

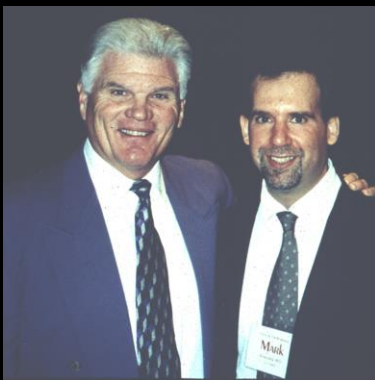
DOES ALTERED BIOMECHANICS CAUSE BONE MARROW EDEMA?

Alicia M. Yochum RN, DC, DACBR, RMSK



DOES ALTERED BIOMECHANICS CAUSE BONE MARROW EDEMA?

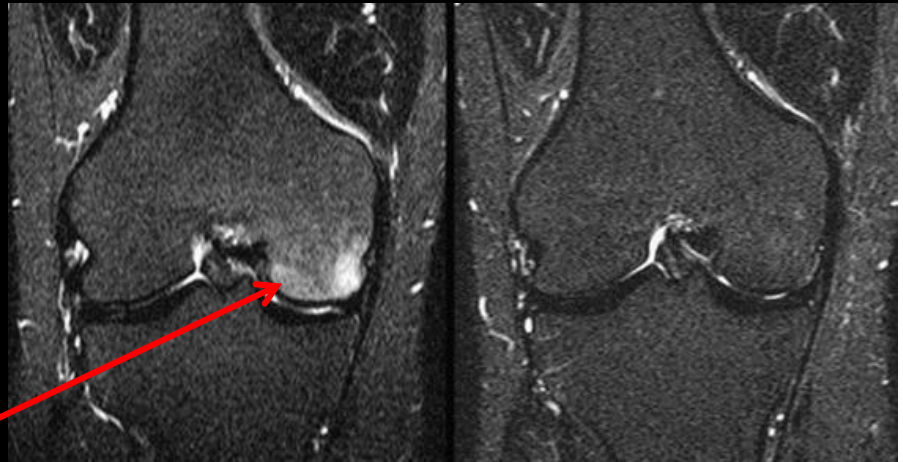
Mark E. Schweitzer, MD and Lawrence M. White MD



Department of Radiology
Thomas Jefferson University Hospital
Philadelphia, Pennsylvania
Radiology 198:851
March 1996

WHAT IS BONE MARROW EDEMA?

- Inflammation in the bone
- Injury to the trabeculae causing it to bleed
 - Repetitive
 - Impact
- Controversial Etiology
- Blood= Fluid
- Fluid= High signal



Fluid = White

Marrow (Fat)= Black

MATERIALS AND METHODS

• 12 Participants

- 6 Women 6 Men
- Age: 19-41 (Mean 30)
- All asymptomatic and without abnormal pronation

• MRI – baseline

- Bilateral foot, ankle, knee, and hip
- Scans utilizing a 1.5 Tesla magnet was done utilizing STIR imaging which suppresses fat signal and enhances water signal

• Insert

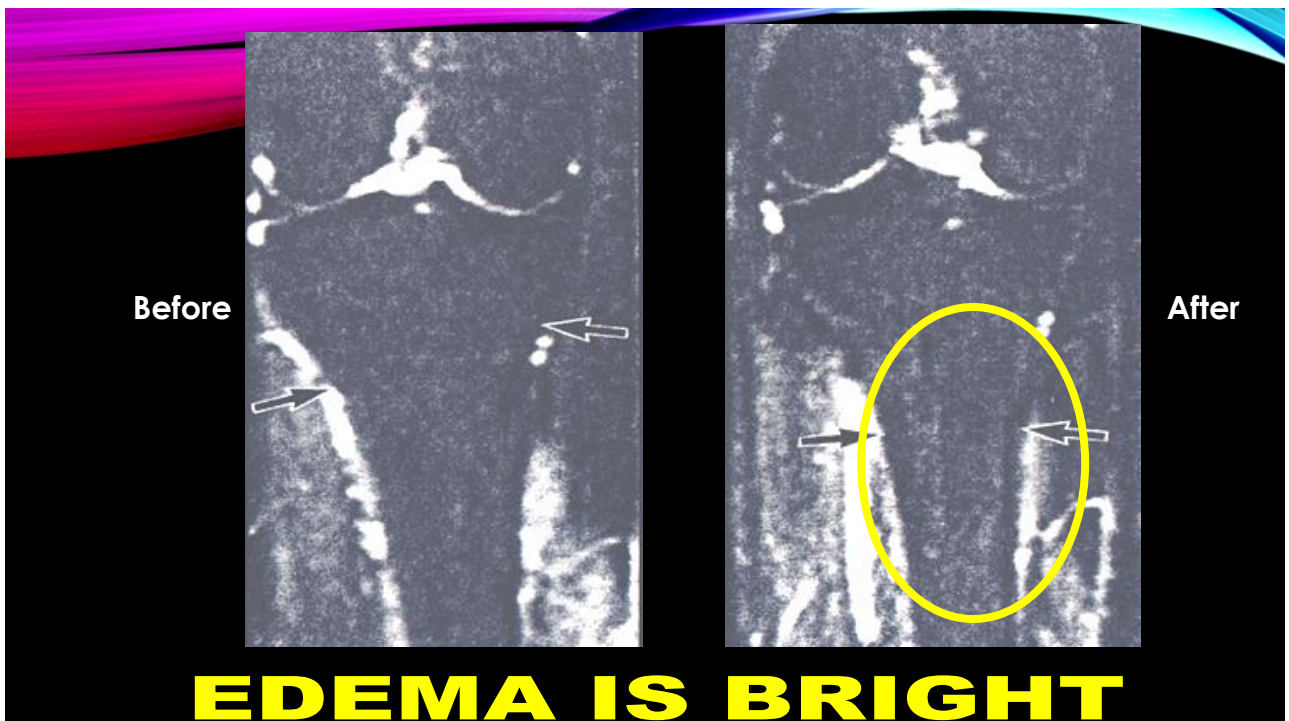
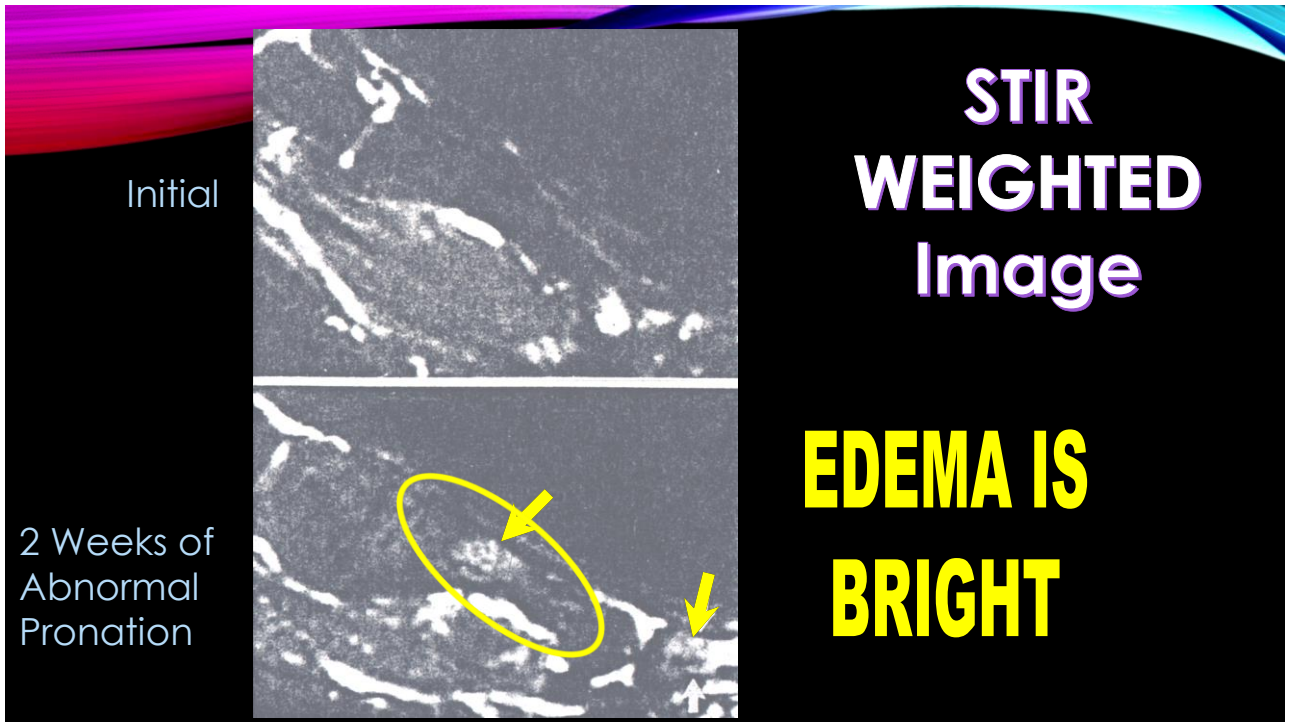
- 9/16" (1.4cm) longitudinal metatarsal arch pad inserted into the shoes of one foot of each volunteer
- Forces the participant into unilateral abnormal foot pronation

RESULTS

- An additional MRI scan was done after 2 weeks of forced abnormal foot pronation utilizing the insert
- 11 participants developed bright signal consistent with fluid/water indicating bone marrow edema (BME)
- 1 participant showed involvement on the contralateral foot

LOCATION OF BME

- Locations: **Foot, Tibia, Femur**
 - Most were at metatarsal and phalangeal joints
 - 8 phalanges
 - 4 metatarsals
 - The most common was the first ray
- Some were more pronounced than others with 2 appearing similar to a stress fracture



RESULTS

Clinical

- Nearly all participants complained of pain or discomfort in the lower extremity during the study
- All volunteers were asymptomatic immediately after insert removal and at clinical follow up
 - 1 day, 1 week, 1 month

Imaging Follow Up

- 3 volunteers were imaged a 3rd time (2 weeks after removal of the insert) to determine if the BME had resolved
- NO signal alteration was noted in the previous areas of BME in 2/3
- One participant demonstrated *minimal* persistent edema that was more diffuse than when originally noted

ALTERED BIOMECHANICS AND BONE MARROW EDEMA – REVISITED

Logan College of Chiropractic Research Study, St. Louis, MO

PARTICIPATING INVESTIGATORS

- Dr. Alicia M. Yochum – Principal Investigator
- Dr. Gary M. Guebert
- Dr. Jeff Thompson
- Dr. Terry R. Yochum
- Dr. Kim Christensen
- Dr. Reed B. Phillips
- Dr. Norman W. Kettner
- Dr. Mark Schweitzer (M.D.)



MATERIALS AND METHODS

- **22 total student participants**

- 17 treatment participants
- 5 control participants

- **Inclusion Criteria**

- Normal BMI
- 20-30years old

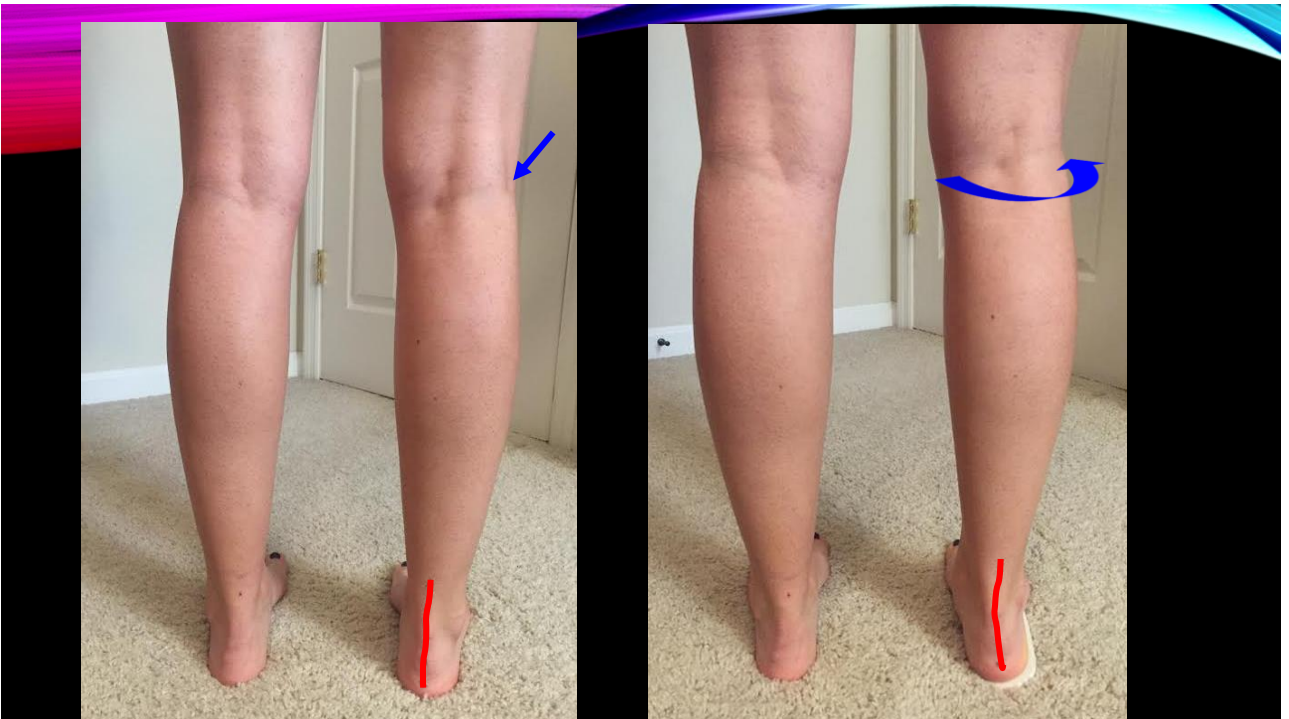
- **Exclusion Criteria**

- Pre-existing **abnormal pronation** of the foot- Physical examination
- History of **chronic low back** or **lower extremity pain** in the last 6 months
- Use of **opioid medications**
- **Runs** more than **10 miles/week**
- **Preexisting conditions** (metabolic, bone softening)
- Device that that would be incompatible with MRI (**pacemaker**)

METHODS

- 17 participants placed in unilateral **FORCED pronation** utilizing a 9/16 inch insert in their right shoe
- Control Group: 5 Randomly Selected Participants- No insert
 - Undergo all other aspects of study (VAS, Biomechanical Pictures, MRI's)
- All students are instructed to go about their normal activities of daily life to include their normal exercise routine (running under 10mi/wk).





TIME LINE

6 Week Protocol

- **Initial** MRI scan to make sure participants do not have preexisting BME
- **2 Weeks**- MRI Scan after insert was in place for 2 weeks
- **4 Weeks**- MRI Scan after 2 additional weeks of abnormal pronation with the insert
 - After this scan the insert was removed
- **6 Weeks**- Follow up scan after 2 weeks without the pronation device to look for resolution of symptoms/edema
- At the time of each MRI scan, biomechanical pictures (overhead squat) were taken and a Numerical Rating Scale (NRS) was performed.

IMAGING STUDIES

- All participants were scanned with a 1.5 Tesla MRI magnet.
- **STIR** images obtained
 - Suppress all signal from fat so FLUID/EDEMA stands out **White**
 - Bone marrow/trabecular bone is **Black**
- The areas scanned: **BILATERAL**
 - **Foot**- Sagittal
 - **Ankle**- Sagittal
 - **Knee**- Coronal
 - **Hip**- Coronal
 - **Sacroiliac Joint**- Coronal
 - **Lower lumbar spine**- Sagittal

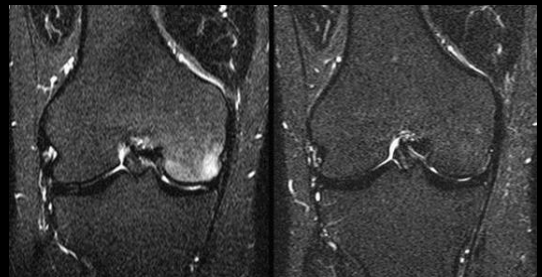
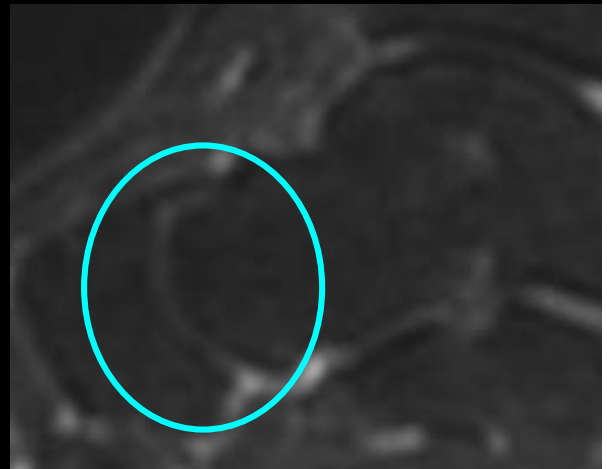
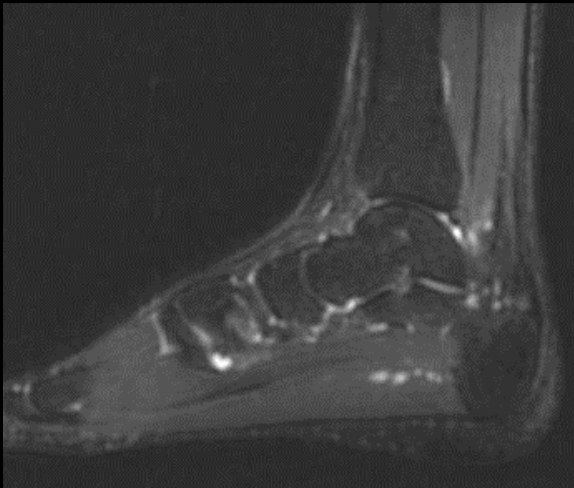


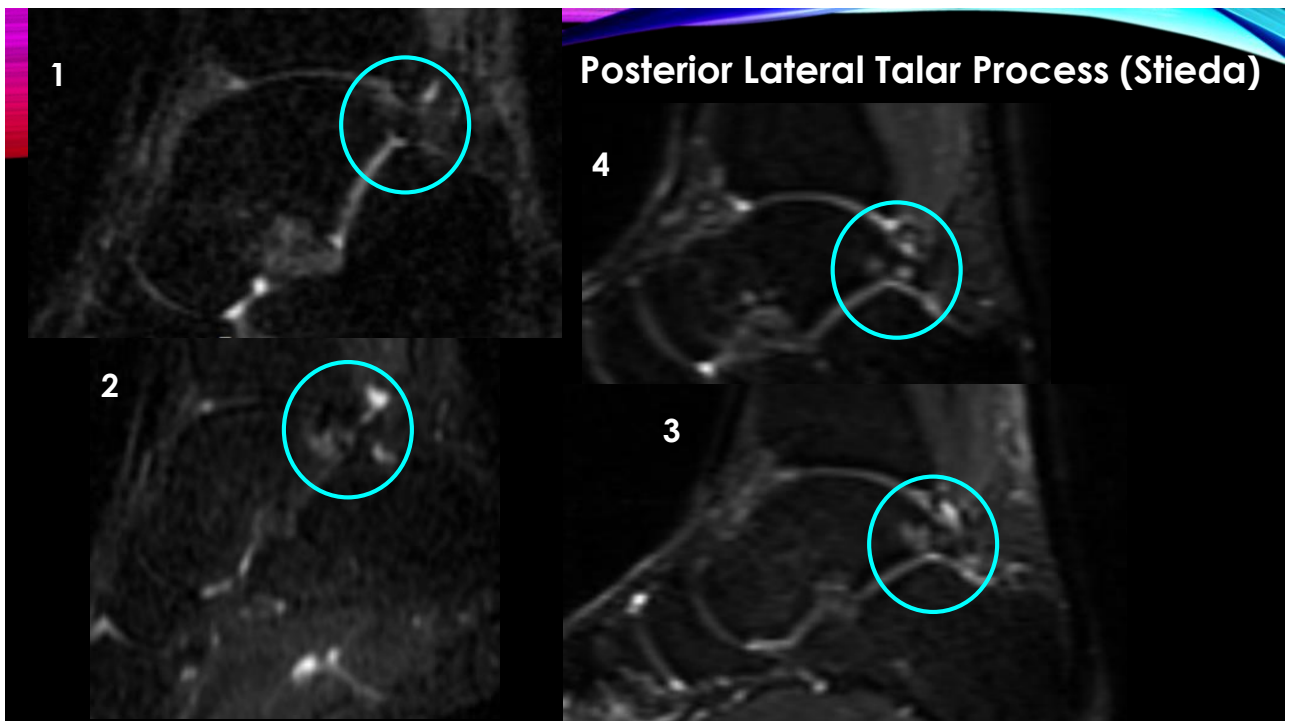
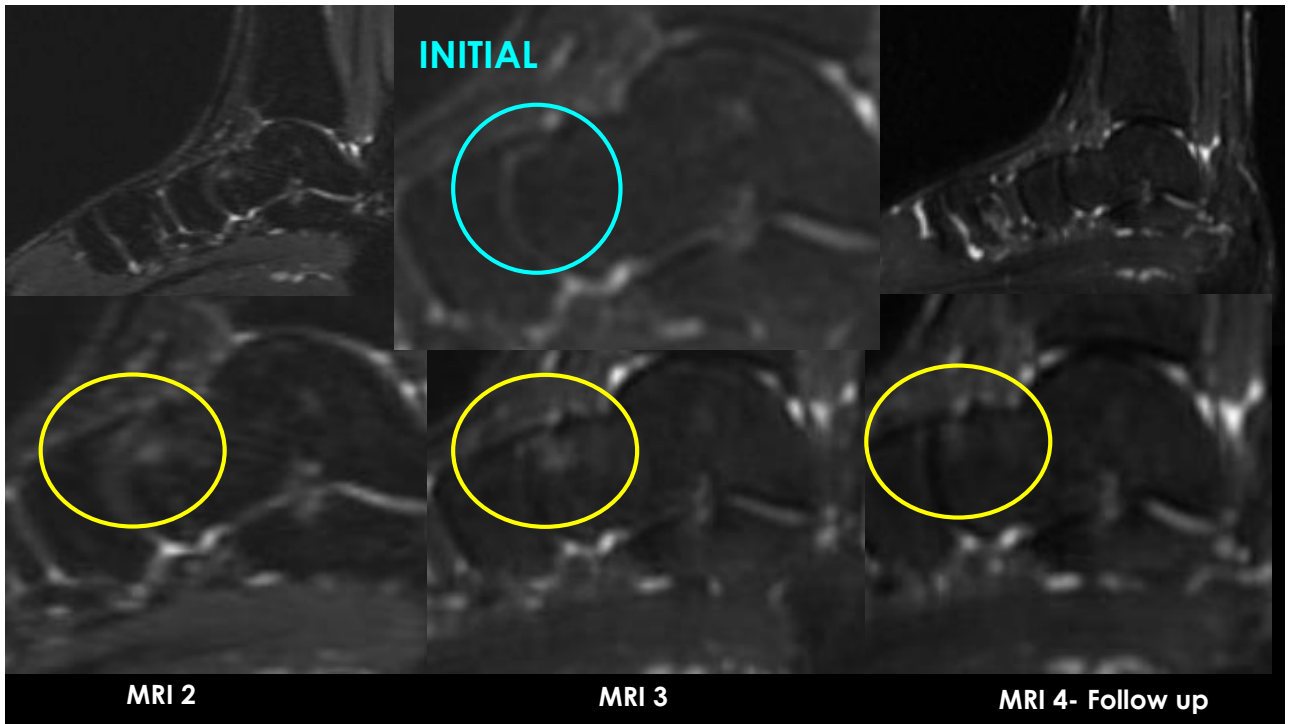
IMAGE INTERPRETATION

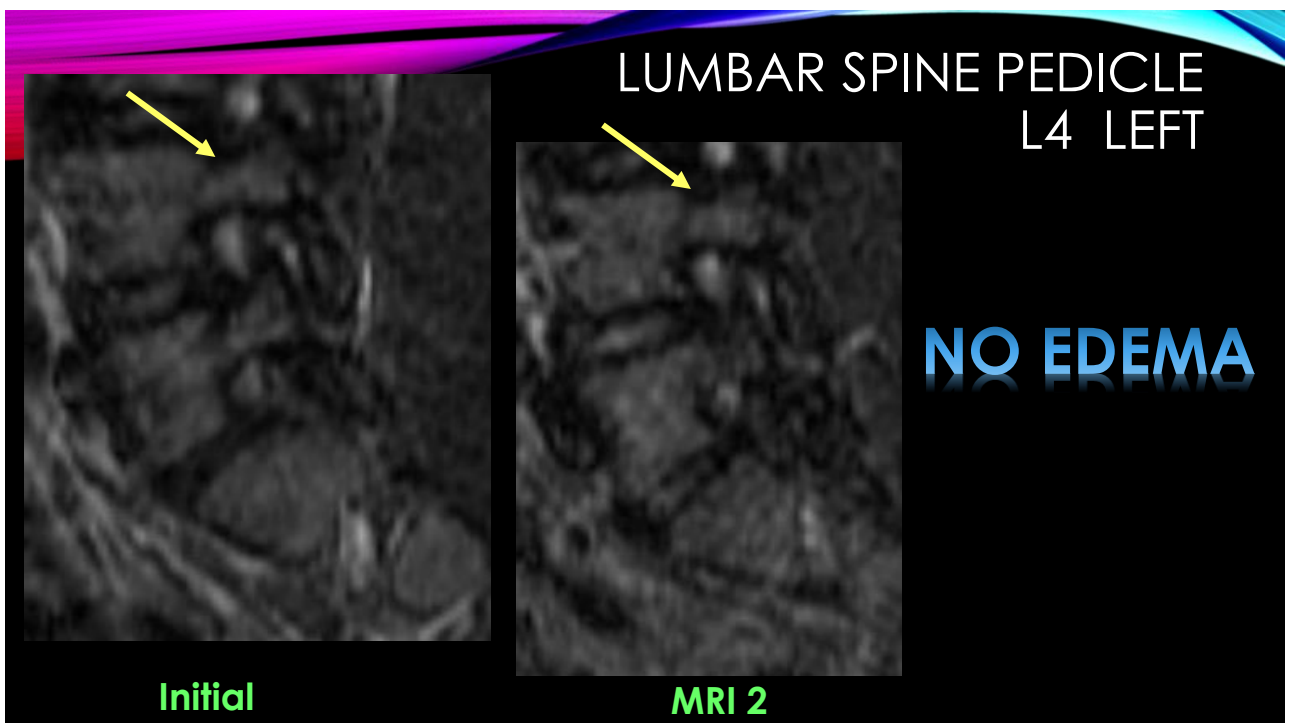
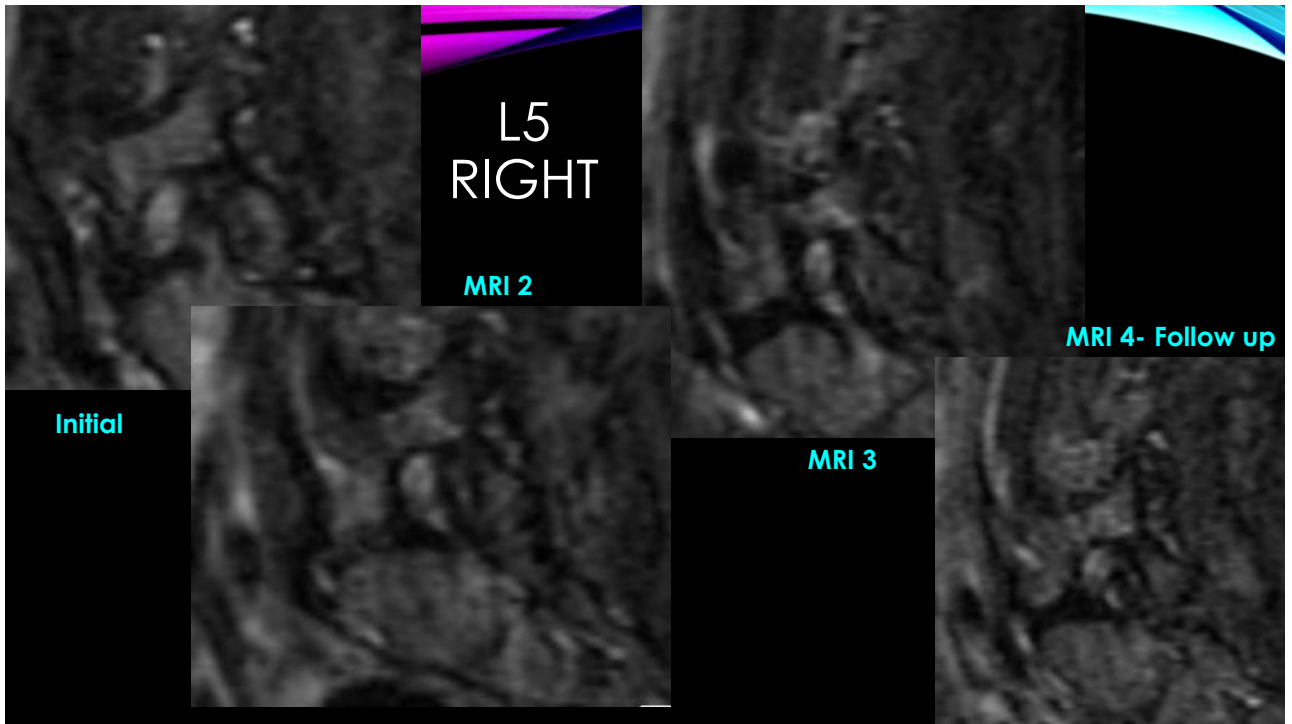
- Two Radiologists certified by the American Chiropractic Board of Radiology (ACBR)
 - Dr. Gary Guebert and Dr. Jeff Thompson
- Blinded as to which students have been pronated and which ones have not.

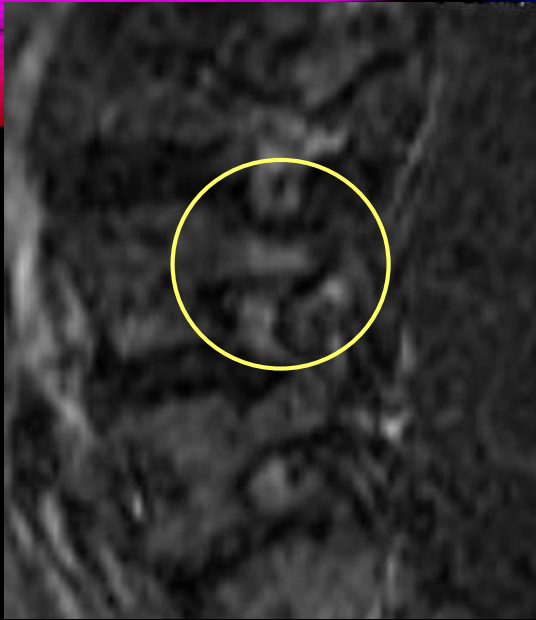
IMAGING RESULTS

- Talonavicular Joint- Initial Study NO BME









MRI 3



MRI 4- Follow Up

PAIN EVALUATION

- Done before the study began and every 2 weeks (MRI)
 - All scores were 0 initially = Patients had NO low back pain or lower extremity pain
- **Oswestry**: Done before study began and at the time of the 3rd MRI
 - Right before the insert was taken out

**100% of Participants with inserts
developed Low Back Pain!**

- 13 participants developed pain in their foot and knee
- NO hip pain

Range: 6-58% Disability **Oswestry**
Average: 27% All began at 0%
17% of participants = SEVERE disability!
1 participant was 3% away from CRIPPLED

| | |
|--------------------------------|---|
| 0% to 20%: minimal disability: | The patient can cope with most living activities. Usually no treatment is indicated apart from advice on lifting sitting and exercise. |
| 21%-40%: moderate disability: | The patient experiences more pain and difficulty with sitting, lifting and standing. Travel and social life are more difficult and they may be disabled from work. Personal care, sexual activity and sleeping are not grossly affected and the patient can usually be managed by conservative means. |
| 41%-60%: severe disability: | Pain remains the main problem in this group but activities of daily living are affected. These patients require a detailed investigation. |
| 61%-80%: crippled: | Back pain impinges on all aspects of the patient's life. Positive intervention is required. |
| 81%-100%: | These patients are either bed-bound or exaggerating their symptoms. |

DATA ANALYSIS

- **Statistical Significance with p-value <0.05**
- **Bone Marrow Edema**
 - Fisher's Exact (small sample size)
 - Not statistically significant although those that developed BME were all in the treatment group
 - Not random incidence
 - p value- 0.59 and 0.77 (time point 2 and 3)
 - Study is underpowered= not enough people
- **Numerical Rating Scale**
 - Repeated ANOVA and T-Test
 - Overall significance of pain over time: p-value <0.001
 - Significance between time point 1 and 2 as well as 3 and 4.
 - Significance between the treatment and control: p-value <0.05
 - Significance in Knee pain in those who developed BME (p 0.01)
- **Oswestry**
 - Pair-wise T-test
 - Statistically significant difference in participants at the beginning of the study verses the end: p-value <0.001
 - Statistically significant difference in control verses treatment

WHAT IS PRONATION?...



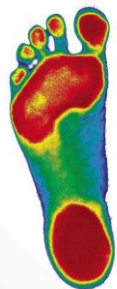
Normal part of the gait cycle

- Heel Strike: Supinated
- Midstance: Pronated
- Toe Off: Supinated

Abnormal Pronation

- Toe out- Pronounced heel strike in supination
- Excessive pronation in midstance
- Increased load on 1st toe at toe off

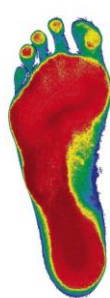
3 ARCHES...



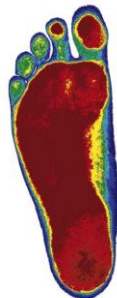
Well-Balanced



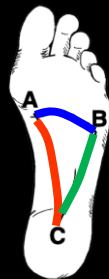
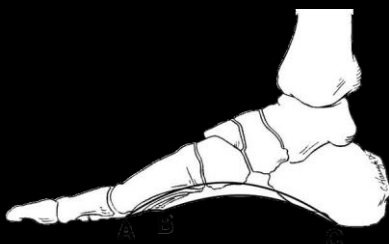
Mild Pronation



Moderate Pronation



Severe Pronation



Anterior Transverse Arch

Lateral Longitudinal

Medial Longitudinal

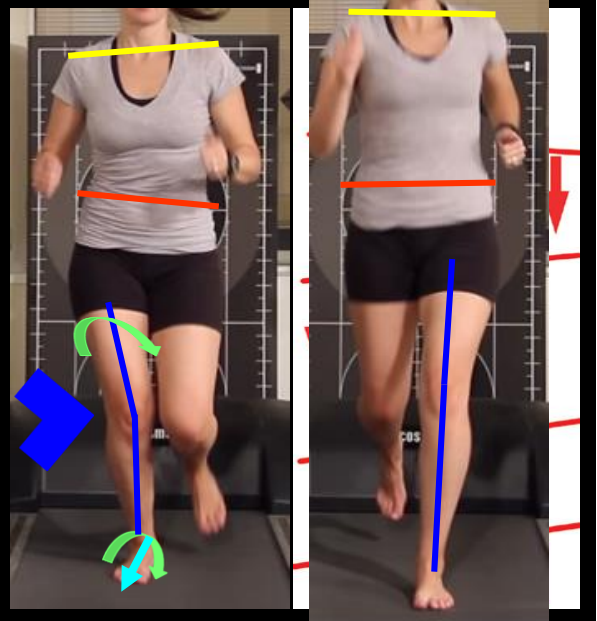
BIOMECHANICAL FAULTS

Possible Biomechanical effects of **ABNORMAL** Pronation

- Dropped Arch (Calcaneal eversion)
- Toe out
- Medial deviation of the knee
 - Internal rotation and femur
 - Genu valgus deformity
- Pelvic Unleveling
- Shoulder Unleveling



<https://www.youtube.com/watch?v=DN9KGP1g0>



WHAT DID WE SEE IN OUR STUDY?... OVERHEAD SQUAT ANALYSIS

Most Common

1. Toe Out
2. Arch Drop (calcaneal eversion)
3. Knee Deviation (Medial/Lateral)
4. Forward Arms
5. Forward Lean

Uncommon

- Forward Head
- Low Back Arch/Rounding
- Weight Shift

NOT FOUND

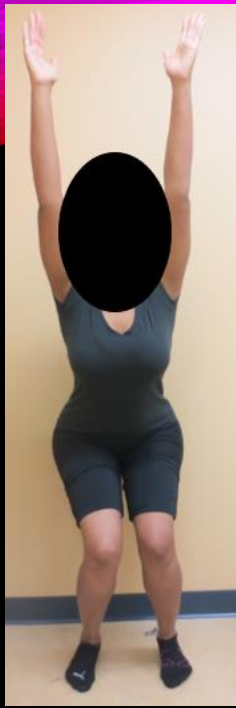
- Heels Up

PRE-EXISTING FUNCTIONAL BIOMECHANICAL FAULTS!



Knee Deviation

- More commonly encountered on the left



Medial



Lateral



Forward Arms/Lean

So What if WE don't
do anything?

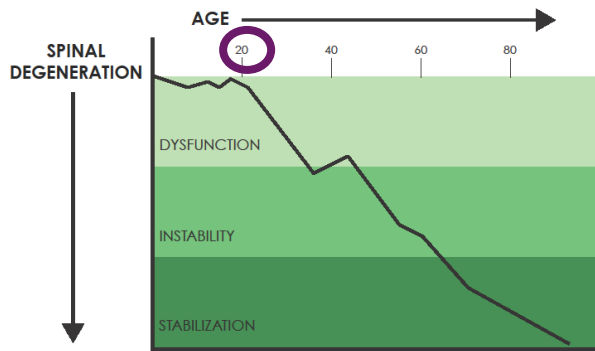
Structural Imbalances Leads to Dysfunction

Wolff's Law: Any bone under stress, given time, may cause bone production in attempt to strengthen and/or stabilize the bony structure



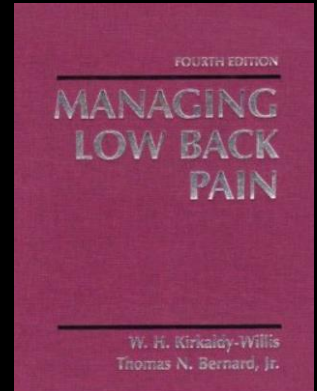
SIR KIRKALDY WILLIS MD

NATURAL HISTORY OF SPINAL DEGENERATION



3 Stages of Degeneration

- Dysfunction
- Instability
- Stabilization



PRE-EXISTING FUNCTIONAL BIOMECHANICAL FAULTS!

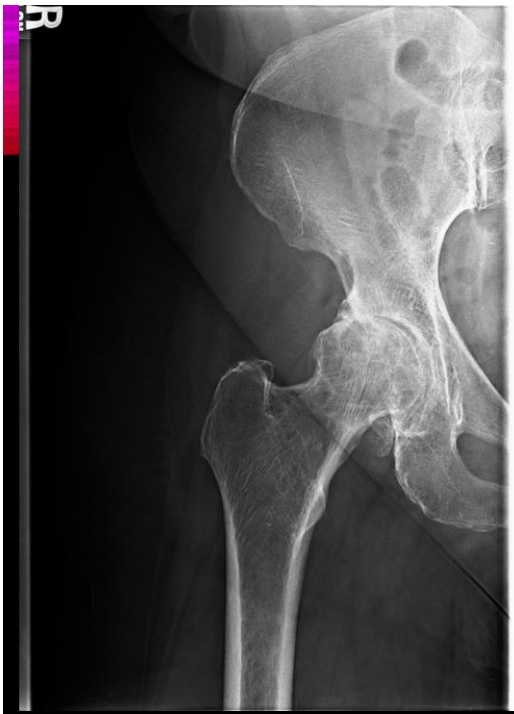
KNEE DEVIATION



VARUS



VALGUS



Case Courtesy of Logan University



- Compression Fracture = Altered Mechanics

