HIT THE GROUND RUNNING:
Appreciating the Importance of Foot Strike in NBA Injuries

- Bruce Williams, D.P.M.
- Breakthrough Podiatry
- Breakthrough Sports Performance
Injury in the National Basketball Association: A 17-Year Overview

- Injury Rate by specific pathology
  - Lateral Ankle Sprain
  - Patellofemoral Inflammation
  - Lumbar Sprain / Strain
  - Hamstring Strain
  - Adductor Strain

Sagittal Plane Progression Theory

Pivot or Rocking Phases of Gait

There are three primary pivotal phases:

- Sagittal Plane Progression Theory
  - In the foot, Sagittal plane progression may be blocked at the
    - calcaneus,
    - ankle joint,
    - or the 1st MPJ

Sagittal Summary

- “the foot is viewed as a sagittal plane pivotal site which the body’s centre of mass is permitted to move forward over the foot during the single support phase of gait.”
- The swing limb helps to maintain propulsion of the body’s center of mass.
- “…precise timing and direction of weight flow through the foot is needed to establish auto supportive functions…”

Assessment of Foot Pathology

- First MPJ Function
- Ankle Joint
- Midfoot Mechanics
- Limb Length Difference

Sagittal Plane Mechanics

ForeFoot Effects

Gait Curve

Heel Curve

Forefoot
First MPJ Assessment

- If there is less than 65 degrees of available 1st mpj ROM during propulsion, the patient is considered to have structural hallux limitus. Root, Orien, Weed: Normal and Abnormal Function of the Foot.
- Level 3 Evidence

First Ray Cutout

- A study by Hall and Nester, shows that a decrease in 1st mpj dorsiflexion motion leads to Sagittal plane compensations at the Ankle Joints, Knee Joint and Hip Joints.
  - Sagittal Plane Compensations for Artificially Induced Limitation of the First Metatarsal Head Joint. A Preliminary Study. C Hall, CJNester, JAPMA, Vol 94; No 3; May-June 2004 – Level 2

First Ray Stability / Stiffness

- “Stability of the medial forefoot is necessary from heel-rise to toe-off to support body weight and propulsive forces”
- “Excessive Movement of the first ray limits the effectiveness of the foot-lever system.”

First Ray Cutout

- An unstable 1st ray will lead to more weight shifted laterally towards the lesser metatarsal heads.
  - Comparison of Two Methods Used to Assess First Ray Mobility. WM Glasoe, MR Allen, CL Saltzman. Foot & Ankle International Vol. 23, No.3 March 2002. – Level 2 Evidence

First MPJ Assessment

- “Functional hallux Limitus (Fhl) represents a complete locking of the primary Sagittal plane pivotal site, the first MTP joint, strictly during all or portions of the single support phase of the gait cycle.
- This is true in spite of the fact that full range of motion occurs in the non-weight bearing examination.”

Midstance Mechanics

- Midstance Overlap
  - Heel Curve
  - Forefoot Curve
  - Gait Curve
**Midfoot Mechanics**

- The majority of motion that allows for dorsiflexion of the forefoot on the rearfoot comes from the medial and lateral columns of the foot, primarily the first and fifth rays, and not so much at the midtarsal joint.

  "The rearfoot plays only a part of overall foot kinematics and we have consistently undervalued the contribution from mid- and forefoot articulations"  


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**Dorsiflexion Stiffness / Hypermobility**

- Hypermobility of the first ray renamed by Kirby to Dorsiflexion Stiffness
- A stiffer 1st ray means higher medial arch, in general.
- A less stiff 1st ray means a hypermobile 1st ray.

- Level 3 Evidence

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**Peroneus Longus**

- Level 2 Evidence

  The peroneus longus stabilizes the medial column of the foot by evverting and “locking” the 1st ray of the foot.

  PL is active in midstance and heel-off and more active in flat footed patients. The muscle also abducts the FF on the RF.

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**Tibialis Posterior**

- Level 2 Evidence

  Used MRI to determine how the Posterior Tibialis really functions.

  ForeFoot adduction is the primary action by this muscle.

  It helps to hold the lateral aspect of the foot against the medial aspect.

  Stabilizes the medial column while the Peroneus Longus stabilizes the lateral column.

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**Achilles Affect**

- Level 3 Evidence

  Increasing the load of the Achilles Tendon caused a reduction of the peroneus longus tendon on the medial column.

  Increased Achilles load caused an inversion of the 1st metatarsal and also a flattening motion of the of the medial arch at the distal segments.
**Leg length inequality (LLI) is so common that it is considered the normal variant.**


- LLI is found in 90% of the population.


- The asymmetry of leg length is a common phenomenon, the left leg being longer in the majority of cases.


**LLD Gait Patterns**

- Functional, or apparent LLD is a result of muscle (tightness/weakness) or (tightness/weakness) across any joint in the lower extremity or spine.
  - Some of the more common causes can be pronation or supination of one foot in relation to the other
  - Hip abduction/adduction or tightness/contracture
  - Knee hyperextension due to quadriceps femoris weakness or early knee flexion
  - Lumbar scoliosis.


**Limb Length Difference**

- They also found that the ankle joint of the long side leg demonstrated increased dorsiflexion at terminal stance and a delay in the timing of this peak, while the short leg ankle produces early heel rise and greater degrees of plantarflexion during stance. References from Leg length discrepancy – an experimental study of compensatory changes in three dimensions using gait analysis. M. Walsh, P. Connolly, A. Jenkinson, T. O’Brien. Gait and Posture 12 (2000) 156-161

- Knee kinematics showed that the long limb side knee became more and more flexed during stance, double support and swing to clear the limb. The short side knee stayed extended late into midstance as the heel lift increased. There were no significant changes in the frontal or transverse planes. References from Leg length discrepancy – an experimental study of compensatory changes in three dimensions using gait analysis. M. Walsh, P. Connolly, A. Jenkinson, T. O’Brien. Gait and Posture 12 (2000) 156-161

**Lateral Ankle Sprain**

- “In closed kinetic chain, Achilles preload from equinus deformity will magnify forefoot load to the lateral column and indirectly resist the action of peroneus longus via ground reaction.”

- “By dampening frontal plane function of peroneus longus, equinus apparently affects the locking mechanism of the medial column.”

- “This investigation suggests that equinus reduces peroneus longus locking influence of the first ray which may also lead to hyper-mobility.”


  - Level 2 Evidence
Lateral Ankle Sprain

- “The tibiofibular-talar unit does not function independently of the subtalar or midtarsal joint but acts cooperatively in closed-kinetic chain performance.”
- “The various changes in ankle joint function influence the functional performance of the entire tarsus. – citing Inman.”
- Level 2-3 Evidence

Chronic Knee Pain

- Causes of Anterior Knee Pain
  - Trauma
  - Extensor Knee Muscle Weakness
    - Vastus Medialis Oblique (VMO)
  - Increased Varus alignment of the lower extremity
  - Tight Iliotibial Band
  - Abnormal Q angle – debated involvement
  - Weak Hip Abductors
  - Excessive STJ pronation in Stance Phase

- Results of Plantar Pressure measurements in subjects with patellofemoral pain:
  - More laterally displaced pressure at initial foot contact
  - Significantly shorter time to maximum pressure on the 4th metatarsal
  - A significant slower maximum velocity of the lateral to medial center of pressure movement

- The study authors concluded:
  - Patients with anterior knee pain have a heel strike in a less pronated position
  - Roll over more on the lateral side compared to controls
  - What does this mean?
Chronic Knee Pain

- Since we need the STJ to pronate to provide adequate shock absorption, less pronation may set these patients up for more impact or shock at the knee.
- This study found that runners suffering from anterior knee pain had 25% less pronation during the first 10% of support phase.
  

Knee Flexion

- The study found that “Achilles Tendon subjects were found to have greater peak, and range of Ankle DFion, Knee Flexion, and Eversion during stance.
- “This resulted in collapse of the knee and foot into prolonged knee flexed, everted and dorsiflexed movement patterns.”

Gait Related Back Pain

- There is a continuation of the deep fascia linking the ipsilateral gluteus maximus and latissimus dorsi, with the sacroiliac joint at the center of the connection.
- The long head of the biceps femoris then continues on from the sacrotuberous ligament down to the head of the fibula.
  
  Vleeming et al. The Role of the Sacroiliac Joints in Coupling Between Spine, Pelvis, Legs and Arms.

Gait Related Back Pain

- From the head of the fibula the peroneal musculature descends to the midfoot and blends with the posterior tibial and anterior tibial musculature to complete the foot to back connection.
- Weakness in any segment of this connection can greatly contribute to subtle gait abnormalities.
  
  The Role of the Sacroiliac Joints in Coupling Between Spine, Pelvis, Legs and Arms. A Vleeming et al.
**Gait Related Back Pain**

- **Gait Analysis Studies**
  - Hallux Limitus and Non-Specific Gait Related Bodily Trauma. H.J. Dananberg, M. Lawton, D. DiNapoli
  - The authors describe the relationship of gait to chronic postural pain. They performed a study involving 18 patients with non-specific pain disorders ranging from knee pain, hip pain, chronic low back pain, and TMJ / Neck pain. In this study, 42% of the patients got 75-100% better, 35% got 50-75% better, and 23% got 0-25% better. None of the patients’ symptoms got worse!

- **The improvement was nearly two times as great as compared to traditional back pain care (Physical Therapy).**
  - Therefore, pts utilizing gait analysis had twice as much improvement from the gait analysis alone, without any other concurrent treatment modalities, and only utilizing the custom orthotic devices!

**Hamstring Strain**

  - Conclusions: ...Restricted ankle dorsiflexion range of movement warrants consideration in the development of prevention programs for hamstring injury.
  - Potentially, dorsiflexion stiffness is a marker for an as yet unidentified or unmeasured factor such as proprioception. Poor proprioception or neuromuscular control could impact hamstring function and timing during the terminal phase of swing during sprinting, increasing the likelihood of hamstring injury at this time. Further studies needed.

**Gait Related Back Pain**

- **Chronic Low-Back Pain and its Response to Custom-Made Foot Orthoses.** H. Dananberg et al
  - This study utilized 32 subjects, average elapsed time was 13.8 months.
  - Of the initial 32 subjects 84% experienced improvement.
  - Of the follow up group, there was a 40% improvement in the outcomes in comparison to the Kobec study utilizing the Quebec pain questionnaire.

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- Relative activity of hip and knee extensors in sprinting - implications for training
  - by Klaus Wiemann and Günter Tidow
Adductor Injuries

- Hallux Limitus and its Relationship with the Internal Rotational Pattern of the Lower Limb; J Am Podiatry Assoc 101(6): 467-474, 2011; G Lafuente, P Munuera, G Dominguez, M Reina, G Lafuente

- Results: The capacity of internal rotation of the lower limb was significantly lesser in patients with mild hallux limitus (P < .0001).

- Conclusions: Patients with mild hallux limitus had a lesser capacity of internal rotation of the lower extremity than did individuals in the control group. The more limited the internal rotational pattern of the lower limb, the more limited was hallux dorsiflexion.

Adductor Injuries


- Decreased range of movement (ROM) of the hip has been suggested as a risk factor for sports-related chronic groin pain in athletes.

- Decreased internal rotation and ROM of the hip are associated with chronic groin pain.

- Patients who have recovered from groin pain have a greater hip ROM than those who are still having pain.