Essential Pediatric Biomechanics

Who, What, Where, When & Why’s of The Pediatric Forefoot

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The APMA's only recognized clinical interest group for the management of pediatric foot and ankle pathologies.

As an Affiliate Clinical Interest Group, under the APMA, our goal is to educate both our colleagues and the general public on the importance of caring for children’s feet.
5th Annual ACFAP Conference
The Great Smoky Mountains National Park
Gatlinburg Convention Center
Black Bear Inn
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Goals

Understand the Rearfoot
Understand the Forefoot
So...From the Second We Stand
The **Rearfoot Position** is **ALWAYS** Important!
Age Specific Parameters for Pediatric Foot Development

- A child begins to walk around 10-14 months of age, at which time up to 6° heel valgus is considered normal.
- Calcaneal valgus diminishes by 1° per year until age 6 at which time the heel should be vertical.
- By age 13 a youth's foot will take on its final adult form and the calcaneus will ideally be inverted 4-5°.
- 10-15% of the population will end up with excessively inverted heels (Pes Cavus).

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Sequence of Ossification of the Tarsal Bones

Metatarsals and phalanges: 9-12 weeks
Calcaneus: 4-7 months
Talus: 6 months
Cuboid: around birth
Lateral cuneiform: during year 1
Medial cuneiform: during year 2
Intermediate cuneiform: during year 3
Navicular: during year 3 (after intermediate cuneiform)

radiopaedia.org/articles/ossification-centres-of-the-foot

Arch and Forefoot Development – Key Considerations For Orthotic Management:
• At birth only 24% of the talus is bony tissue;
• Pediatric feet are generally flexible (if not – r/o coalitions; consider hypermobility)
• Positional supination of the forefoot is normal in early childhood, but should not persist past 6 years of age;
• Ossification of the Navicular begins around age 3yo at which time the arch is forming.

*It is quite “normal” for young children to have flat feet but formation of an arch should occur by 3 – 4 yo.*
What To Do With a Patient Before 4 Years Old?
How Do I know?

3 Questions

Ask Yourself & The Parents

1. How Flat is it?

1. Is there a Family Hx. / Parent Involvement?

1. Does the foot impair the child? AT ALL!!!!!
Father
40ish
Can’t walk for more than 3 hours without pain
Since 1989
Heel Pain
Back Pain
Destructive FF Varus

Son
3yo
Unstable Running
Unstable Jumping
Destructive FF Varus

Too Young??
Developmental Flatfeet (4 until 8/10 year olds)

Why is it a Problem?

“This often overlooked, inconspicuous condition is the most common musculoskeletal abnormality affecting the foot of the child under 6 years of age. Recognition of the fact that the developmental flatfoot is the logical precursor of foot dysfunction, deformity, and resultant disability later in life will allow the practitioner to design a management program for today that will meet the foot health needs of tomorrow.”


*LACK OF SYMPTOMS is an UNRELIABLE indicator of foot function in any age group...*

YES YOU Treat!!!!

➢ Educate The Patient and Family — Use the Family
➢ Reduce Calcaneal Valgus (Pronation)
➢ Promote Ideal Development (Posture, Balance, Coordination & Strength)
TREATMENTS FOR DEVELOPMENTAL FLAT FEET
(At least Up to 8-10 Years Old)

Orthotic Specifications for Custom Children’s Foot Orthoses:

• 30mm Heel Cup Depth
• Deep Medial and Lateral Flanges
• Medial Rearfoot Posting
• Medial Skive
Why Its Important To Control The Rearfoot

Myth: “Wearing Foot Orthoses Causes Dependency And Weakens The Ankles”.

Orthotics May Actually Strengthen The Ankles!

Prolonged barefoot walking on an overpronated foot may at times exaggerate the deformity. Flatfeet can lead to excessive muscle elongation of the foot supinators and can cause muscle spindle inhibition and increased production of sarcomeres (contractile unit of skeletal muscle).

The change in muscle length alters the length–tension curve of a muscle and creates a “stretch weakness”, or “positional weakness”, that is associated with overuse injuries and postural dysfunction.

The Golgi organ (also called Golgi tendon organ, GTO, tendon organ, neurotendinous organ or neurotendinous spindle) senses changes in muscle tension. It is a proprioceptive sensory receptor organ that is at the origins and insertion[1] of skeletal muscle fibers into the tendons of skeletal muscle. It provides the sensory component of the Golgi tendon reflex.
Kids to 8-10 Years
The “Foot-Formative” Years
DEVELOPMENT OF THE FOREFOOT

There is no Defying Genetics!

Kids get it all – the good and the bad! Even the Forefoot!
Development of the Adult Forefoot
Ages 8-10

VARUS
FOREFOOT INVERTED ON REARFOOT
Inadequate Derotation of the Talar Head and Neck

NEUTRAL
FOREFOOT PERPENDICULAR TO REARFOOT
Normal Derotation of Talar Head and Neck

VALGUS
FOREFOOT EVERTED ON REARFOOT
Excessive Derotation of the Talar Head and Neck
A true forefoot varus is a structural deformity caused by failure of the talar head and neck to derotate during early childhood development.

**Forefoot Varus**

A congenital, osseous, structural deformity showing inversion of the plantar plane of the forefoot relative to the rearfoot, when the STJ is in neutral and the MTJ is maximally pronated about both its axes;

Characterized by firm resistance to pronatory force applied to the dorsum of the TNJ.

*Positional supination of the forefoot is normal in early childhood, but should not persist past 6 years of age.*

| SMALL:          | 1-3° VARUS |
| MEDIUM:        | 4-6° VARUS |
| LARGE:         | ≥7° VARUS  |
4 Steps To Knowing How A Foot Works
What Does The Arch Tell You?
What Does The “Toe Sign” Tell You?
3

What Does The Walk Tell You?

Narrow Gait
Propels from 1st MTH

Pivots at 5th MTH in Propulsion
What Do The Callouses Tell You?
COMMON “Forefoot” INJURIES IN TEENS
With Arch

Periostitis or “Shin Splints” are an overuse injury caused by repetitive stress to the muscles, tendons and/or tissues associated with the shin bone (tibia) over a period of time, without enough rest to give the leg enough time to heal (strain on Anterior or Posterior Tibialis).

Calcaneal Apophysitis / Sever’s Disease occurs between the ages of 8 and 13 and is a common cause of heel pain in the athletically active child. Aggrevated by increased activity causing strain on the Achilles tendon from activities involving jumping or sprinting, and a tight gastroc-soleus.

Osgood Schlatter’s Disease or Syndrome is an irritation of the patellar ligament at the tibial tuberosity.

Sinding-Larsen-Johansson disease (SLJ) affects the proximal end of the patellar tendon as it inserts into the inferior pole of the patella, and represents a chronic traction injury of the immature osteotendinous junction. Some authors class SLJ as “Jumper’s Knee” in the pediatric setting.

Plantar Fasciitis is inflammation of the plantar foot ligament that can cause heel pain. Usually coincides with calcaneal apophysitis. Over pronation and obesity can exacerbate the symptoms.

Accessory Navicular is the most common accessory bone in the foot. Incidence is 4-21% and may be asymptomatic. In adolescents, symptoms can arise secondary to pressure over the boy prominence, a tear in the synchondrosis, or tibialis posterior tendonitis.
Common “Forefoot” Injuries in Teens

Without Arch

**Posterior Tibial Tendon Dysfunction (PTTD)** is a condition caused by changes in the tendon, impairing its ability to support the arch and resulting in failure of the ligaments and joints on the inner side of the ankle and foot. This results in flattening of the foot and may become debilitating later in life.

**Functional Hallux Limitus** is a progressive arthritic condition that limits the motion and function of the hallux, usually at the 1st MTPJ, limiting dorsiflexion. Over time, the condition can worsen and lead to the condition **Hallux Rigidus**, or no motion of the big-toe joint at all. Treat kids preventatively to avoid this adult pathology!

**FHL Tendonitis** causes pain along the posteromedial ankle, common in young dancers. The tendon will sometimes lock in demi pointe and become unable to release in plié.

**Cuboid / Peroneus Brevis pain** – dorsolateral pain and impingement

**Adolescent Bunions** are most common among adult women, they also tend to occur among young teenagers, especially girls between the ages of 10-15. Hallux Valgus affects 22-36% adolescents. Common in dancers.

Remember kids feet are not just small adult feet due to open growth plates, ligamentous laxity, and less muscle tone than adults.

Barefoot Running!?!?
At What Age is The Forefoot / Forefoot Post Necessary?

8 - 10 +
Consider that Idiopathic Toe Walking May be a Compensation for Flat Feet Also!
Consider that Idiopathic In-Toeing May be a Compensation for Flat Feet Also!
8yo Transition
8yo Transition