DOES ALTERED BIOMECHANICS CAUSE BONE MARROW EDEMA?

Alicia M. Yochum RN, DC, DACBR, RMSK

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

Department of Radiology
Thomas Jefferson University Hospital
Philadelphia, Pennsylvania
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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
Initial

2 Weeks of Abnormal Pronation

STIR WEIGHTED Image

EDEMA IS BRIGHT

Before

After

EDEMA IS BRIGHT
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 images 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
  • 20-30 years 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 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).
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
L5
RIGHT
MRI 2

MRI 4 - Follow up

LUMBAR SPINE PEDICLE
L4 LEFT

NO EDEMA

Initial

MRI 2

Initial

MRI 2

Initial

MRI 3

4/23/2018
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
Average: 27%
17% of participants = SEVERE disability!
1 participant was 3% away from CRIPPLED

<table>
<thead>
<tr>
<th>Disability Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% to 20%: minimal disability</td>
<td>The patient can cope with most living activities. Usually no treatment is indicated apart from advice on lifting sitting and exercise.</td>
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<tr>
<td>21%-40%: moderate disability</td>
<td>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.</td>
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<tr>
<td>41%-60%: severe disability</td>
<td>Pain remains the main problem in this group but activities of daily living are affected. These patients require a detailed investigation.</td>
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<tr>
<td>61%-80%: crippled</td>
<td>Back pain impinges on all aspects of the patient’s life. Positive intervention is required.</td>
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<tr>
<td>81%-100%:</td>
<td>These patients are either bed-bound or exaggerating their symptoms.</td>
</tr>
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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...

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**Well-Balanced**  **Mild Pronation**  **Moderate Pronation**  **Severe Pronation**

**Anterior Transverse Arch**

**Lateral Longitudinal**

**Medial Longitudinal**
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

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**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!**
TOE OUT

Dropped arch (calcaneal Eversion)
Knee Deviation

• More commonly encountered on the left

Medial

Lateral

Forward Arms/Lean
Wolff’s Law: Any bone under stress, given time, may cause bone production in attempt to strengthen and/or stabilize the bony structure.
3 Stages of Degeneration
- Dysfunction
- Instability
- Stabilization

PRE-EXISTING FUNCTIONAL BIOMECHANICAL FAULTS!

KNEE DEVIATION

VARUS

VALGUS
Compression Fracture = Altered Mechanics