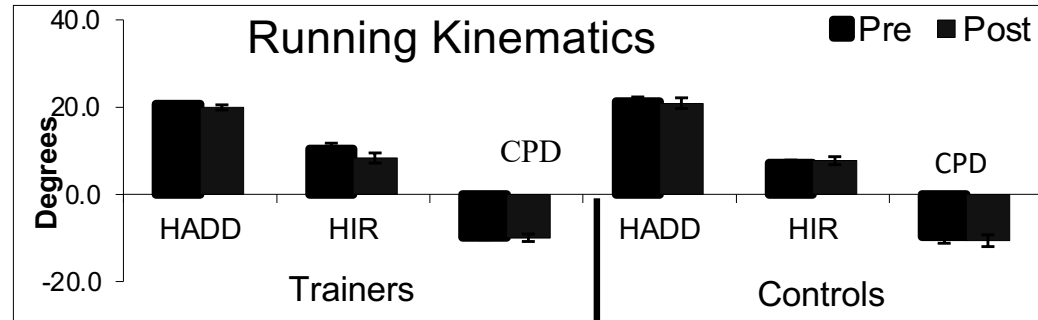
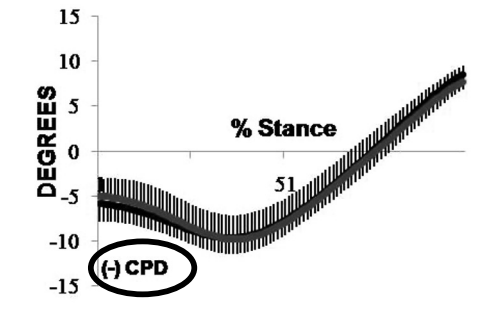
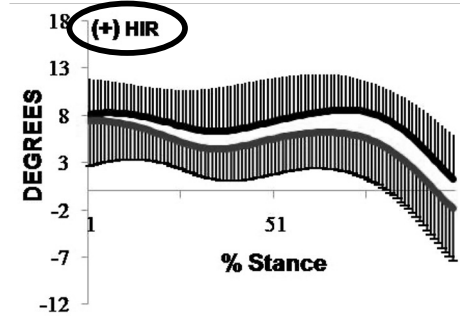
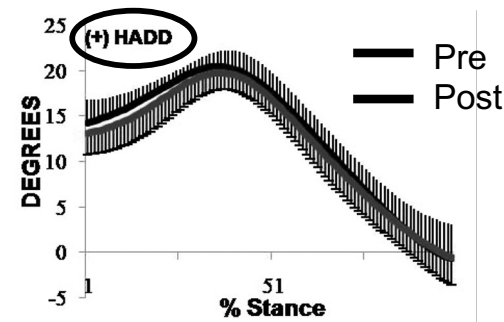


*Willy et al, 2011*



**Hip Muscle Strength Increased**

# Effect on Mechanics



Strength = 'Hardware' Motor Pattern = 'Software'

You have to address the **Software** if you want to change the motor pattern

Unless the underlying mechanics are addressed, injury risk may be increased

# Gait Retraining

.....but how do we do it?

# Promoting New Motor Patterns

## **Faded Feedback Design**

Internalization of a motor skill is facilitated by acquisition and transfer phases

**Acquisition:** extrinsic feedback on a predetermined schedule

Inherent intrinsic components – kinesthesia, proprioception, etc.

**Transfer:** extrinsic feedback gradually removed -  
Rely on intrinsic components

Faded feedback integrates the two phases gradually

*Winstein, 1999*

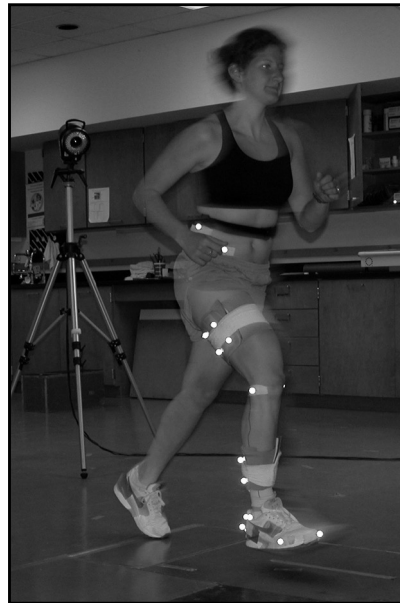
# Gait Retraining: Alignment

## Mirror Retraining Study

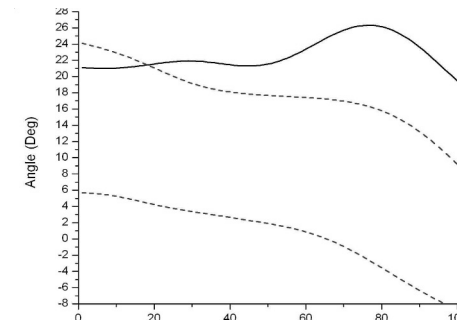
10 recreational runners, 15-45 yrs  
PFP >3/10 >2 mos (**avg 54 months**)



Initial video screen for  
Hip ADD and/or IR



Instrumented Gait  
Analysis



Hip ADD > 1sd of NL

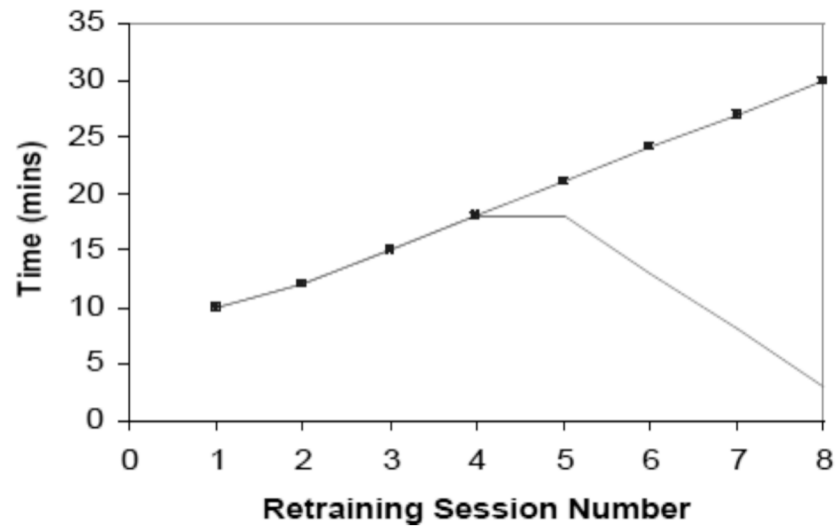
*Willy et al., 2012*



# Retraining



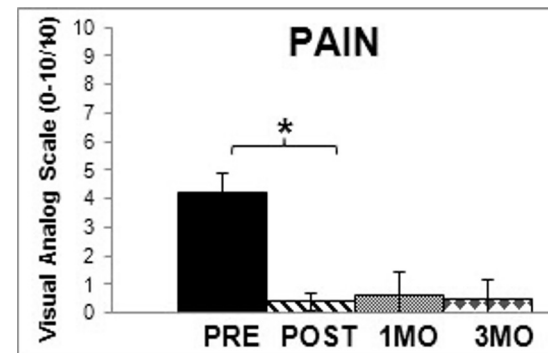
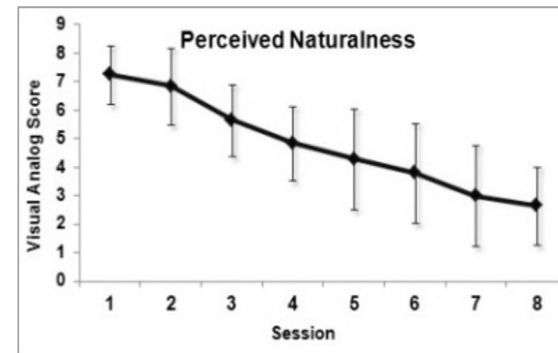
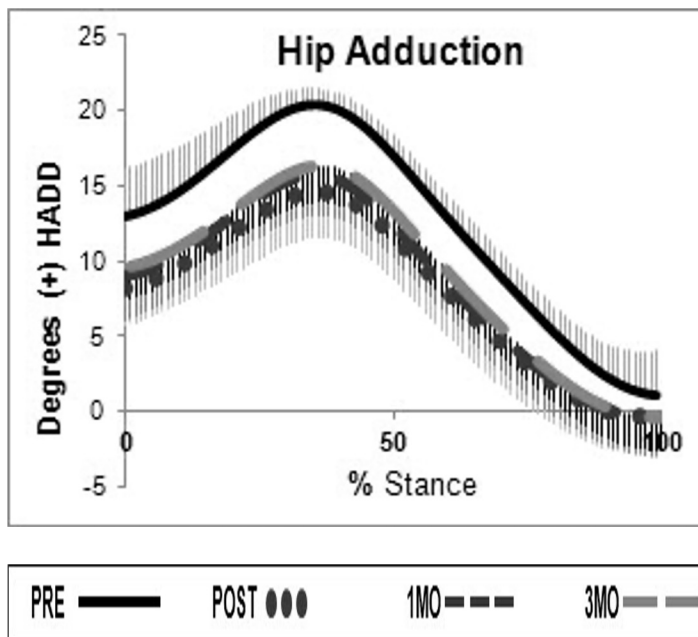
Activate glutes



Faded FB design

No additional strengthening

# Results

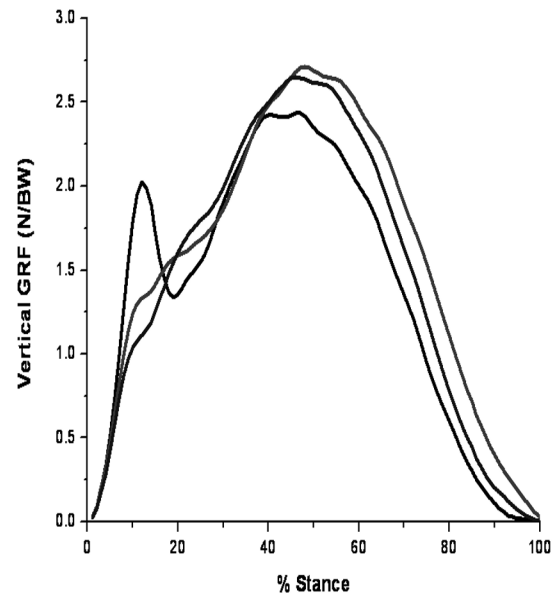


Suggests alignment changes can be made, can become more natural and and can persist!

# Mechanics



Alignment



Loading

Goal: Well-Aligned, Soft Landings

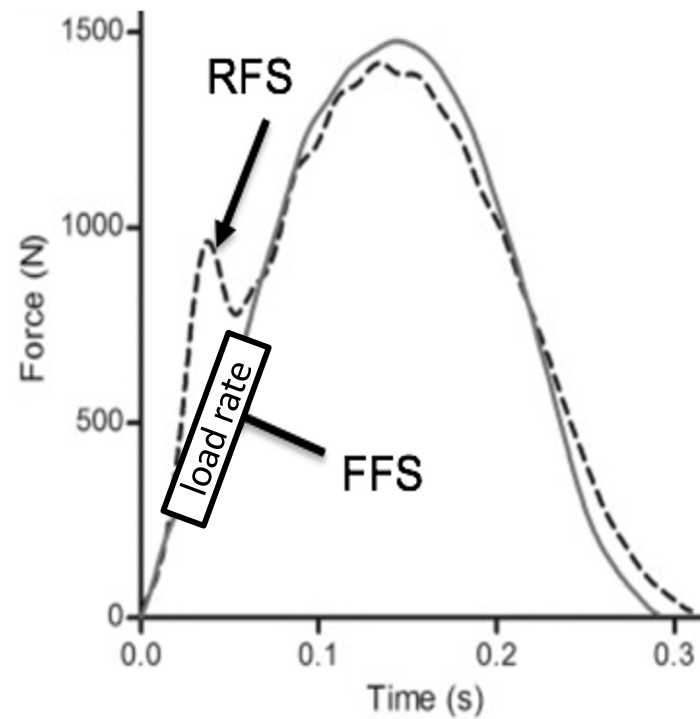
# Loading: Ground Reaction Force Impacts



RFS  
95%



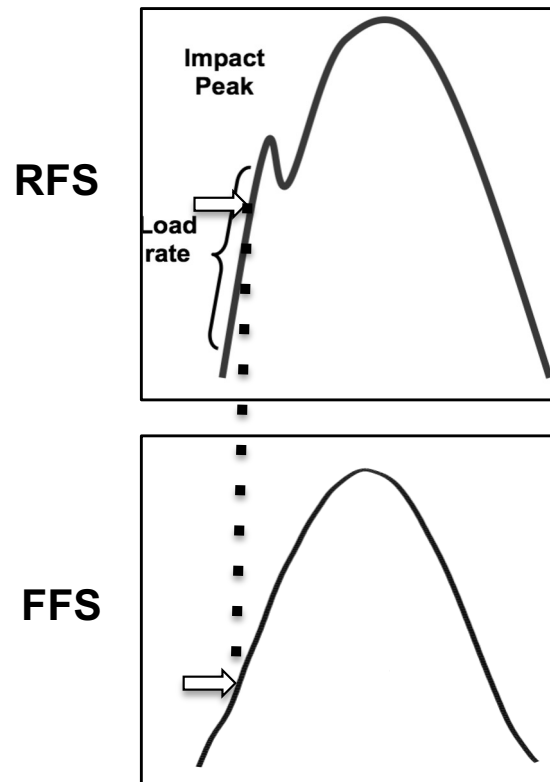
FFS  
1%



*DeAlmeide et al., 2015*

Distinct impact peak and higher loadrate in RFS

# Why does Footstrike matter to the knee?



High forces at time with Knee EXT –  
patellar contact areas are small

High Force/small area =  
**HIGH PFJ stress**



Lower forces and Knee FL - patellar  
contact areas are larger

Low Force/large area =  
**LOW PFJ stress**

**PFP associated with high loadrates**

*Johnson et al, 2020*

# Retraining to Reduce Impacts



Contents lists available at ScienceDirect

Clinical Biomechanics

journal homepage: [www.elsevier.com/locate/clinbiomech](http://www.elsevier.com/locate/clinbiomech)

## The effects of gait retraining in runners with patellofemoral pain: A randomized trial

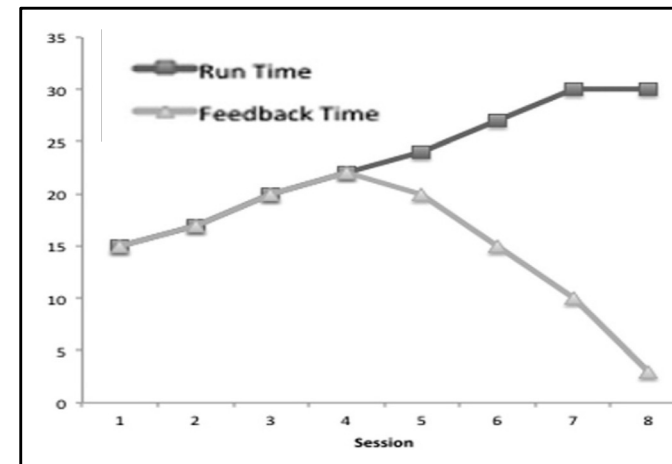
Jenevieve L. Roper<sup>a,\*</sup>, Elizabeth M. Harding<sup>a</sup>, Deborah Doerfler<sup>b</sup>, James G. Dexter<sup>b</sup>, Len Kravitz<sup>a</sup>, Janet S. Dufek<sup>c</sup>, Christine M. Mermier<sup>a</sup>

<sup>a</sup> Department of Health Exercise, and Sports Sciences, University of New Mexico, Johnson Center, MSC04 2610, Albuquerque, NM 87131, USA

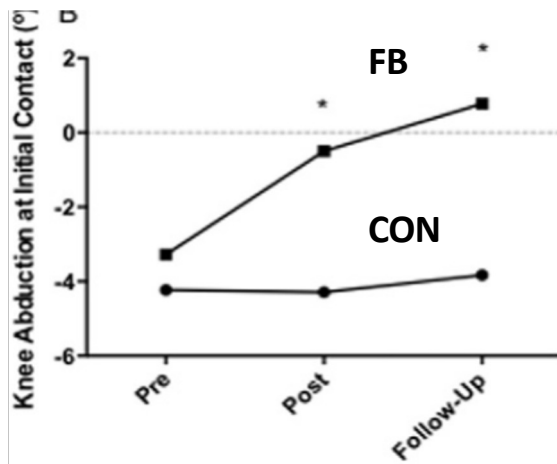
<sup>b</sup> Division of Physical Therapy, Department of Orthopedics, University of New Mexico, MSC09 5230, Albuquerque, NM 87131, USA

<sup>c</sup> Department of Kinesiology and Nutrition Sciences, University of Nevada, Las Vegas, 4505 S. Maryland Pkwy, Las Vegas, NV 89154, USA

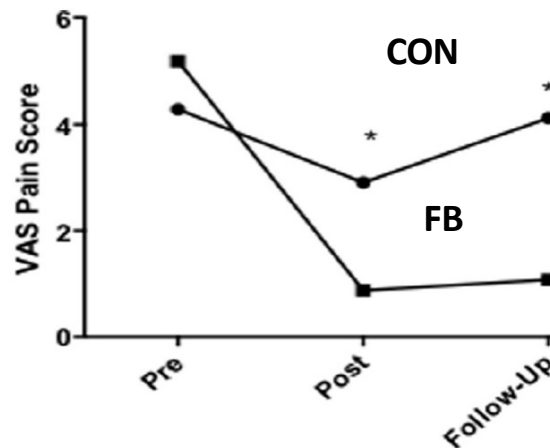
16 Runners (avg 23 yrs)  
(8 Con, 8 FFS retrain)  
Running avg 24 mpw  
PFP >3/10



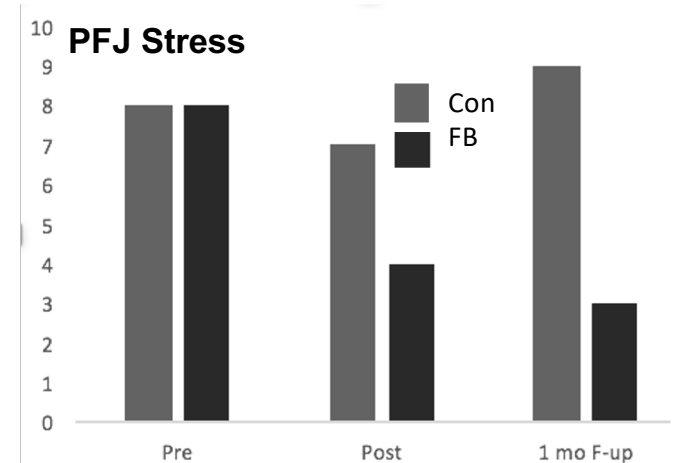
# Roper et al: Results



**FB:** Significant reduction knee abduction (valgus)



**FB:** Significant reduction in pain

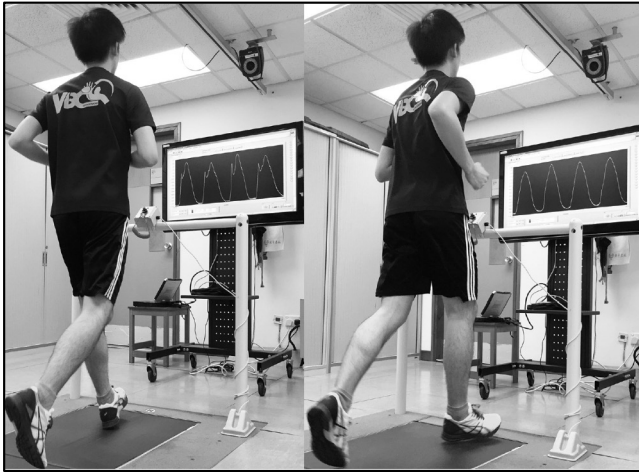


**FB:** 50% reduction in early stance PFJ stress post and at 1 mo f-up

Control group did not change in any of the variables!

# Reducing Loadrates to Reduce Injuries

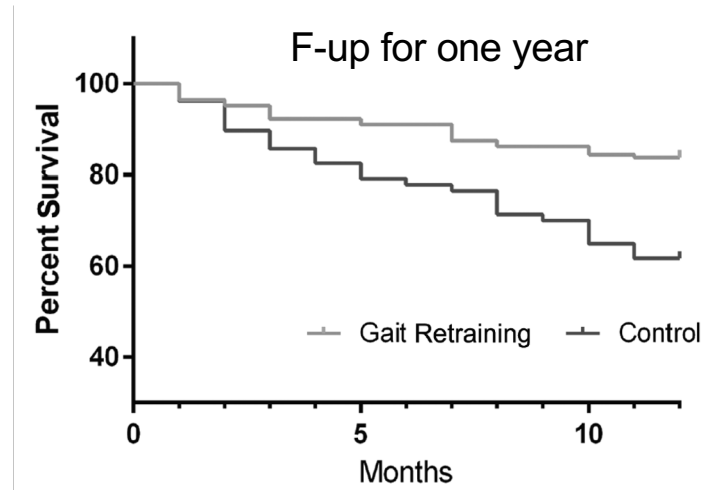
**Chan, 2018**



320 novice (<2 yrs) runners randomized into CON and Gait Retraining groups.

8 sessions of retraining with Realtime FB of VGRF provided. Goal: eliminate impact

**Retrain: Loadrate significantly reduced**



**62% lower injury risk in gait-retrained runners compared with controls.**

**PFP 4X higher in Control group**

**1st study to suggest that reducing LR in uninjured runners can reduce injury risk!**



# Clinical Approach

Strengthen hips, lower legs and feet



Wean out of orthotics



Transition to minimal footwear for walking



Running Retraining on Treadmill

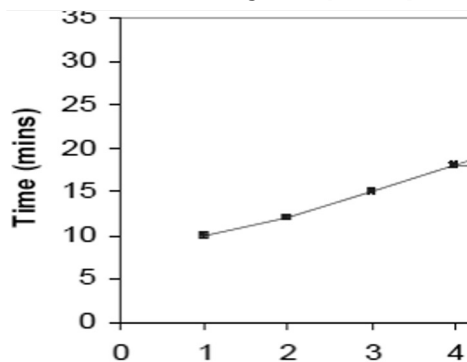
Transition to mild FFS (reduce impacts)

Retrain Alignment (reduce Hip ADD)

# Retraining Process

## FFS training Requirements

30 single leg heel raises  
45 second hold  
10 single leg domed hopping  
1 minute jump rope

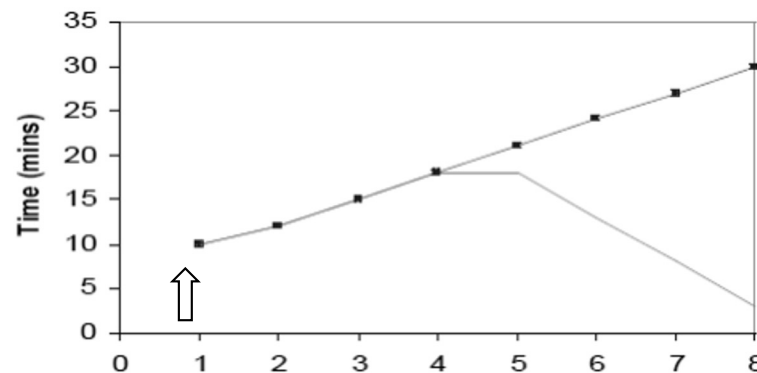


4 Sessions of BF FFS  
From 10-20 min

Use sound/accelerometer as FB

## Realignment training Requirements

10 well aligned single leg squats  
10 well aligned hopping  
30 sec planks



8 Sessions of retraining (with FFS)  
From 10-30 min

Use mirror as FB

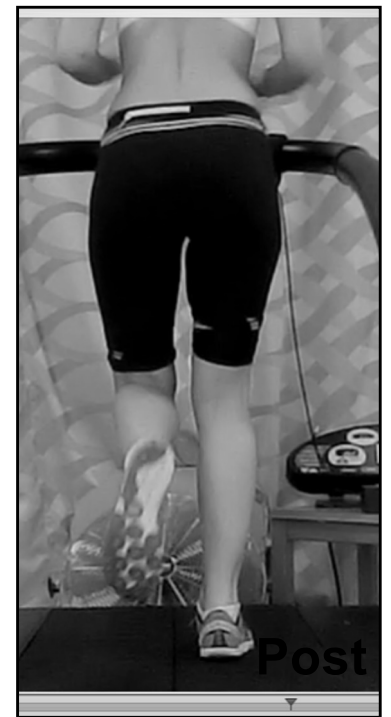
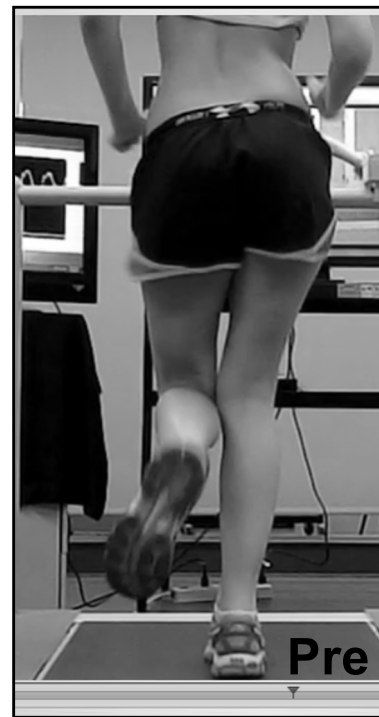
# Outdoor Running Program

Week #	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total Time
1	20 min. outdoors		20 min outdoors		20 min indoors		22 min outdoors	82 minutes
2		25 min outdoors		25 min indoors		30 min outdoors		80 minutes
3*	30 min outdoors		30 min outdoors		30 min indoors			90 minutes
4		35 min outdoors		30 min outdoors		35 min outdoors		100 minutes
5**	30 min outdoors		30 min indoors		20 min outdoors		35 min outdoors	115 minutes
6		40 min outdoors		30 min outdoors		40 min outdoors		110 minutes
7	30 min outdoors		30 min indoors		20 min outdoors		45 min outdoors	125 minutes
8		45 min outdoors		30 min outdoors		45 min outdoors		120 minutes
9	30 min outdoors		50 min outdoors				55 min outdoors	135 minutes
10		45 min outdoors		45 min outdoors		60 min outdoors		150 minutes

• 2 week follow-up

\*\* 4 week follow-up

# Clinical Results



# 15 yr old Competitive Athlete with 3 mo hx of PFP



Could only run 10 min due to  
pain PFP 7/10 on VAS



Running 30 min pain-free!

# Retraining can lead back to Competition



Irene and all,

A quick update on Molly's running – so far, NO PAIN

Each week she seems to be getting closer to where she was last year. This past weekend at a big invitational in NJ, **She won her division finishing with the 6<sup>th</sup> fastest time of the day**

The best news for us was when she looked at photos from the race and **saw her knees were much straighter!**

Thanks,

Terry, Ann and Molly

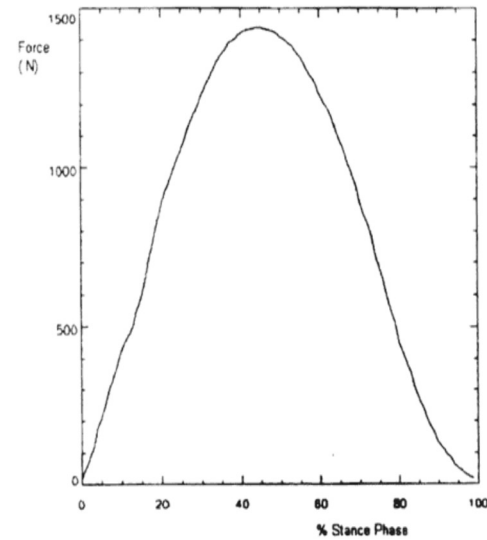
# Overview of Treatment Philosophy for PFP



Build  
Capacity



Well-Aligned



Soft Landings



Footwear Matters

Retraining is not a quick fix....but addressing the underlying cause is worth the effort

# Thank You

