
APTA
American Physical Therapy Association℠

Are We Underserving the Pediatric Ankle?

Supporting Development Through A Multi-System Approach

Amanda Hall, PT, MPT
Board-Certified Pediatric Clinical Specialist
Assistive Technology Professional

Disclosure

- No relevant financial relationship exists

Learning Objectives

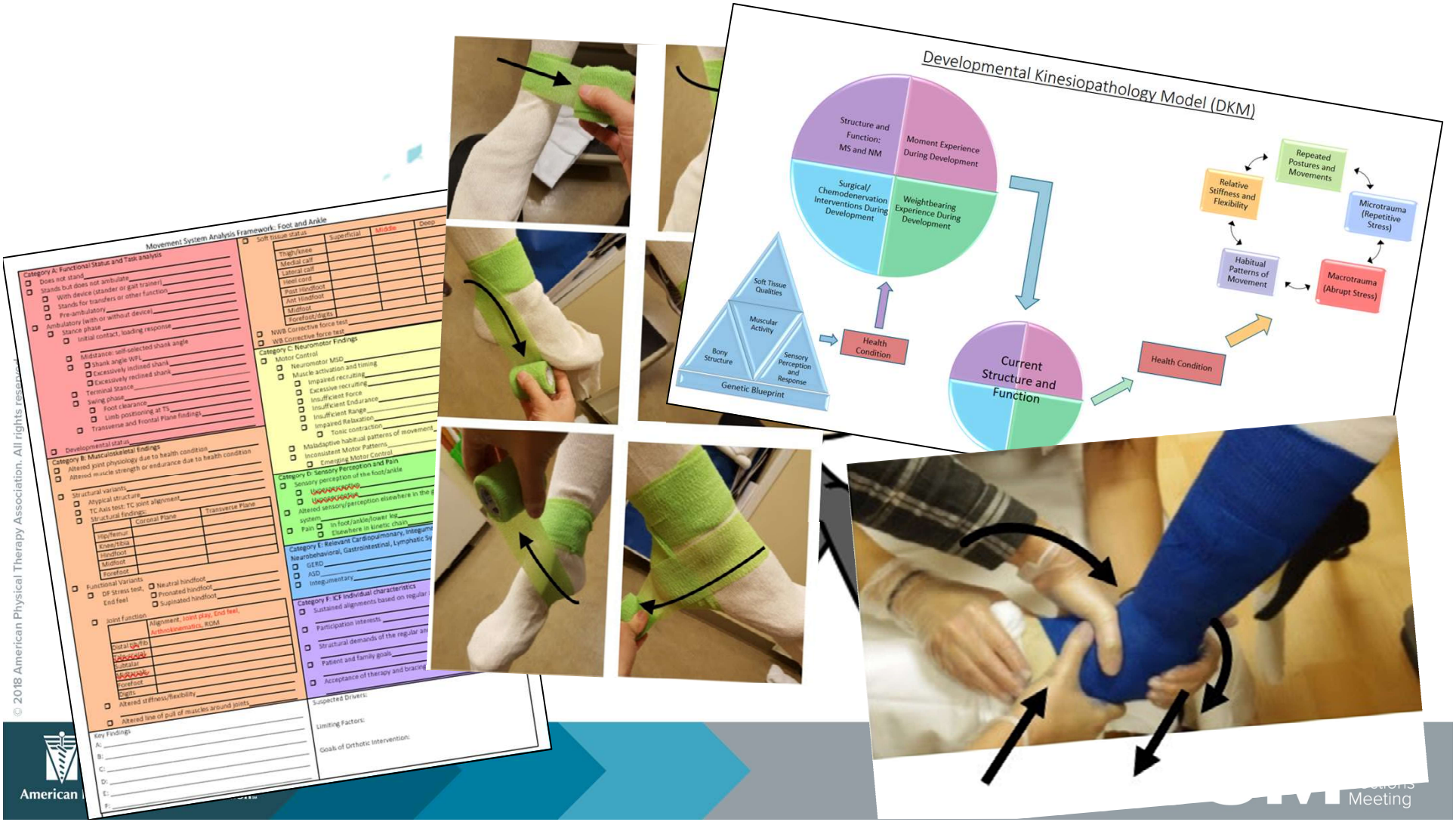
- Recognize the interplay of Musculoskeletal and Neuromuscular Movement System Diagnoses and neuroplastic changes on foot and ankle dysfunction.
- Describe the impact of altered foot and ankle function during development on the structural outcome of the movement system.
- Identify treatment techniques to address relative stiffness and flexibility in foot and ankle mobility and function.
- Design a progressive strengthening program to improve intrinsic stability of the foot and ankle for children with neuromuscular health conditions.

Introduction

- Motor Control/Systems Theory
  - Anne Shumway-Cook
- Shirley Sahrmann
  - Movement Systems
  - Kinesiopathology
- PNF
  - Institute of Physical Art
  - Mary Massery
- Ortho foot and ankle
- Pediatric complex care
- Therapeutic casting

135 YEARS

THE HSC HEALTH CARE SYSTEM



CSM APTA Combined Sections Meeting

WASHINGTON DC • JANUARY 23–26, 2019

APTA American Physical Therapy Association

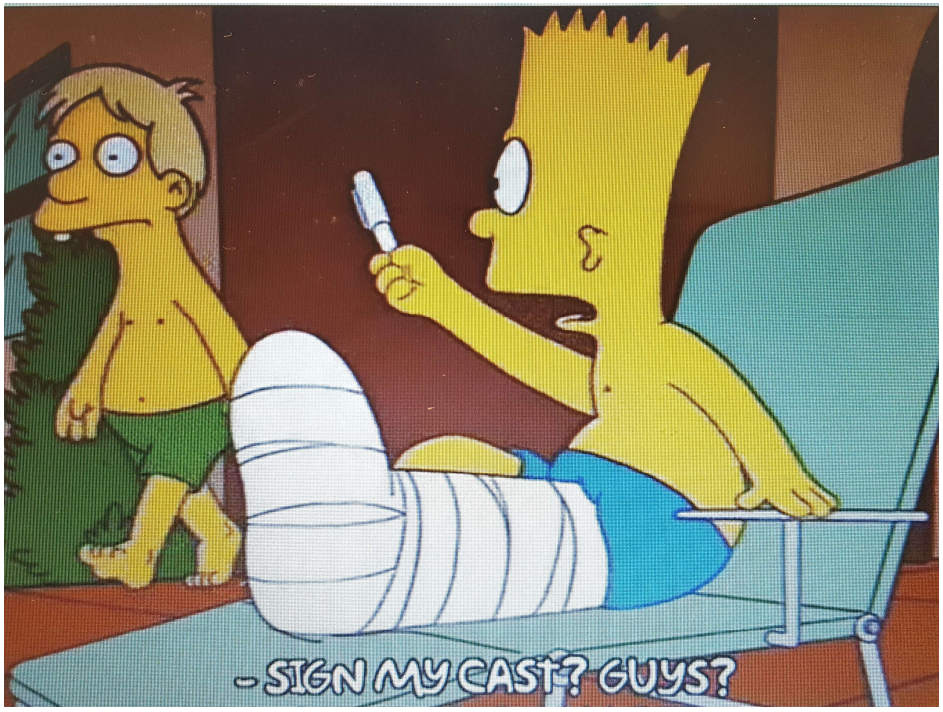
Update on Therapeutic Casting: A Modern Clinical Pathway to Improve Outcomes

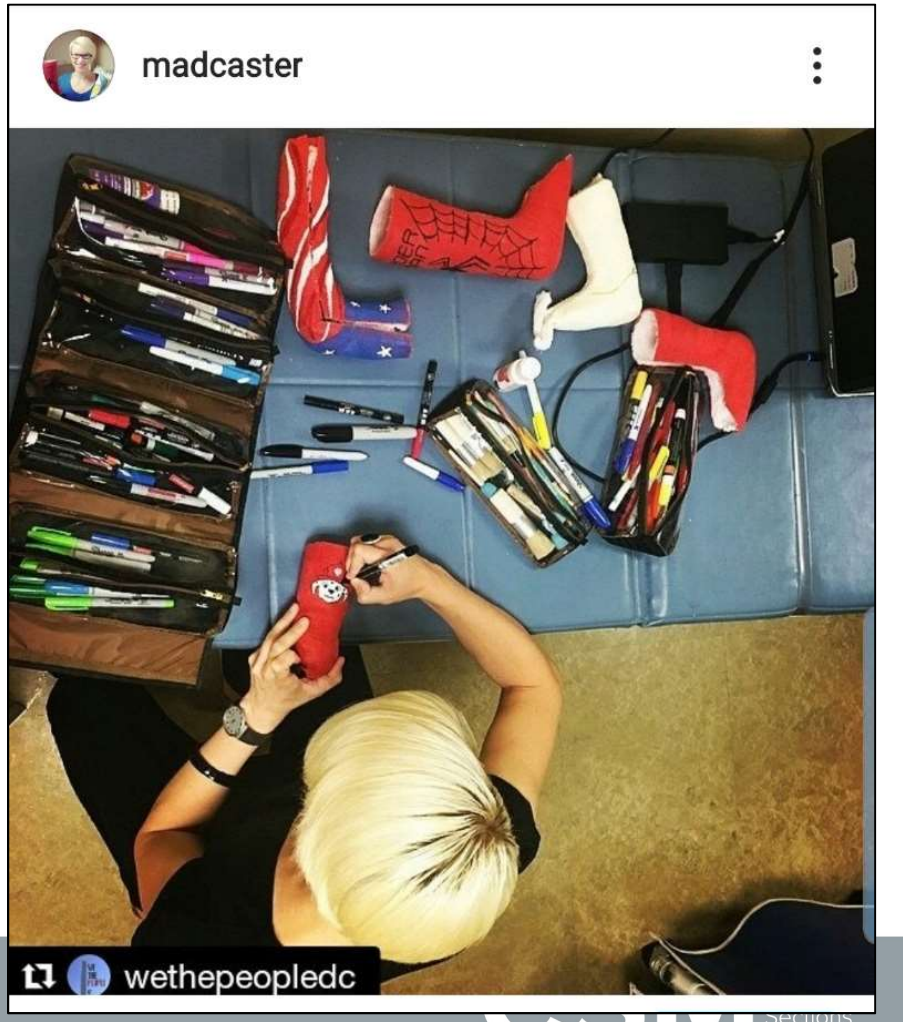
ACADEMY OF PEDIATRIC PHYSICAL THERAPY

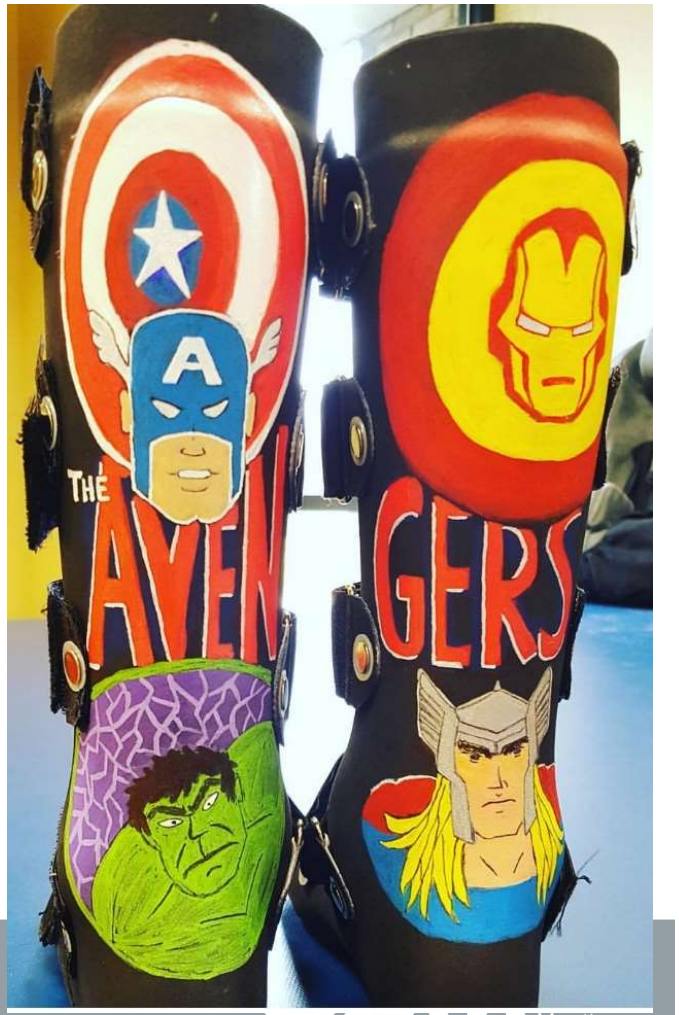
2019 ANNUAL CONFERENCE

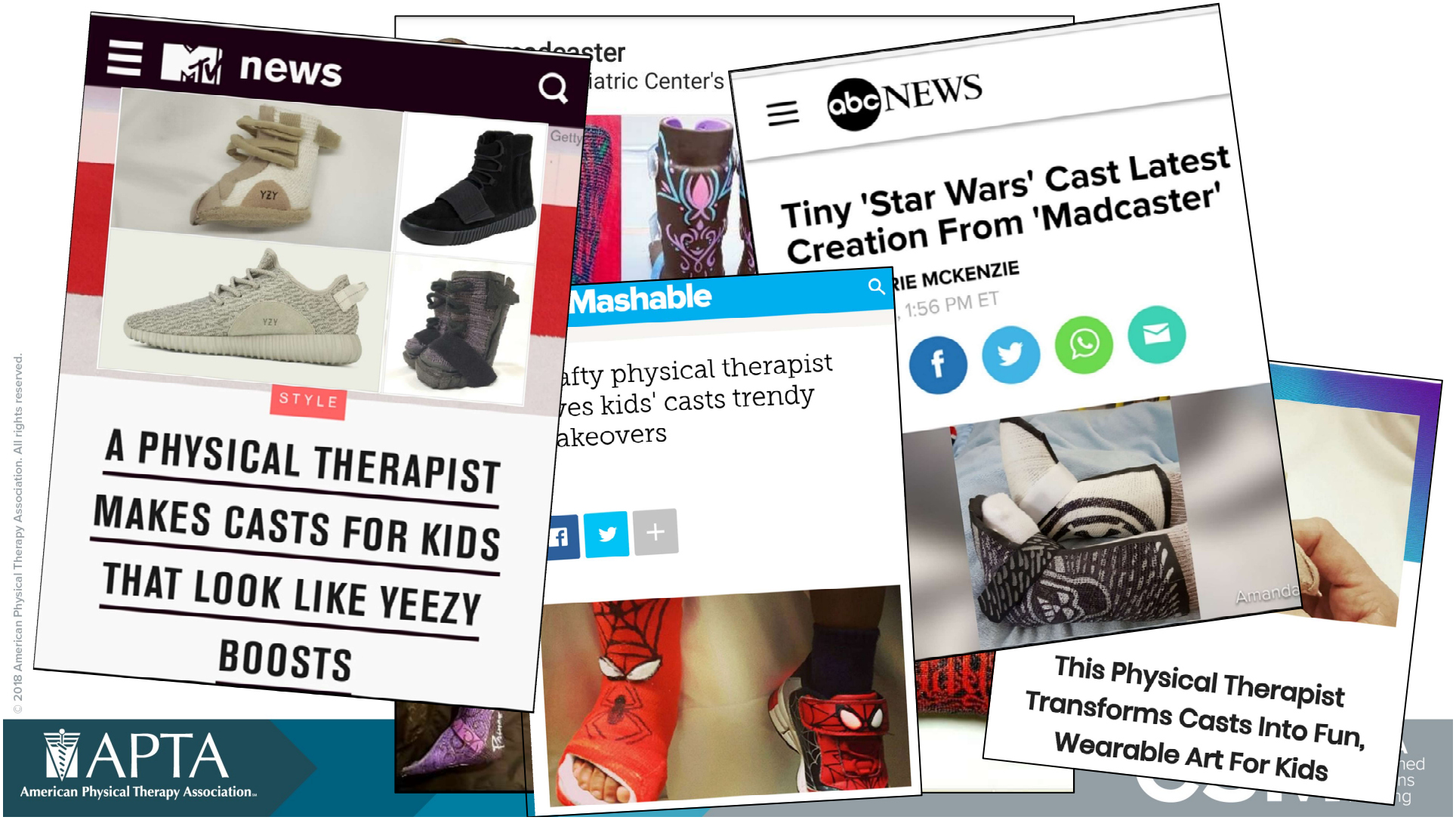
NOVEMBER 15-17 ✦ DISNEYLAND, CA

Orthotic Device Design Using Movement System Diagnoses As A Guide









CSM 2019

- Sports Medicine Secrets: Ankle and Foot Strength, Mobility, and Coordination Deficits. S. Bell, M. LeMoine, D. Marcos. *(AOPT)*

- A Foot Core Approach to Treating Plantar Fasciitis. L. Wasserman. *(AOPT)*

CSM 2019

- The Athlete In Pain, Moving Beyond The Tissues to the Person. Z. Christopherson, M. Gist, T. Lentz, J.W. Matheson, B. Ness, H. Tao, K. Zimney (AASPT)

- PT from head (motor learning, pain psychology) to toe (foot & ankle mechanics). M. Hastings, R. Chimenti, B. Fisher (AOPT)

CSM 2019

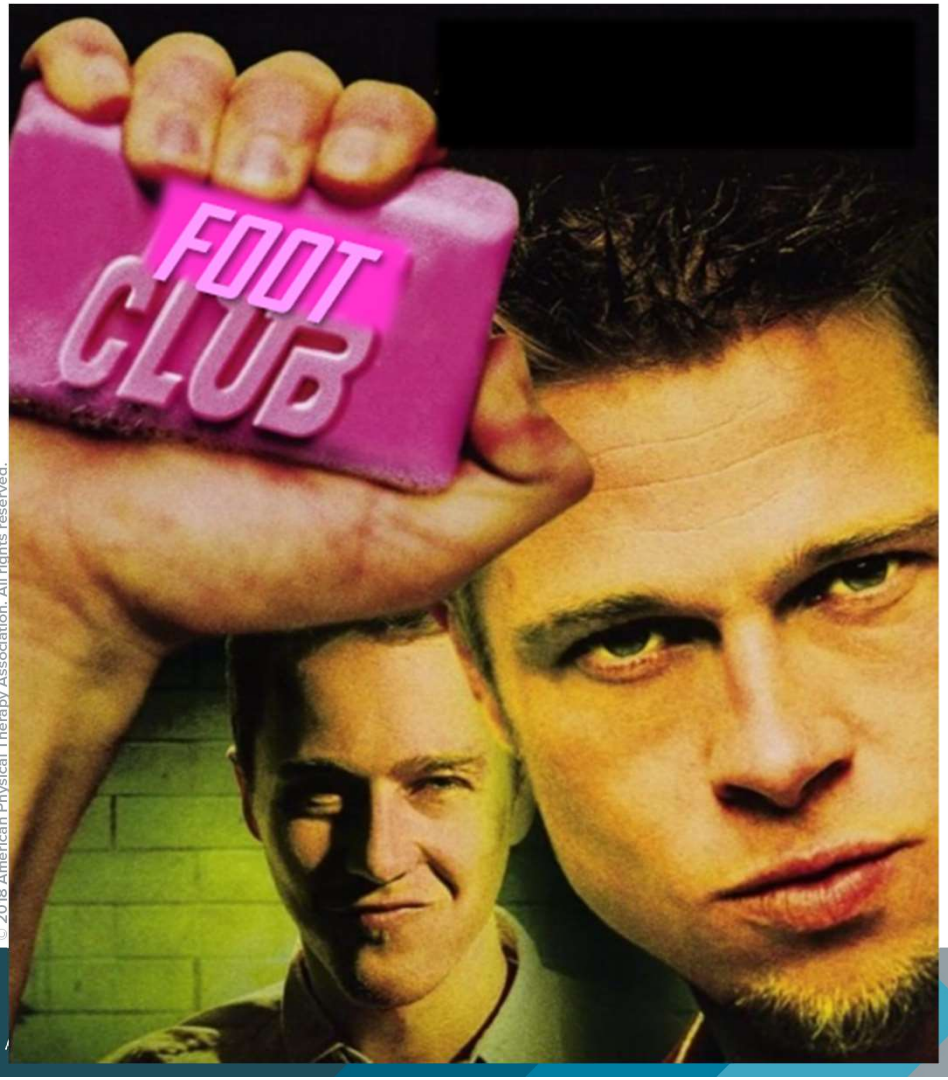
- The Brain has an ACL Problem. T. Grindstaff, D. Grooms, D. Lorenz (AASPT)
- Science Meets Practice: Neuroplasticity Following ACL Injury and ACL Reconstruction. R. Zarzycki, D. Grooms (AASPT)
- Neurocognitive & Motor Control Strategies in ACL Rehab. M. Sherry, PT, D. Cobian, K. Wittman (AASPT)
- The Frozen Shoulder Has A Brain. A. Low, S. Schmidt, P. Mintken (AHUEPT)

CSM 2019

- Dealing with the Dark Side of Neuroplasticity: Pain In Neurorehabilitation. S. Schmidt, A. Low. (ANPT)
- Can Fear or Other Psychological Factors Alter Movement After ACL Reconstruction? T. Chmielewski, A. Meierbachtol, R. Mizner, R. Zarzycki (Section on Research)
- Science meets practice: Watch Your Mouth! Verbal Cues Effect Lower Extremity Performance. J. Thein-Nissenbaum, M. Paterno, C. Mack (AASPT)

Are We Underserving the Pediatric Ankle?

Supporting Development through a Multi-System Approach

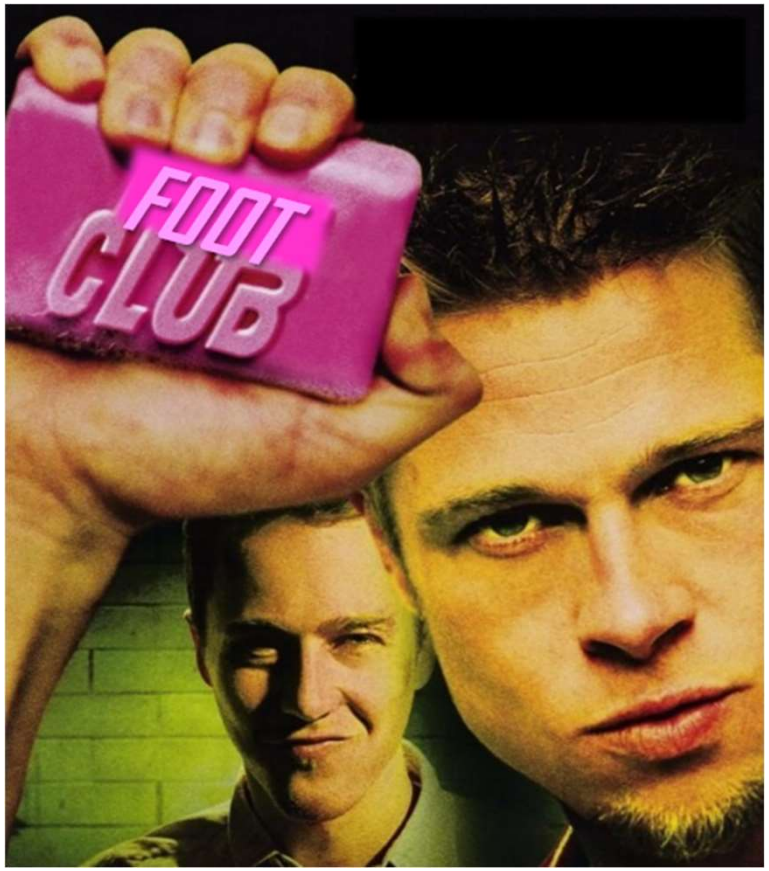


Rules

1. We do not talk about foot club
2. We use relevant adult research to benefit our patients
3. Final Slides:

amandahallpt.com/csm2020

I. Introduction
II. Pediatric Ankle Impairments
III. Do We Need to Intervene?
IV. How Should We Intervene?



What Are We Even Saying?

- Terminology

Terminology: Inconsistency - Neuromotor

*Tone**

*Hypertonus**

*Dynamic spasticity**

*Flatfoot**

*Spastic**

*R1/R2**

Used in current literature describing foot and ankle involvement in the* ***neurotypical* *population*

Terminology: Inconsistency

"You keep using that word. I do not think it means what you think it means."

-Inigo Montoya

Terminology: Inconsistency - Neuromotor

Passive muscle properties are contributing to perceived hyperreflexia in:

- Cerebral palsy
- Acquired brain injury
- Hemiplegia
- Stroke

Terminology: Inconsistency - Neuromotor

Passive muscle properties are altered in children with cerebral palsy before the age of 3 years and are difficult to distinguish clinically from spasticity. (Willerslev-Olsen 2013)

- Only 7/35 children determined as having spasticity via MAS/Tardieu had enhanced stretch reflexes with EMG.
- Enhanced stretch reflexes contributed to muscle stiffness in a minority of cases.
- Change in passive muscle properties were much more frequently contributing.

Terminology: Inconsistency - Neuromotor

The relationship between medial gastrocnemius lengthening properties and stretch reflexes in cerebral palsy. (Bar – On 2018)

- “large variability in the amount of muscle lengthening and hyperactive stretch reflex”
- “muscle lengthening and stretch reflex hyperactivity in medial gastrocnemius muscles of children with CP is highly variable and that the two do not necessarily co-exist."
- Authors noted: "muscle stiffness may actually be considered as a protective mechanism"

Terminology: Inconsistency - Neuromotor

Assumptions → Observations

Terminology

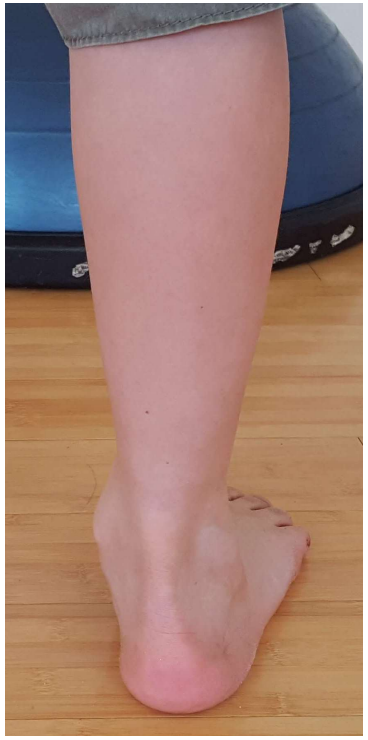
Assumption/Unclear		Specific/Observation
Tight	→	Short
		Stiff
		Increased density
		Increased response to stretch
		Tonically contracting

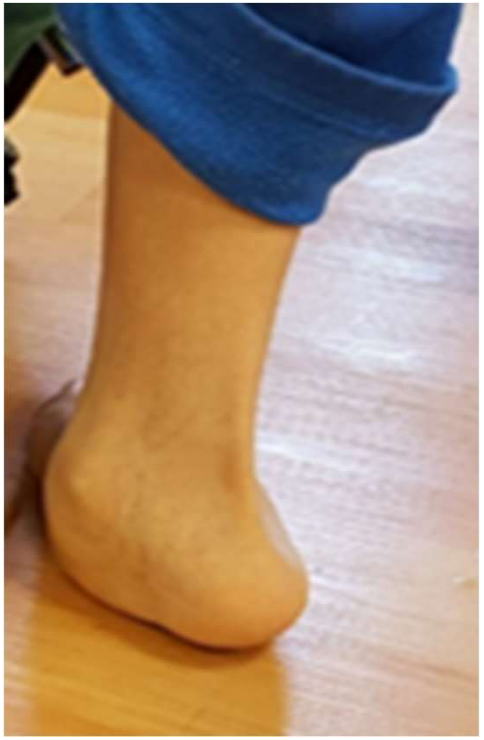
Terminology

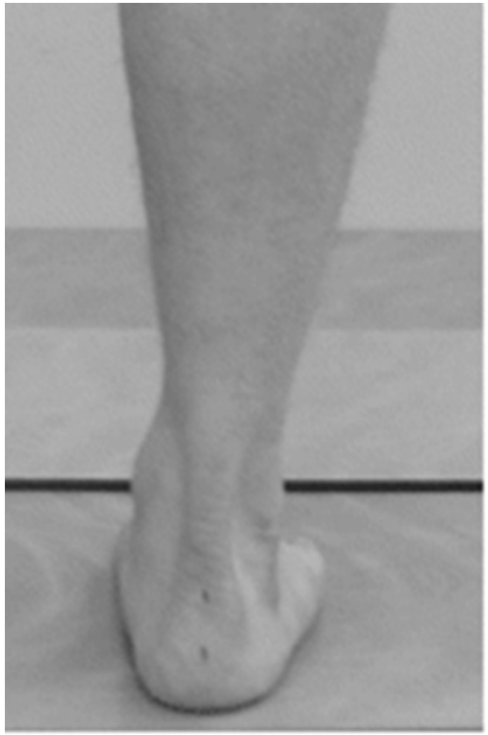
Assumption/Unclear		Specific/Observation
Tight		Short
Spasticity		Stiff
Hypertonia	→	Increased density
Hyperreflexia		Increased response to stretch
Guarding		Tonically contracting
Fixing		Muscle contraction in _____ (muscles) with _____ (circumstance)

Terminology: Inconsistency

”Flatfoot” *(Pes Planus)*





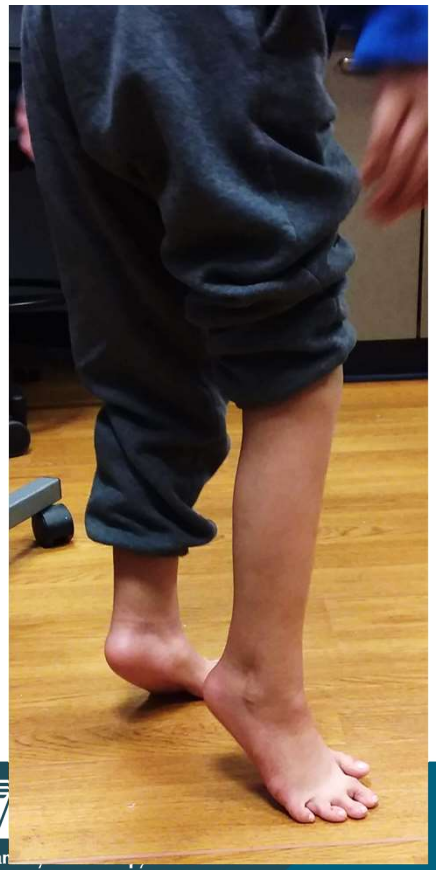


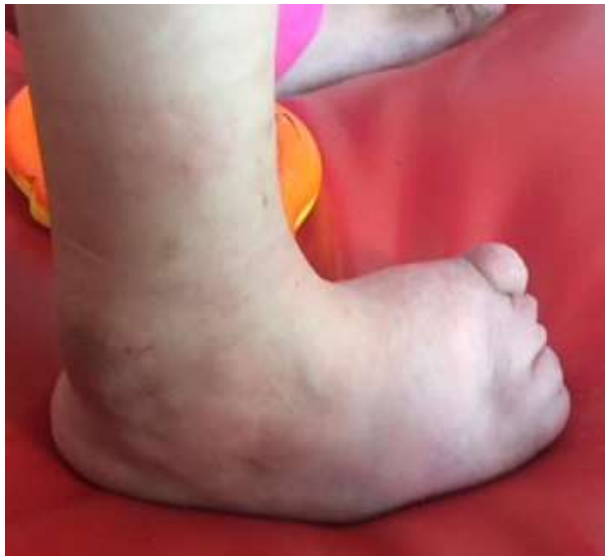
Terminology

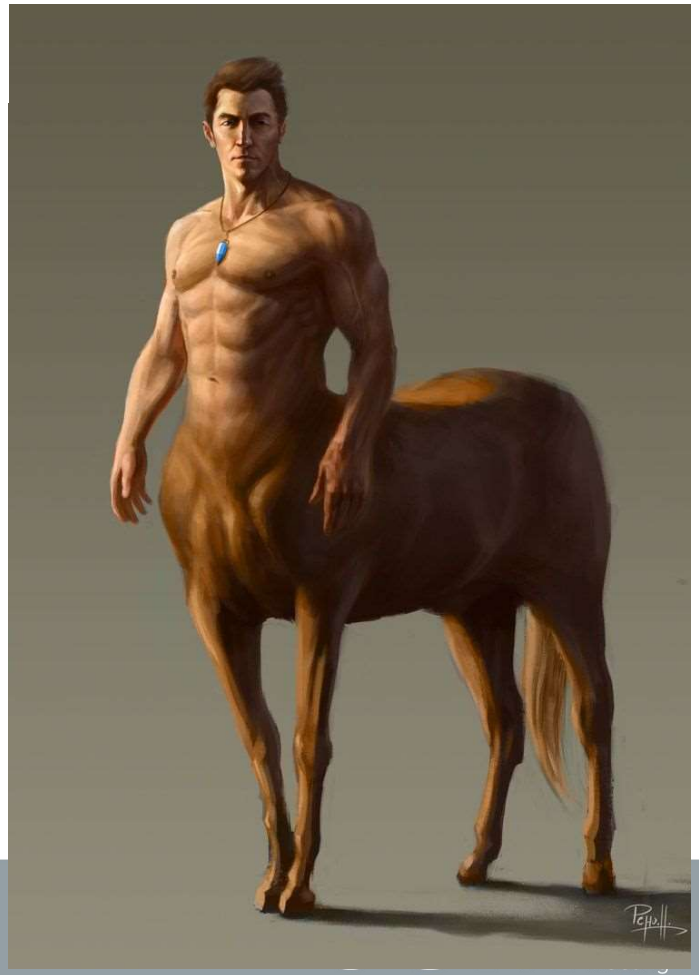
Incompatible definitions → Differentiation

Terminology: Inconsistency and Jargon

”Equinus Deformity”







Terminology: Words Have Power

"Contracture"
"Deformity"

- Implied permanence
- Nocebo effect

Terminology: Words Have Power

Contracture

A muscle contracture is a permanent shortening of a muscle or joint.

www.wikipedia.com

deformity

1 the quality or state of being deformed, disfigured, or misshapen.

2 *Pathology*. an abnormally formed part of the body.

3 a deformed person or thing.

noun **disfigurement, distortion**

Synonyms for *deformity*

abnormality

defect

impairment

malformation

aberration

asymmetry

unsightliness

warp

malconformation

misproportion

misshape

Dictionary.com/Thesaurus.com

Terminology: Words Have Power

Terminology: Words Have Power

Pejorative		Neutral “lay” meaning
Pessimistic	→	Optimistic
Ableist		Positively googleable
Rude		Respectful

restriction [ri-strik-shuhn]

SEE DEFINITION OF *resti*

noun **limit**

1 something that restricts; a restrictive condition or regulation; limitation.

2 the act of restricting.

3 the state of being restricted.

Synonyms for *restriction*

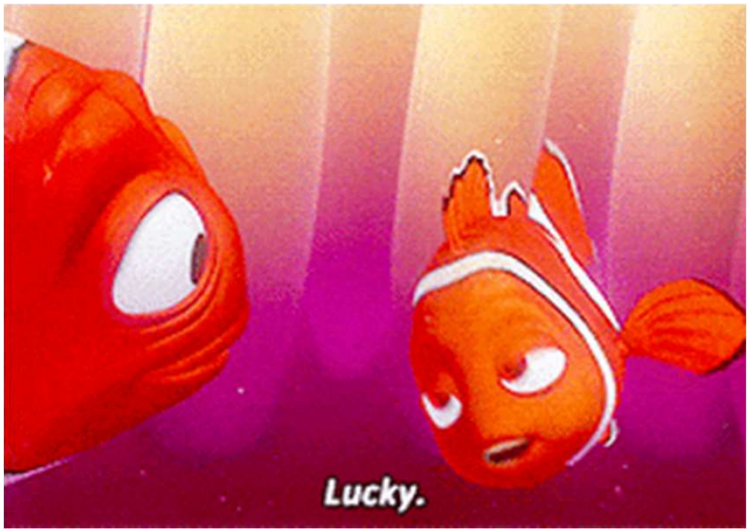
check	stipulation	cramp	limits	fine print
condition	stricture	custody	lock	grain of salt
constraint	bounds	demarcation	qualification	no-no
control	brake	glitch	reservation	small difficulty
curb	catch	handicap	stint	stumbling block
regulation	circumscription	hang-up	string	
restraint	confinement	inhibition	ball and chain	
rule	containment			

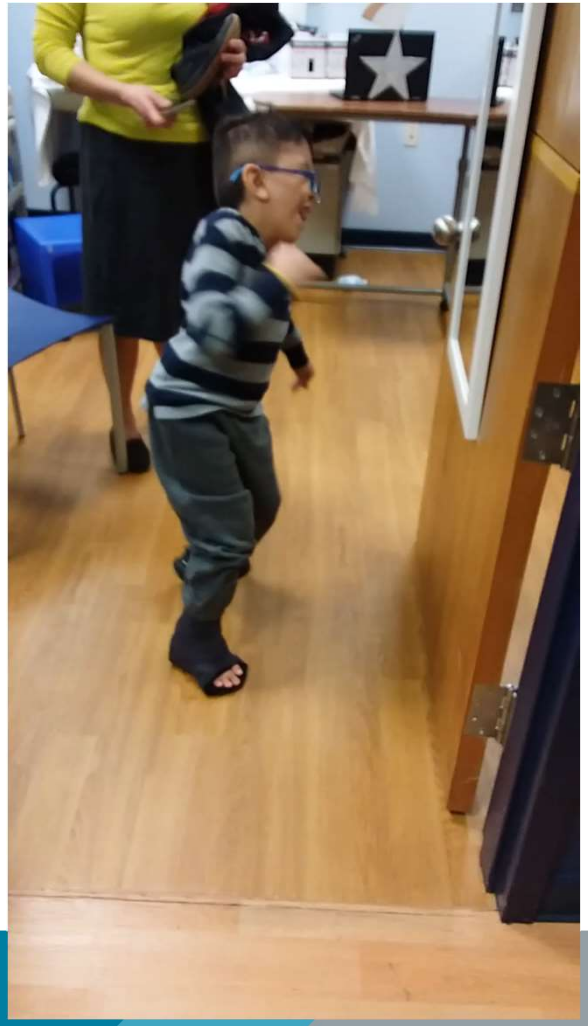
Terminology: Words Have Power

Terminology: Words Have Power

Terminology: Words Have Power

Terminology: Words Have Power



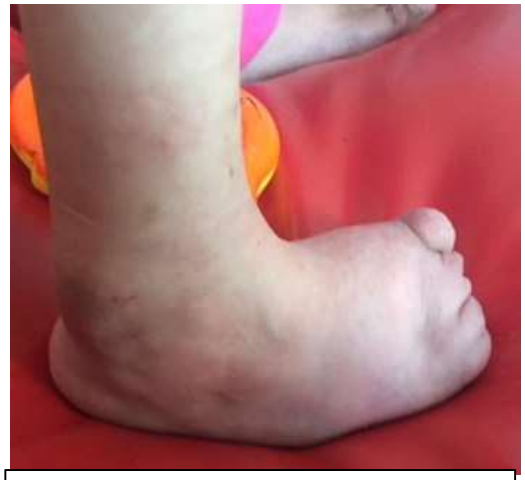


Terminology

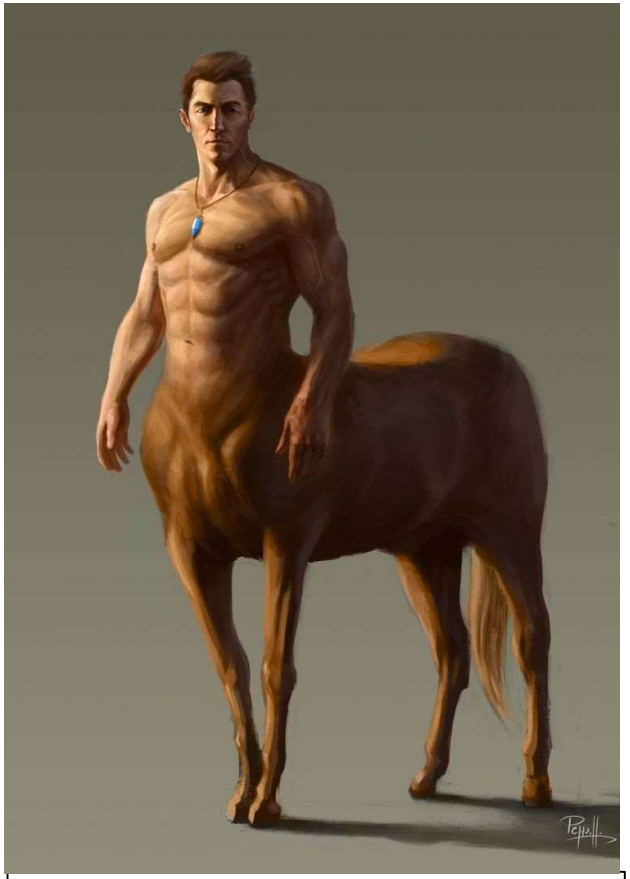
Equinus	→	Plantarflexion
Deformity	→	Structural variance
Contracture		Restriction
		Limiting structure
		Quality of end feel
Flatfoot	→	Everted
		Pronated

Terminology: Specificity

Plantarflexion Restriction

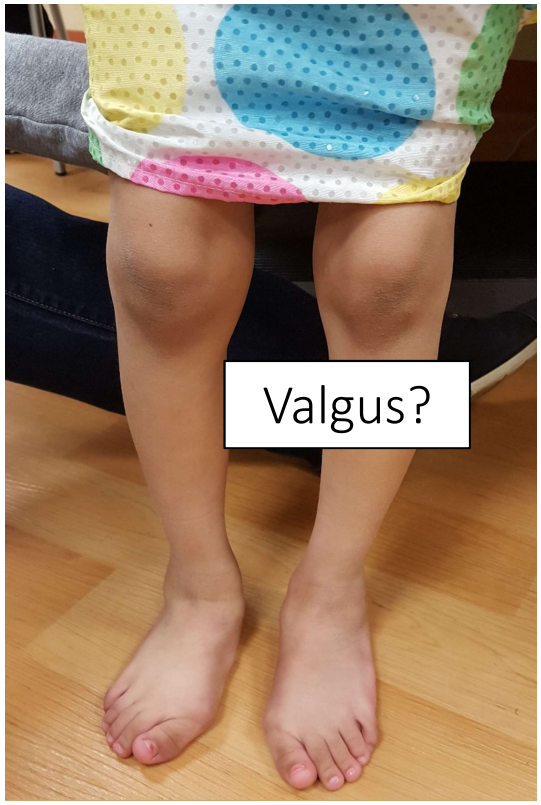


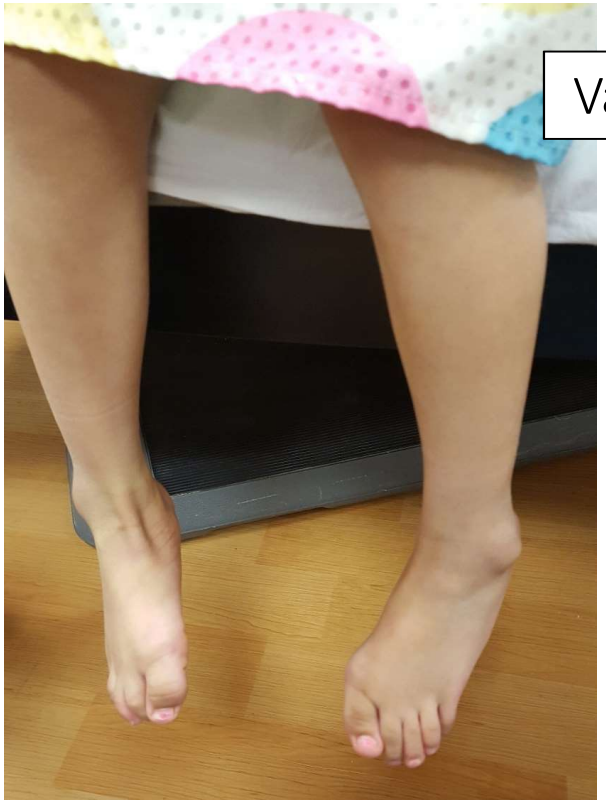
Structural Variance

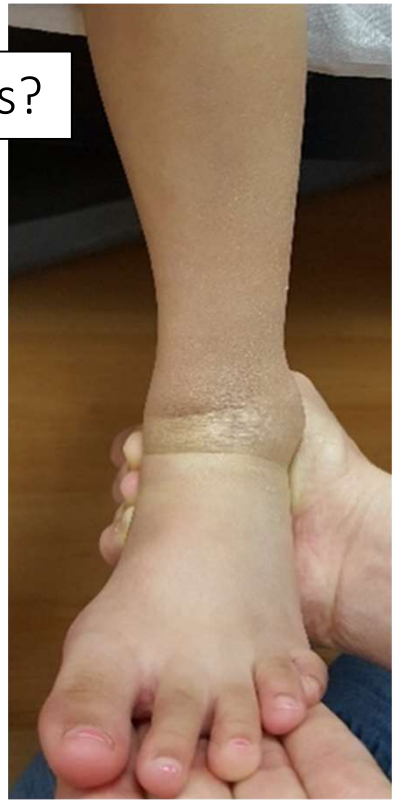


Magical Creature

Terminology: Structure vs. Function

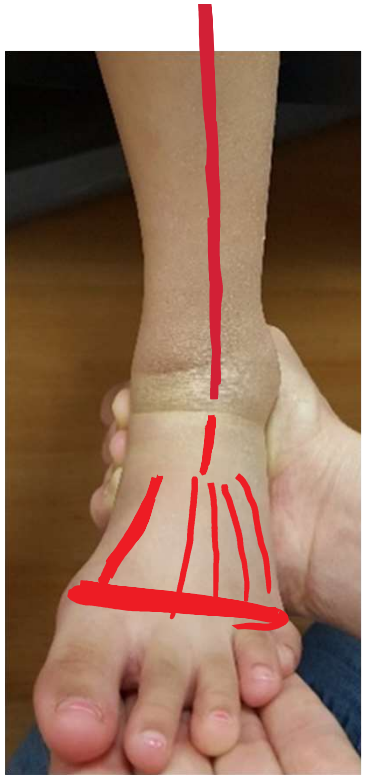






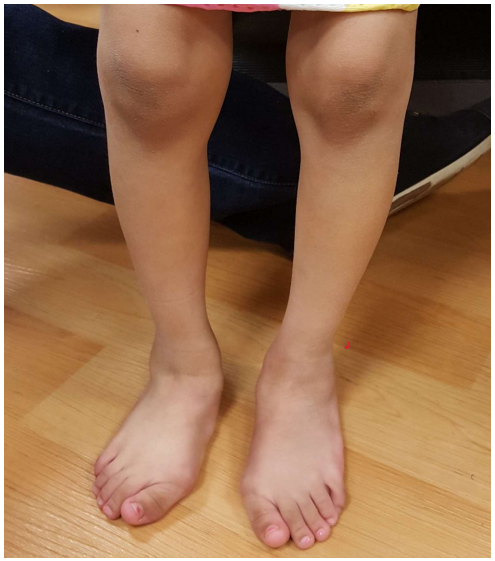
Terminology: Structure vs. Function

Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Adductus – Abductus Med Torsion – Lat Torsion	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus – Valgus	Invert – Evert
Sagittal		Flex – Extend
Triplanar		Supinate – Pronate



Structure:
Hindfoot varus
Metatarsus adductus, varus

Function:
Supination of hindfoot
Abducted MTPs



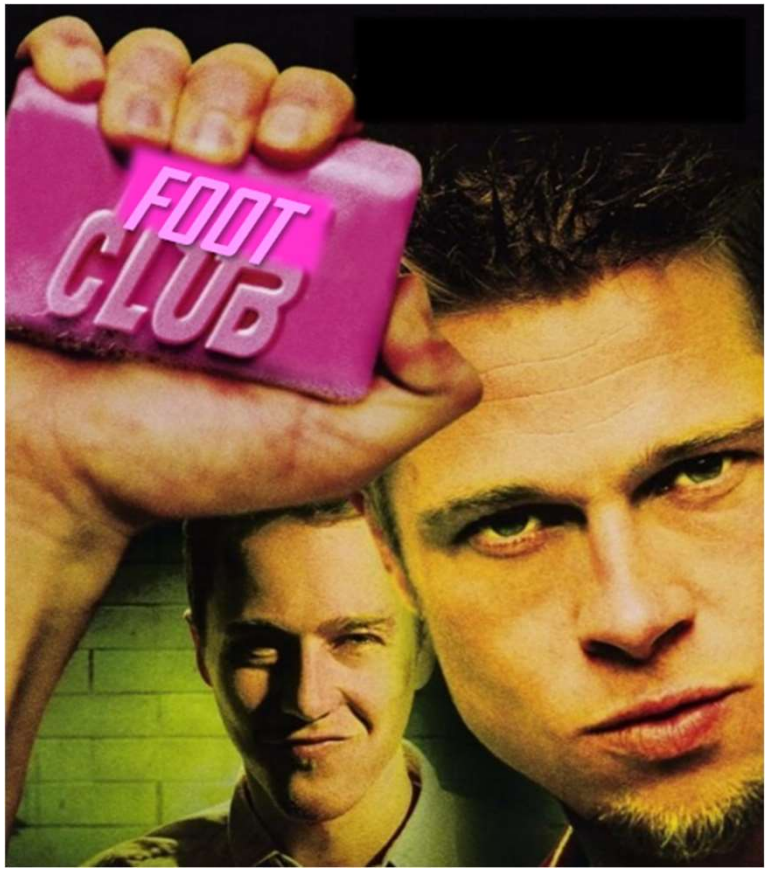
Function: ~~"Pes Valgus"~~
Pronated hindfoot, midfoot
Abducted MTPs

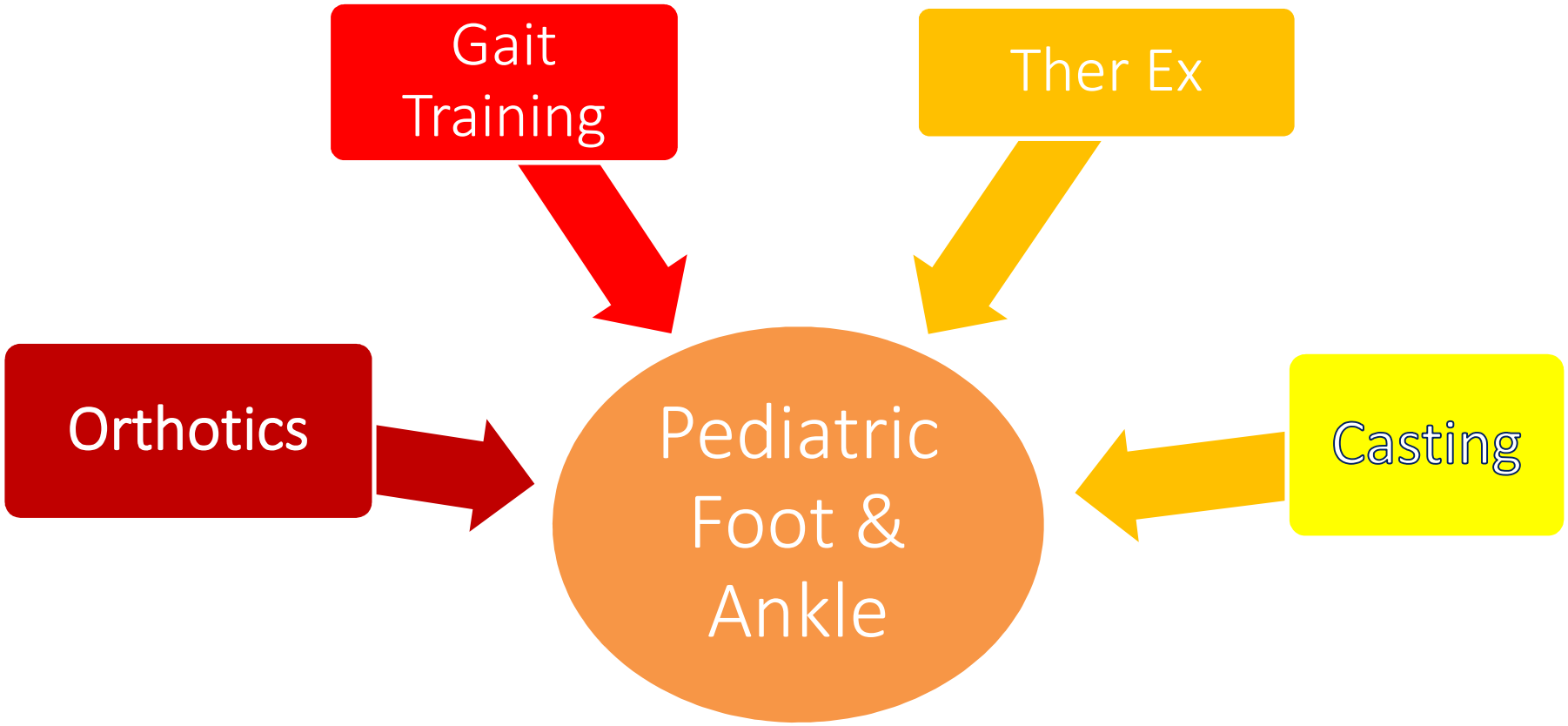
Terminology: Additional Terms

- “Shank”
- “Foot Core”

Terminology: Guilt

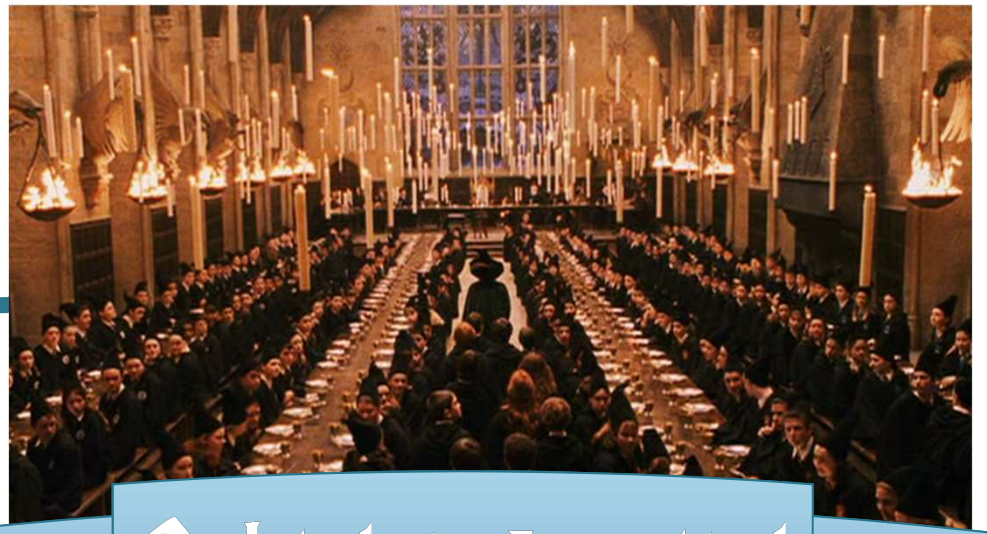
I. Introduction
II. Pediatric Ankle Impairments
    A. Traditional Ankle Model
    B. Complex Ankle Model
    C. Examination
III. Do We Need to Intervene?
IV. How Should We Intervene?





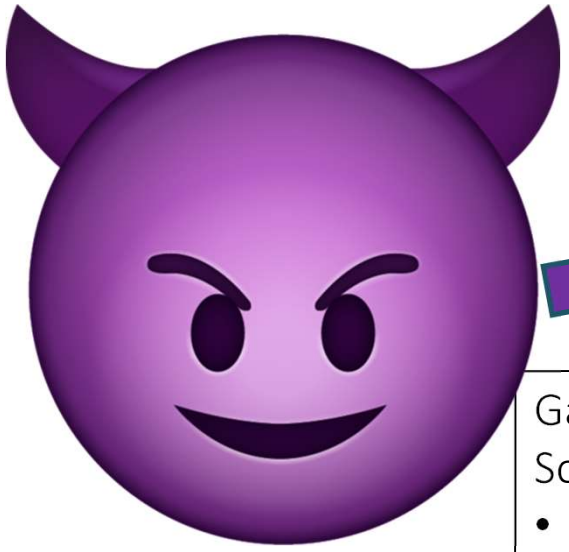
Traditional
Pediatric Ankle Model

Pediatric Ankle Model: Musculoskeletal



Syndesmoses/Sutures/?.....

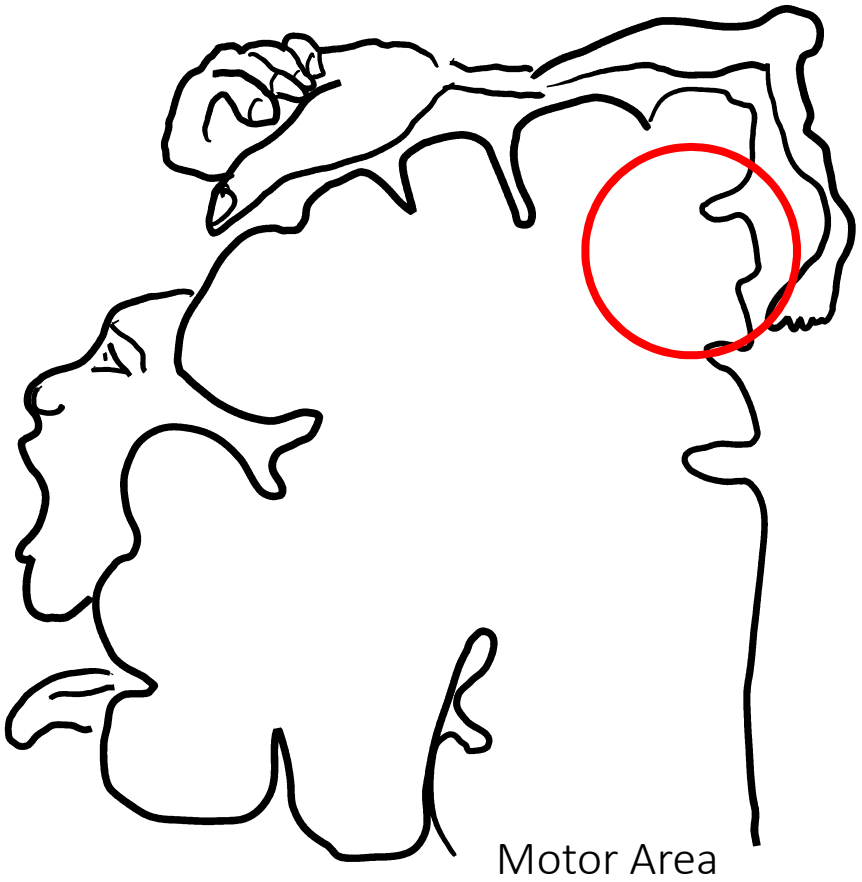
Pediatric Ankle Model



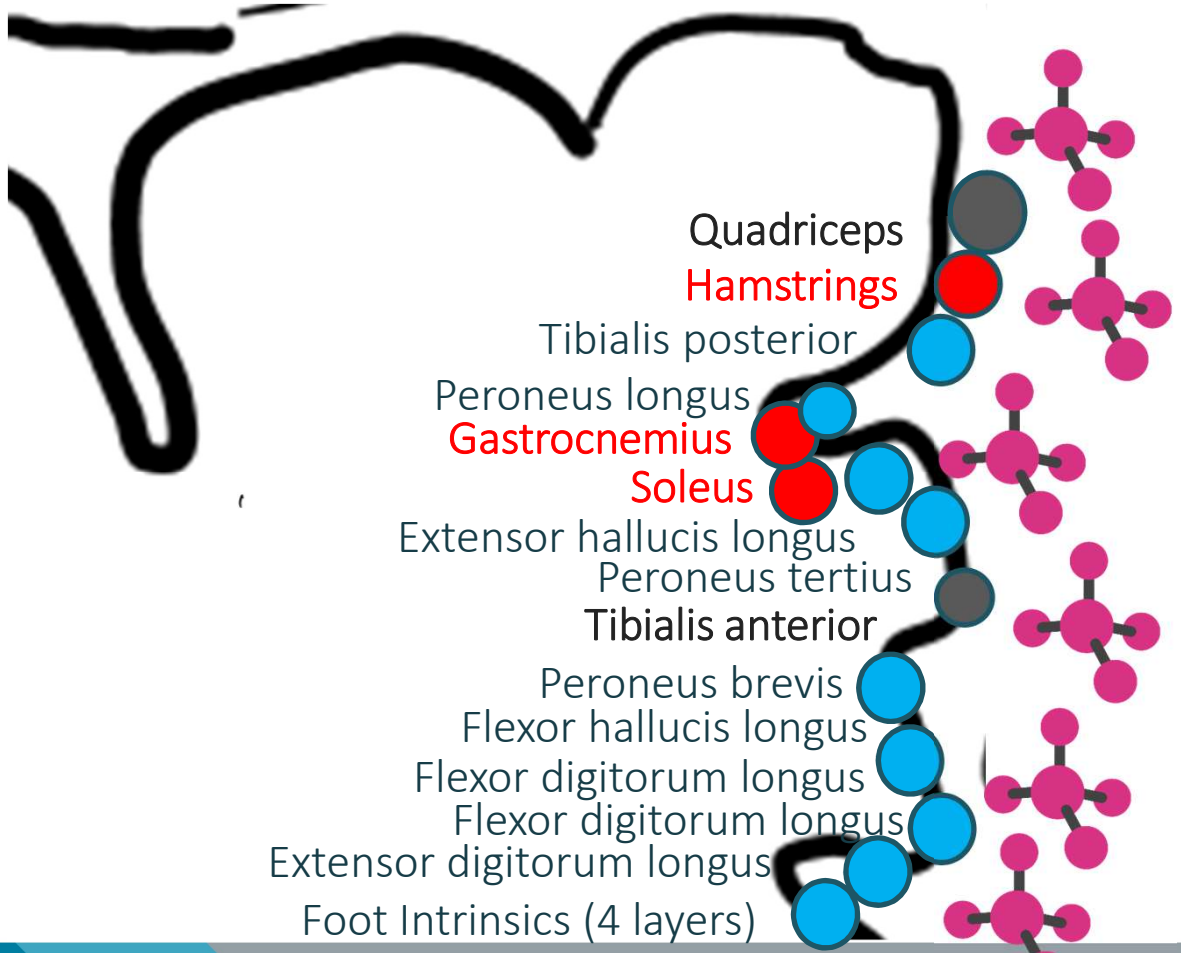
Gastrocnemius, Soleus
- Spasticity
- R1/R2
- Limits DF
- Bad
- Is evil

Tibialis anterior
- Weak
- No spasticity
- Powerless victim
- Good
- Underdog
- Send e-stim, kinesiotape

Pediatric Ankle Model:
Neuropathology

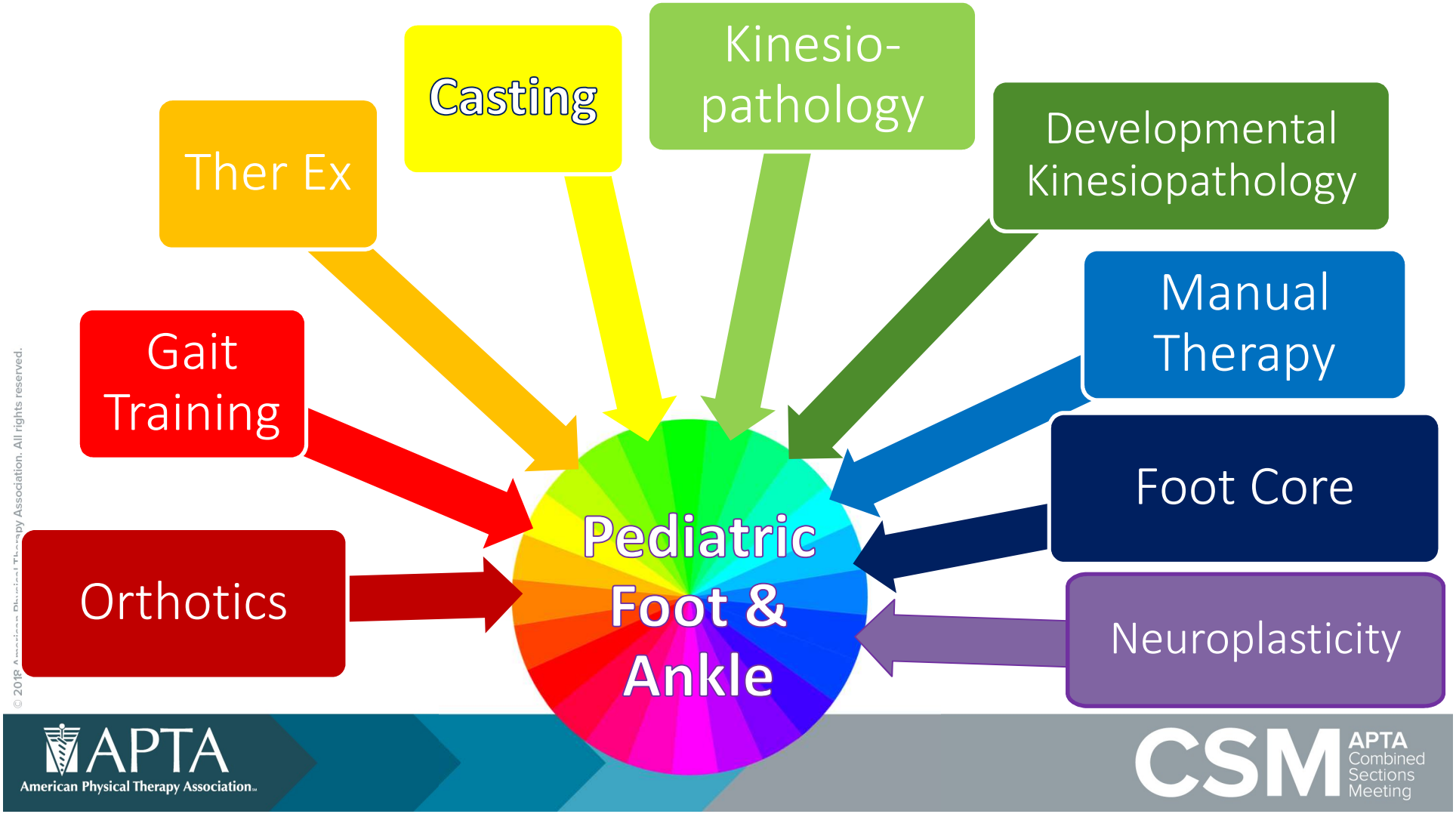


Pediatric Ankle Model:
Neuropathology



Key

- Weak
- Spastic
- Irrelevant



I. Introduction

II. Pediatric Ankle Impairments

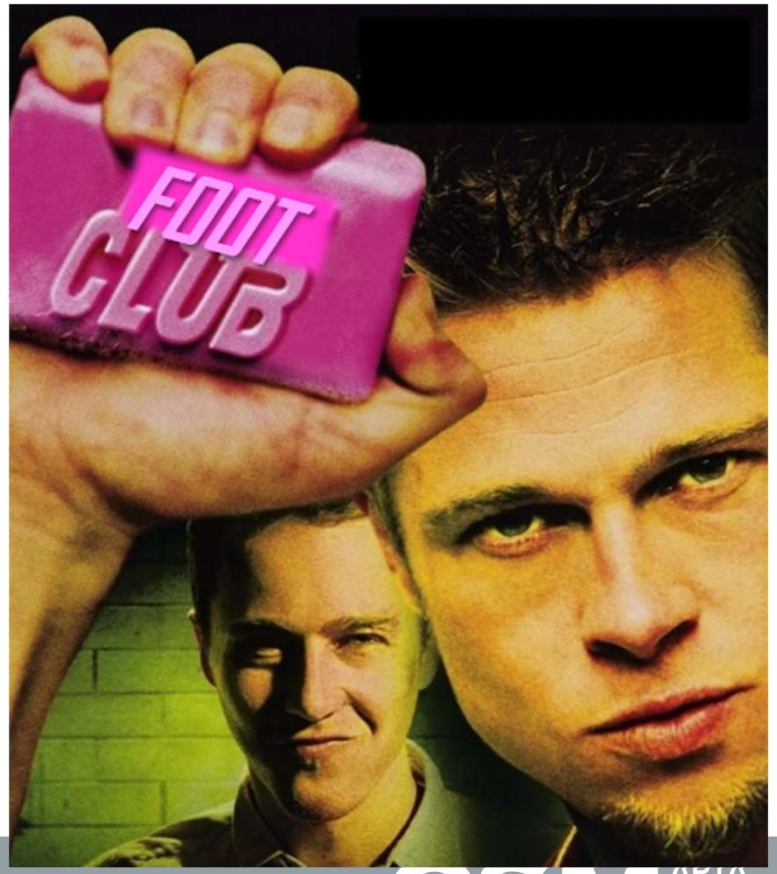
   A. Traditional Ankle Model

   B. Complex Ankle Model

   C. Examination

III. Do We Need to Intervene?

IV. How Should We Intervene?



Building a more complex model

What's unique about the ankle?

What's unique about the ankle?

A: The ankle is uniquely biased to lose functional ROM

- Intrinsic resistance in posterior structures due to passive-elastic properties of the gastrocsoleus soleus complex

What's unique about the ankle?

B: The resting position of the ankle when non-weightbearing is in plantarflexion.

What's unique about the ankle?

C: The key range of motion for *gait* is at end of the range in the direction of DF, not mid-range

Multi-Segment Assessment of Ankle and Foot Kinematics during Elevé Barefoot Demi-Pointe and En Pointe

Kimberly Perrella Veirs, PT, MPT, ATC, Josiah R Rippetoe, Jonathan D Baldwin, Kaitlin Lutz, SPT, DPT, Amgad M Haleem and Carol Pierce Dionne, PT, DPT, PhD

Thursday, February 13, 2020

1:00 PM - 3:00 PM

What's unique about the ankle?

D. Therapeutic Gait

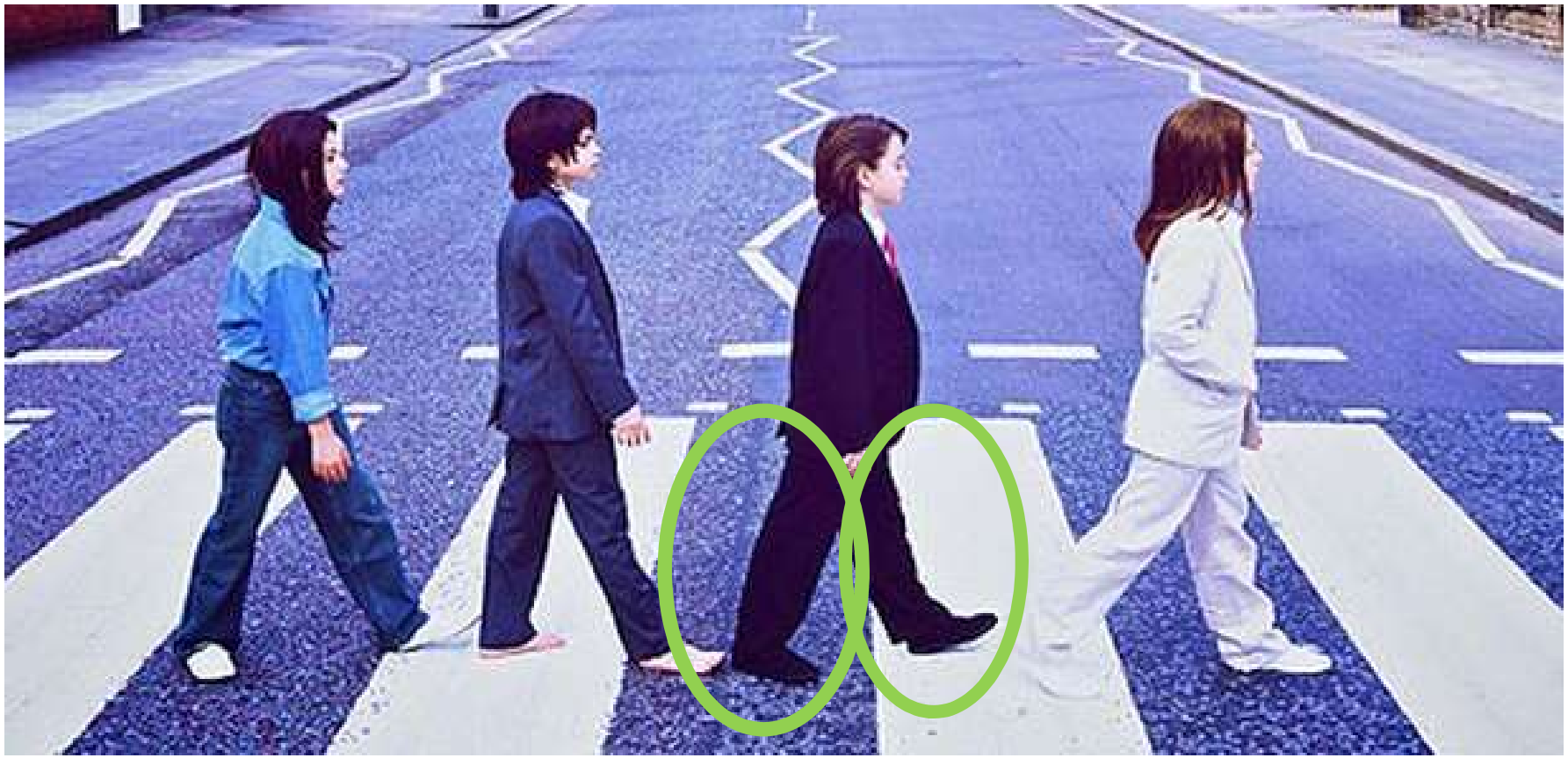
Functional dorsiflexion is achieved

not just *for*

but *through*

regular ambulation!

"Therapeutic Gait" (Elaine Owen)



What's unique about the ankle?

D. Therapeutic Gait

Terminal stance

- Dorsiflexion
- Knee extension
- Hip extension

Functional elongation of:

- GS
- Hip flexors

What's unique about the ankle?

D. Therapeutic Gait

Initial contact

- Dorsiflexion
- Knee extension
- Hip flexion

Functional elongation of:

- GS
- HS

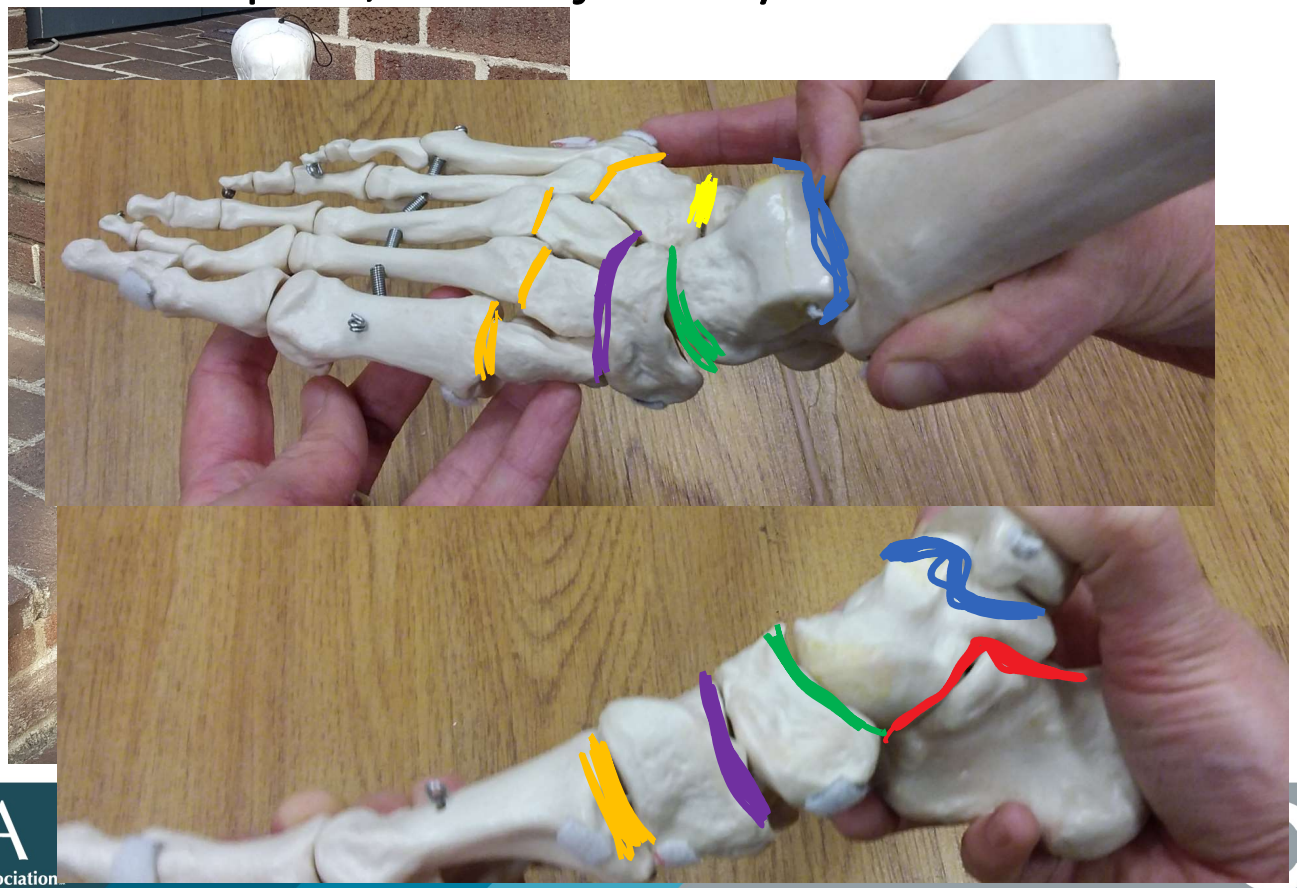
What's unique about the ankle?

D. Therapeutic Gait

- Functional DF is achieved through regular ambulation
- Anyone lacking this movement experience is at risk for restricted DF
- Shift: foot and ankle impairments in most pediatric health conditions are sequelae of the lack of therapeutic gait

What's unique about the ankle?

E. Ankle is a complex, multi-joint system movement system



What's unique about the ankle?

E. Ankle is a complex, multi-joint system movement system

Ankle Structure

Joints - Hindfoot

- Talo-crural (talus-tibia/fibula)
- Subtalar (talus-calcaneous)

Subtalar neutral	→	Talus on axis
“Clinical fiction"		Talocrural dorsiflexion *TC DF*

Challenging the foundations of the clinical model of foot function: further evidence that the **Root Model assessments fail to appropriately classify foot function**. (Jarvis 2017)

If it doesn’t work, why do we still do it? The continuing use of Subtalar Joint Neutral Theory in the face of **overpowering** critical research. (Harradine 2018)

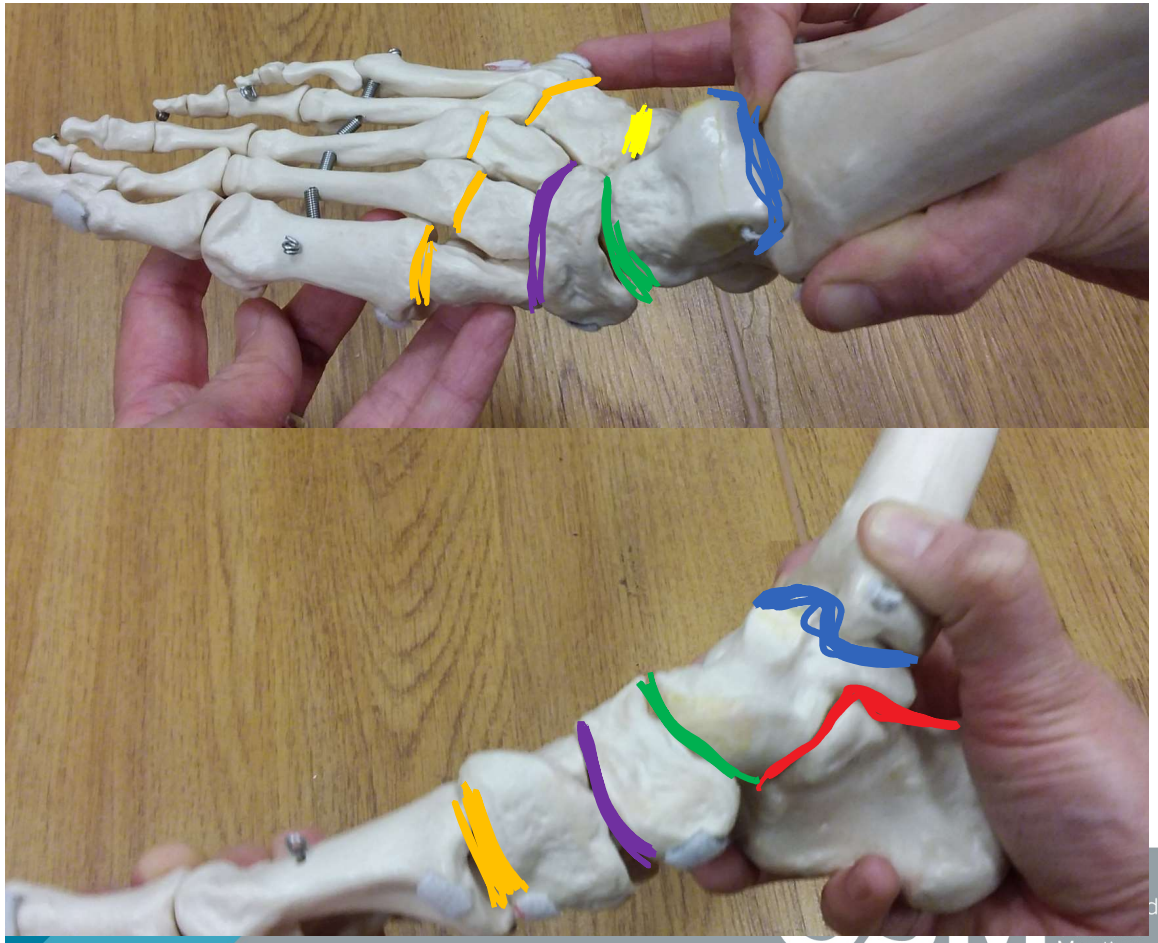
E. Ankle is a complex, multi-joint system movement system

Hindfoot

- Talo-crural (talus-tibia/fibula)
- Subtalar (talus-calcaneous)

Midfoot

- Talus-Navicular
- Calcaneous-cuboid
- Navicular-cuneiforms
- Cunieforms/cuboid-metatarsals



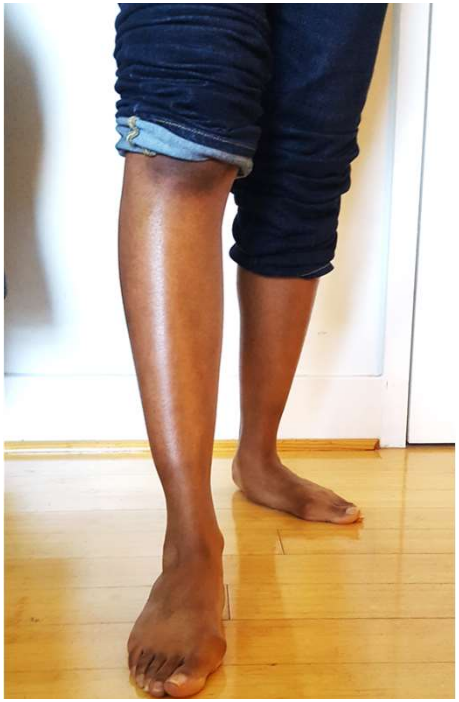
What's unique about the ankle?

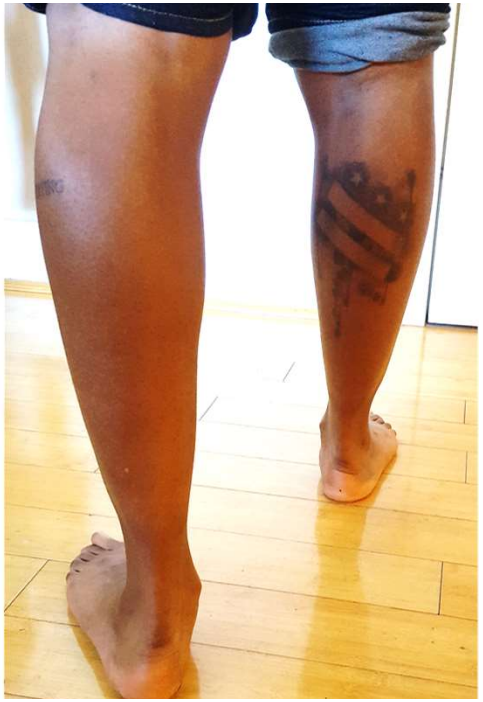
E. Ankle is a complex, multi-joint system movement system

Due to the complexity of the foot and ankle, there are many ways which the system may compensate for MS or NM dysfunction.

e.g. in some systems, accessory motion is ***relatively*** more flexible than talocrural (TC) DF.

E. Ankle is a complex, multi-joint system movement system





False “DF” occurs to bring the foot toward the tibia but the TC joint does not DF.

Movement Systems: Kinesiopathological Model

Shirley Sahrmann, PT, PhD, FAPTA

Diagnosis and treatment of movement system impairment syndromes. (Sahrmann 2017)

Movement Systems: Kinesiopathological Model

- The body, at the joint level, follows the laws of physics and takes the path of least resistance for movement
- Determinants of the path of motion are
  - intra- and inter-joint relative flexibility
  - relative stiffness of muscle and connective tissue
  - motor control

Diagnosis and treatment of movement system impairment syndromes. (Sahrmann 2017)

Movement Systems: Kinesiopathological Model

- Repetitive movement and sustained alignments can induce pathoanatomical changes in tissues and joint structures

Diagnosis and treatment of movement system impairment syndromes. (Sahrmann 2017)

Movement Systems: Kinesiopathological Model

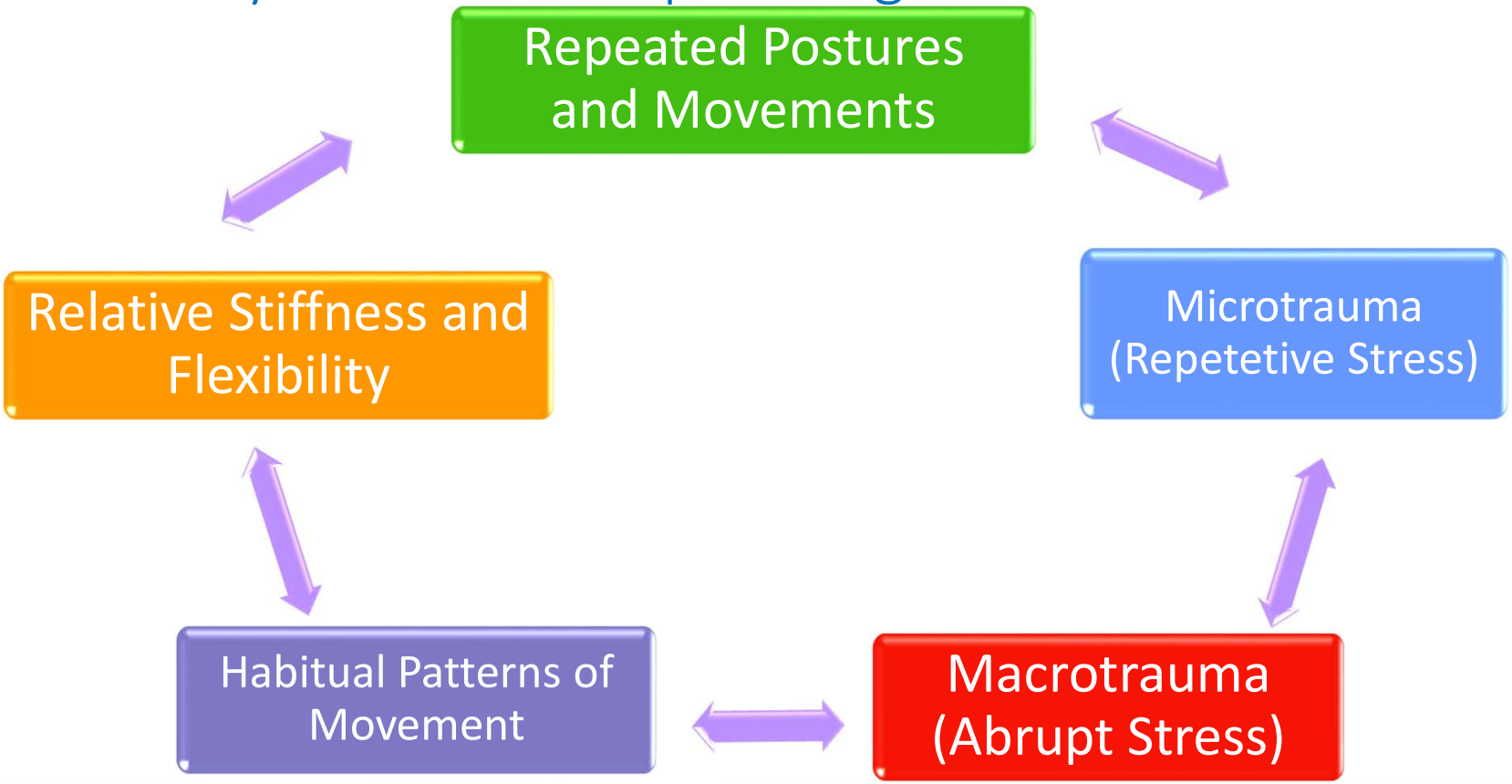
- Sustained alignments and repeated movements associated with daily activities induce tissue adaptations as well as impaired alignment and movement.
- Micro-instability

→ tissue micro-trauma

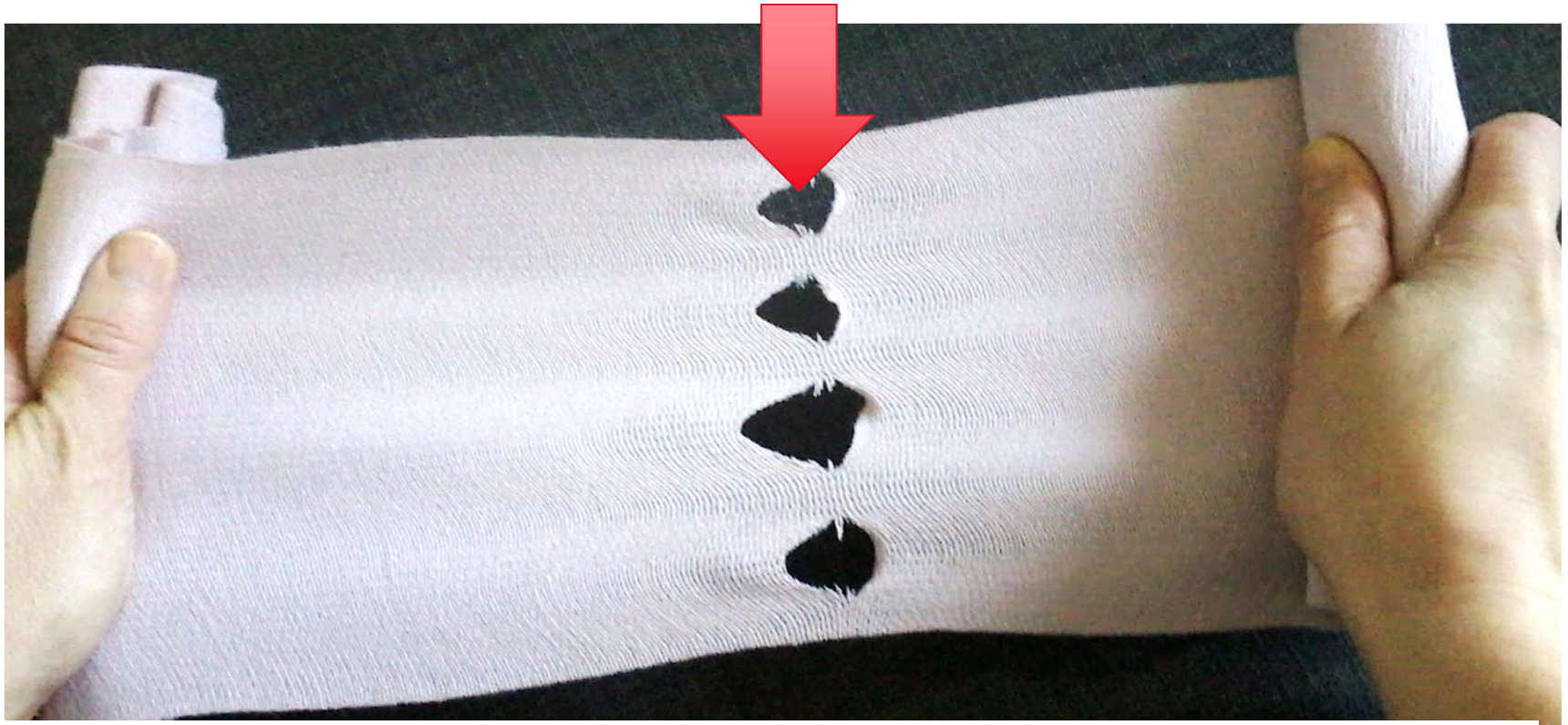
→ macro-trauma

Diagnosis and treatment of movement system impairment syndromes. (Sahrmann 2017)

Movement Systems: Kinesiopathological Model

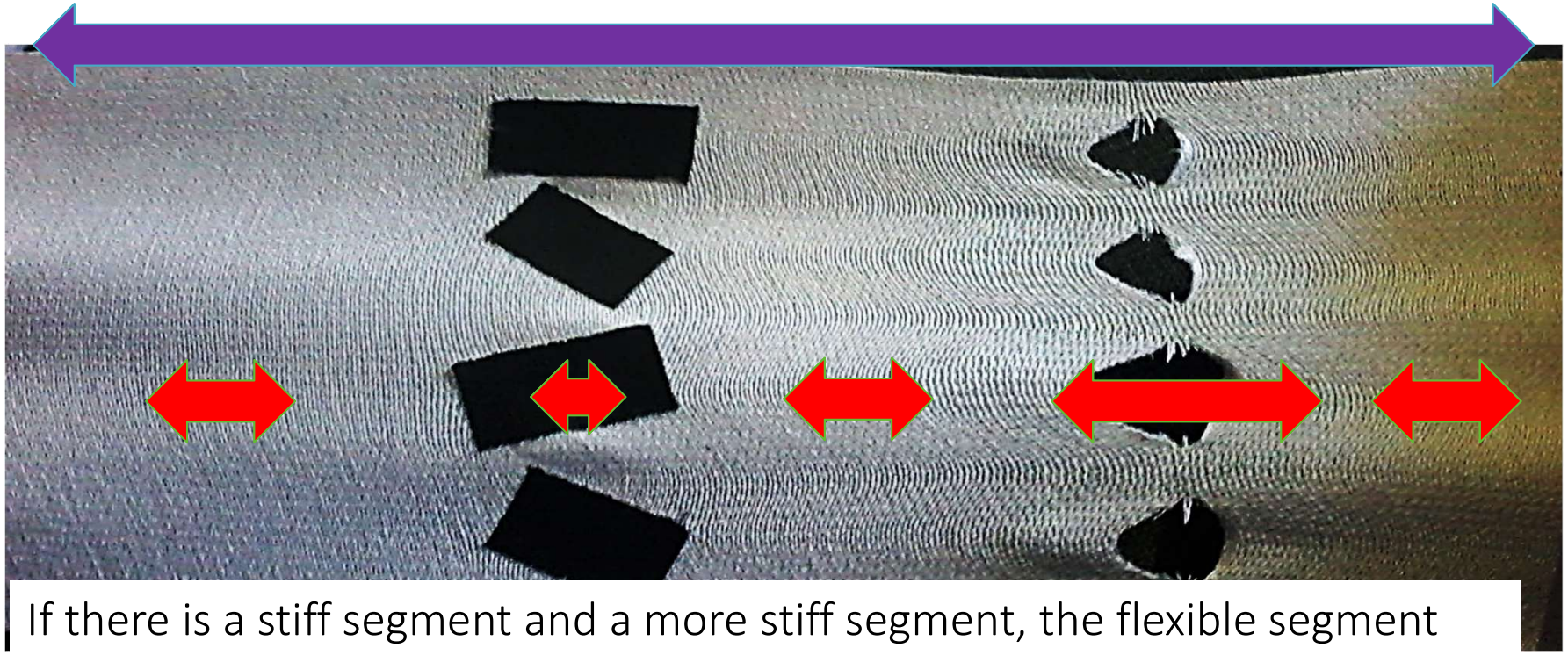


Movement Systems: Kinesiopathological Model



Ace wrap model: In a mechanical system, if a general stretch is applied, the more flexible segment will move the MOST.

Kinesiopathological Model: Relative Flexibility



If there is a stiff segment and a more stiff segment, the flexible segment will move most, and the stiff segment will not stretch until all the slack has been taken out of both the flexible segment and the other less-stiff segments.

Kinesiopathological Model: Relative Flexibility

- Lumbar spine model

Yogi 1 is getting HS lengthening. Yogi 2 is getting HS lengthening only after lumbar spine flexion. Every time she does this activity, she makes the lumbar spine more flexible into flexion.

Kinesiopathological Model: Relative Flexibility

The second stretcher is taking up all her lumbar flexion and rotation motion before she gets to HS lengthening.

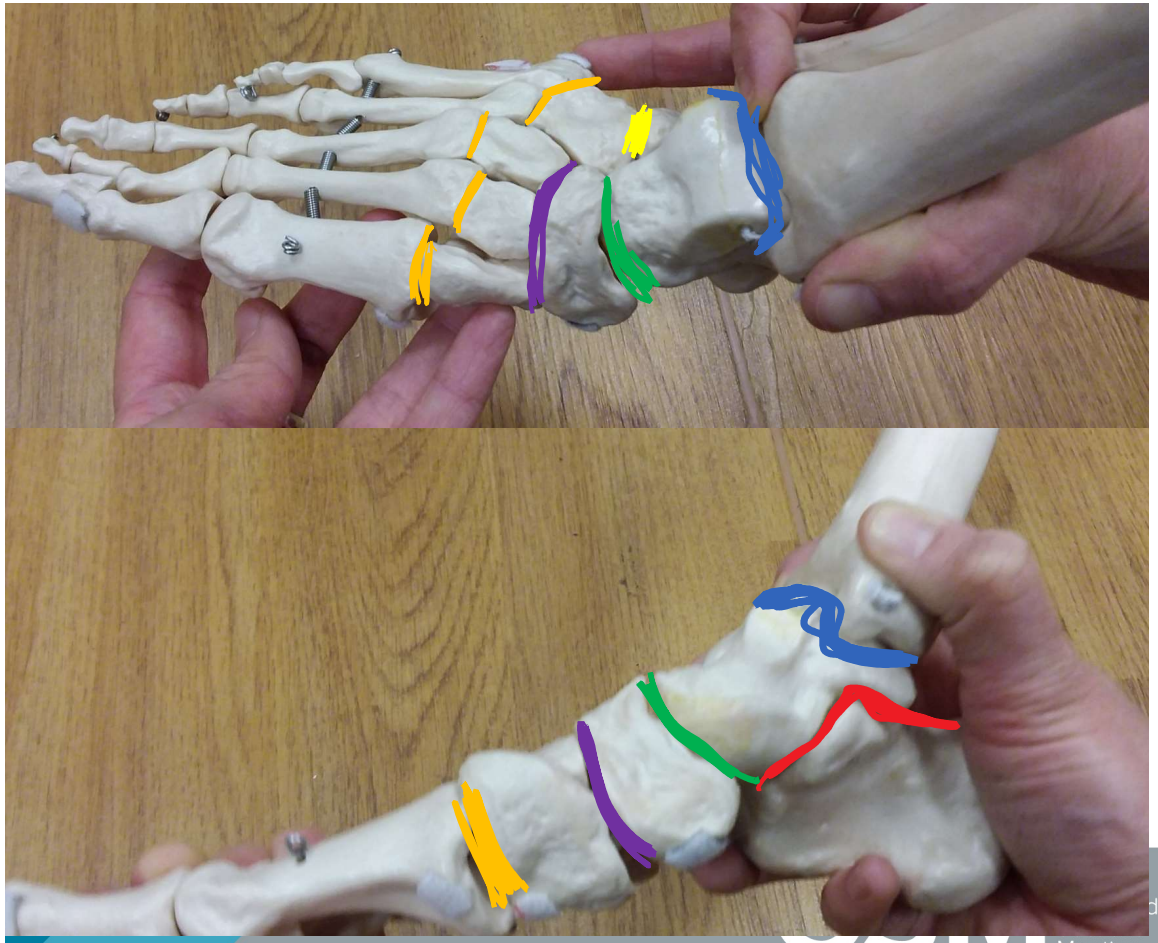
E. Relative Flexibility: The Ankle As A Movement System

Hindfoot

- Talo-crural (talus-tibia/fibula)

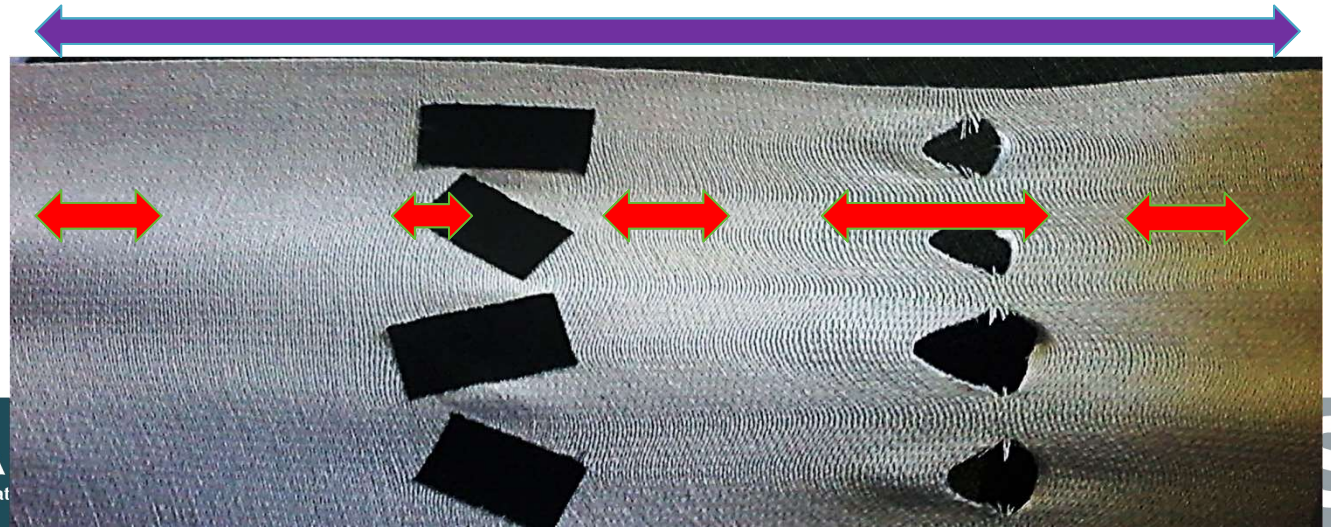
Midfoot

- Talus-navicular
- Calcaneous-cuboid
- Navicular-cuneiforms
- Cunieforms/cuboid-metatarsals

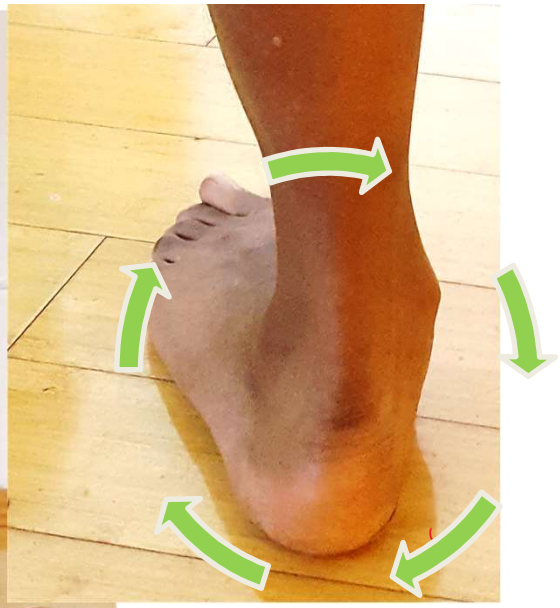


E. Relative Flexibility: The Ankle As A Movement System

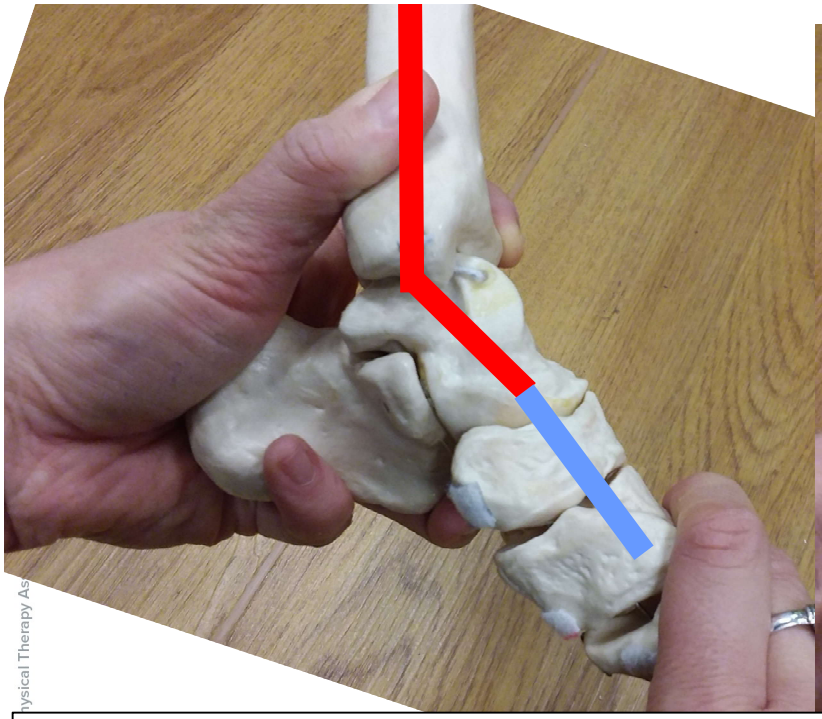
DF is a component movement of many of the accessory joints of the system, so when the hindfoot is stiff, the dorsiflexion component of accessory joint motion sometimes becomes the dominant way that the foot moves toward the tibia.



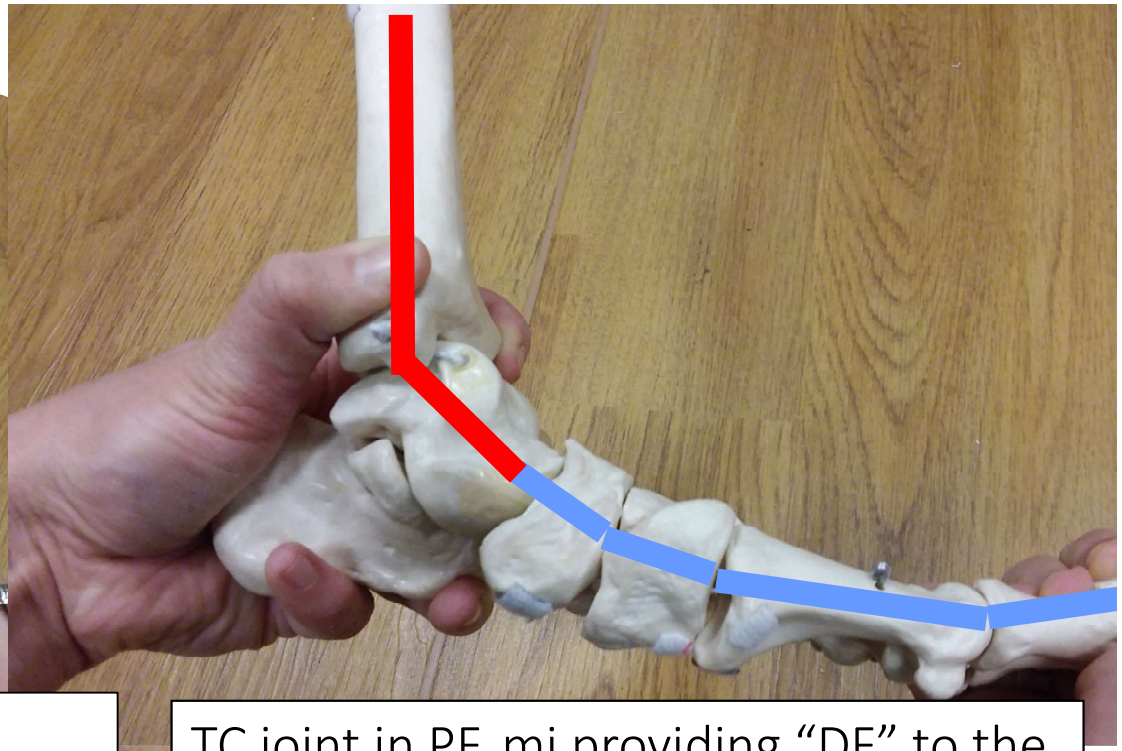
E. Relative Flexibility: The Ankle As A Movement System



E. Relative Flexibility: The Ankle As A Movement System

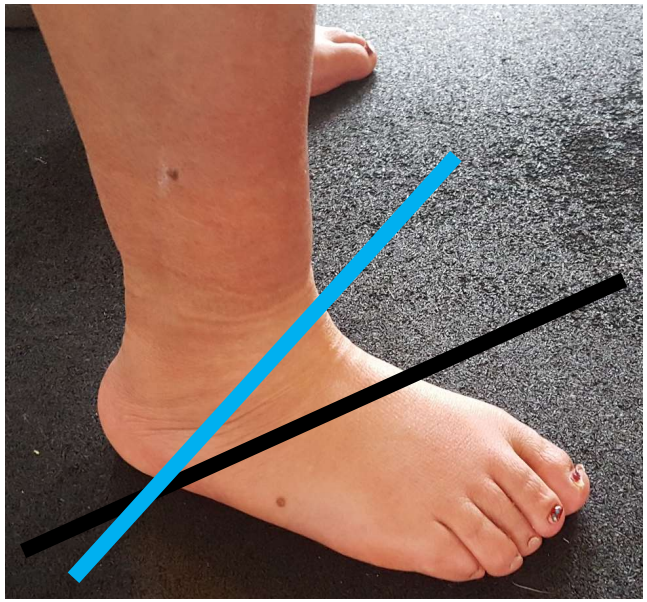


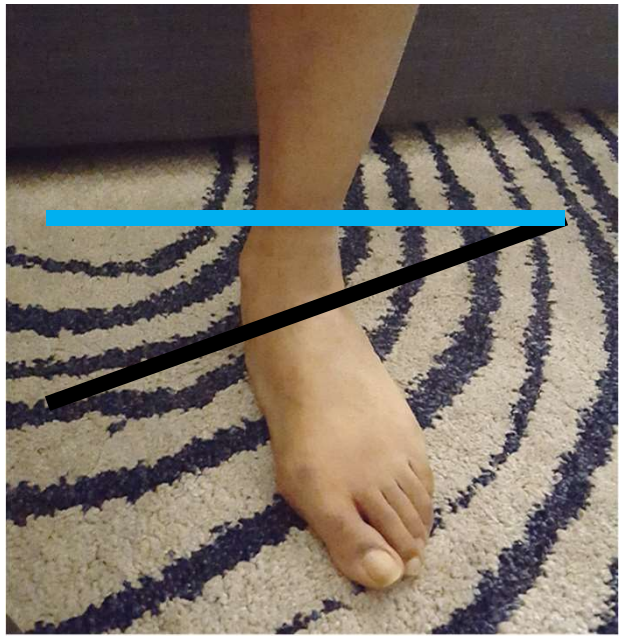
TC joint in PF, midfoot joints congruent.



TC joint in PF, mi providing “DF” to the system.

E. Relative Flexibility: The Ankle As A Movement System





Forces are mechanically directed to relatively more flexible structures and away from TC dorsiflexion.

What's unique about the ankle?

F. Heterogeneity

Kinematic foot types in youth with equinovarus secondary to hemiplegia. (Krzak 2015)

- Participants *with hemiplegia and "equinovarus"* presented with 5 distinct subgroups
- Neurotypical controls were distributed among 4 subgroups
- Noted: inherent variability in foot structure even in neurotypical, asymptomatic movement systems

What's unique about the ankle?

G. The Foot Has A Core?

What's unique about the ankle?

G. Foot Core

The foot core system: a new paradigm for understanding intrinsic foot muscle function. (Mckeon 2015)

What's unique about the ankle?

G. Foot Core: Active Subsystem

- Arch of the foot is controlled by both local stabilizers and global movers of the foot, similar to the lumbopelvic core.
- Local stabilizers ("foot core"):
  - 4 layers of plantar intrinsic muscles that originate and insert on the foot.
  - small moment arms and serve primarily to stabilize the multiple joints of the foot.
  - act to control the degree and velocity of arch deformation with each foot step

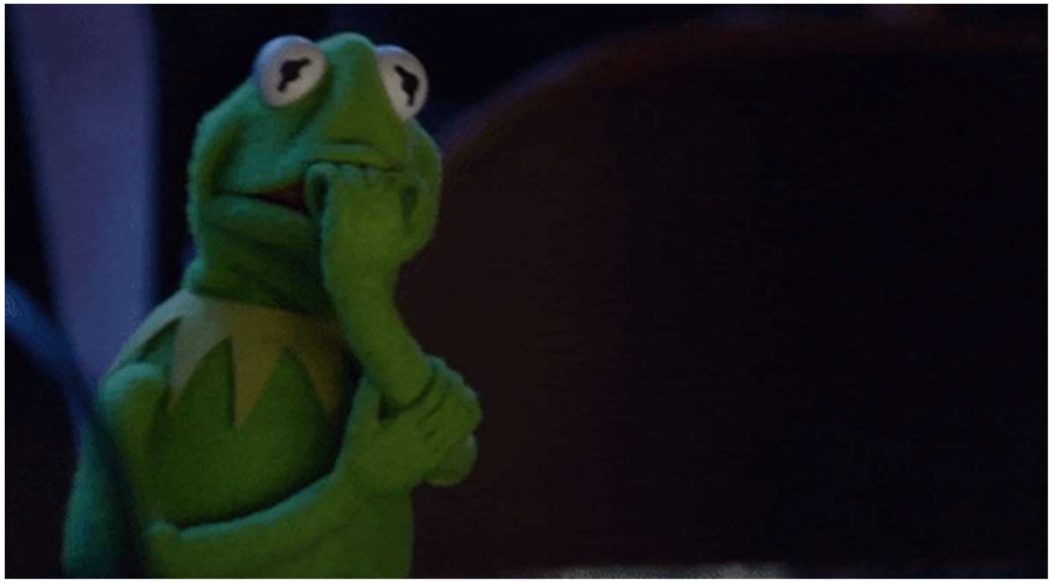
What's unique about the ankle?

G. Foot Core: Neural Subsystem

- Intrinsic muscles are advantageously positioned to provide immediate sensory information about changes in the foot posture, via stretch response
- Loss of alignment of the foot leads to loss of this information

The Ankle:

- Heterogeneous in structure
- Prone to impairment
- Complex
  - Anatomy
  - Function
- Intimidating!



I. Introduction

II. Pediatric Ankle Impairments

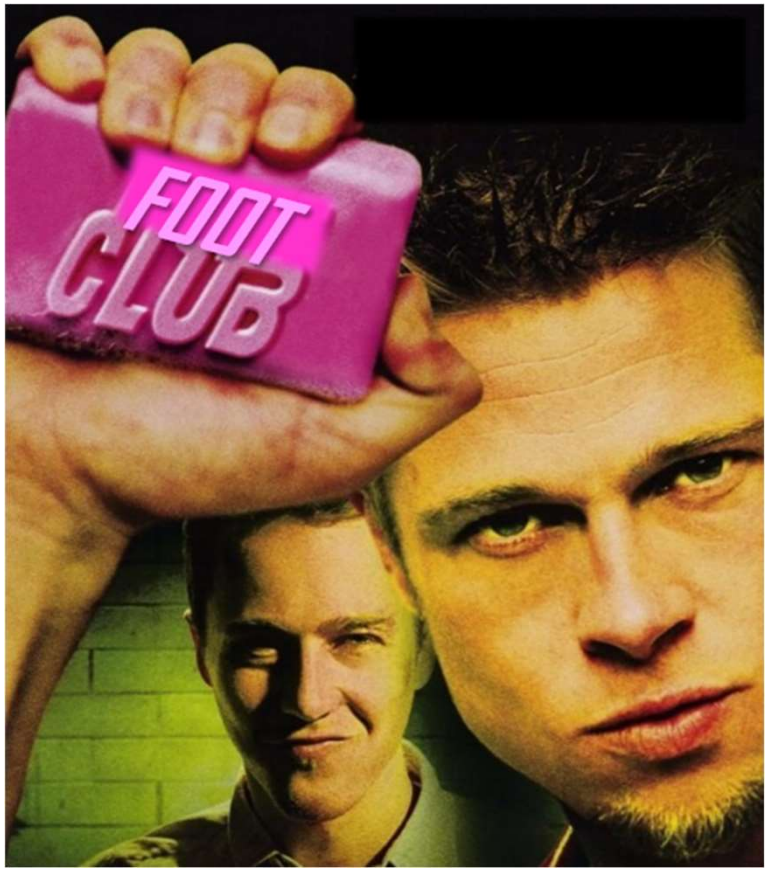
   A. Traditional Ankle Model

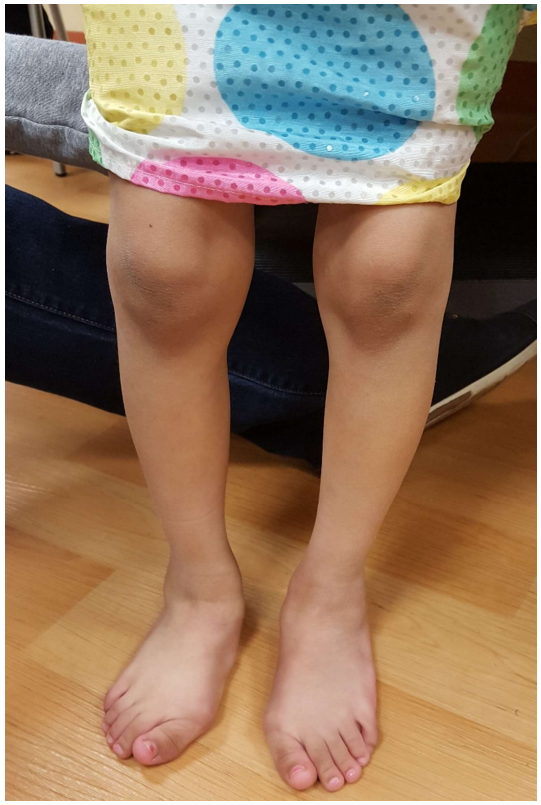
   B. Complex Ankle Model

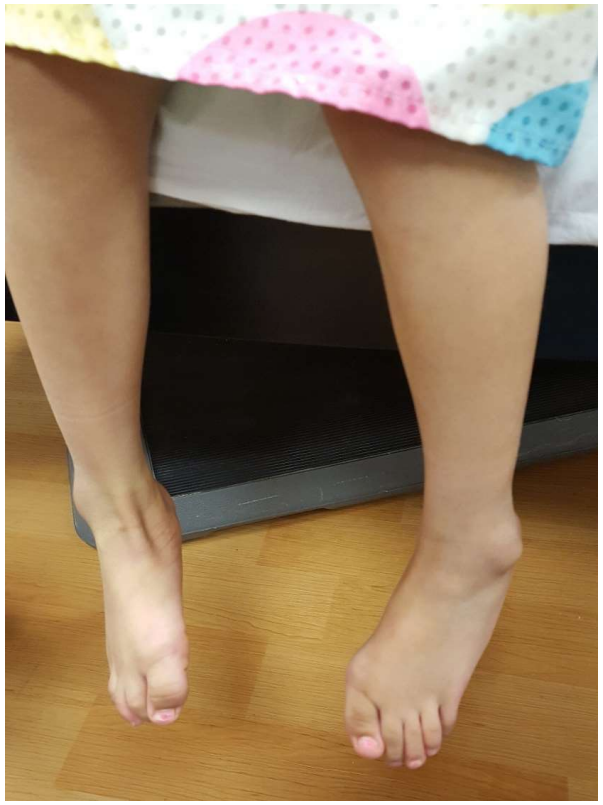
   C. Examination

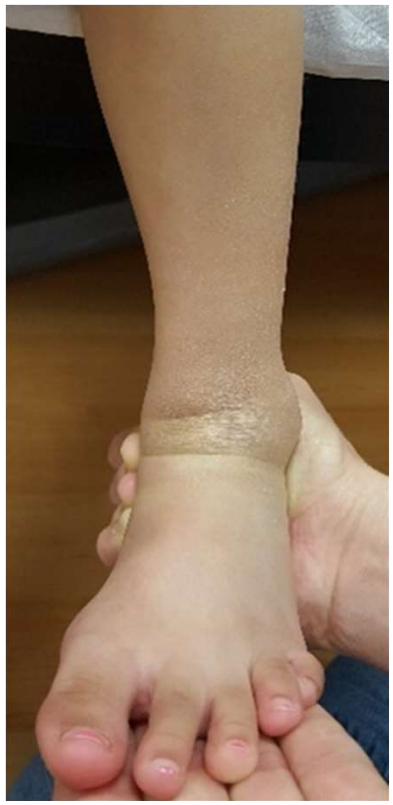
III. Do We Need to Intervene?

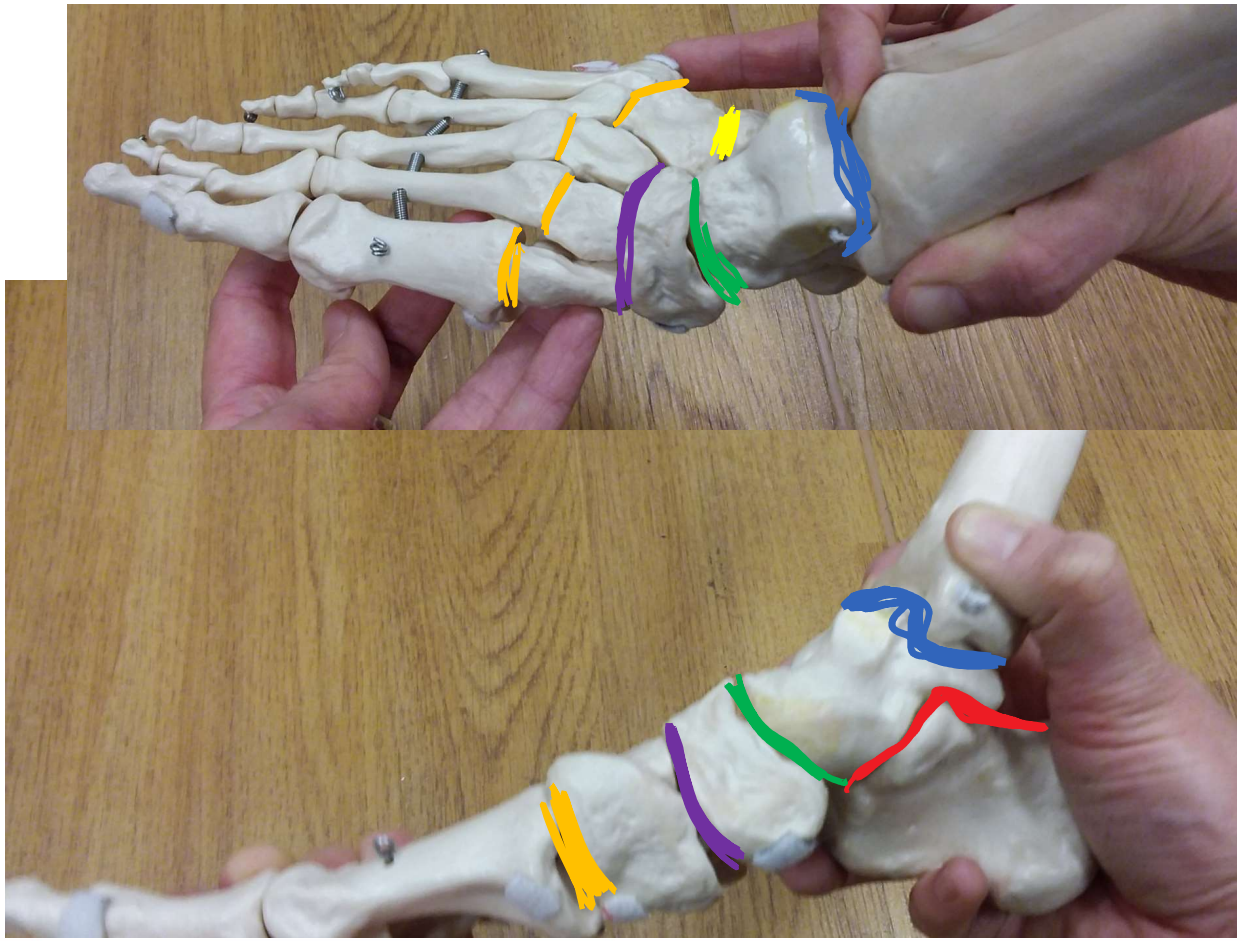
IV. How Should We Intervene?







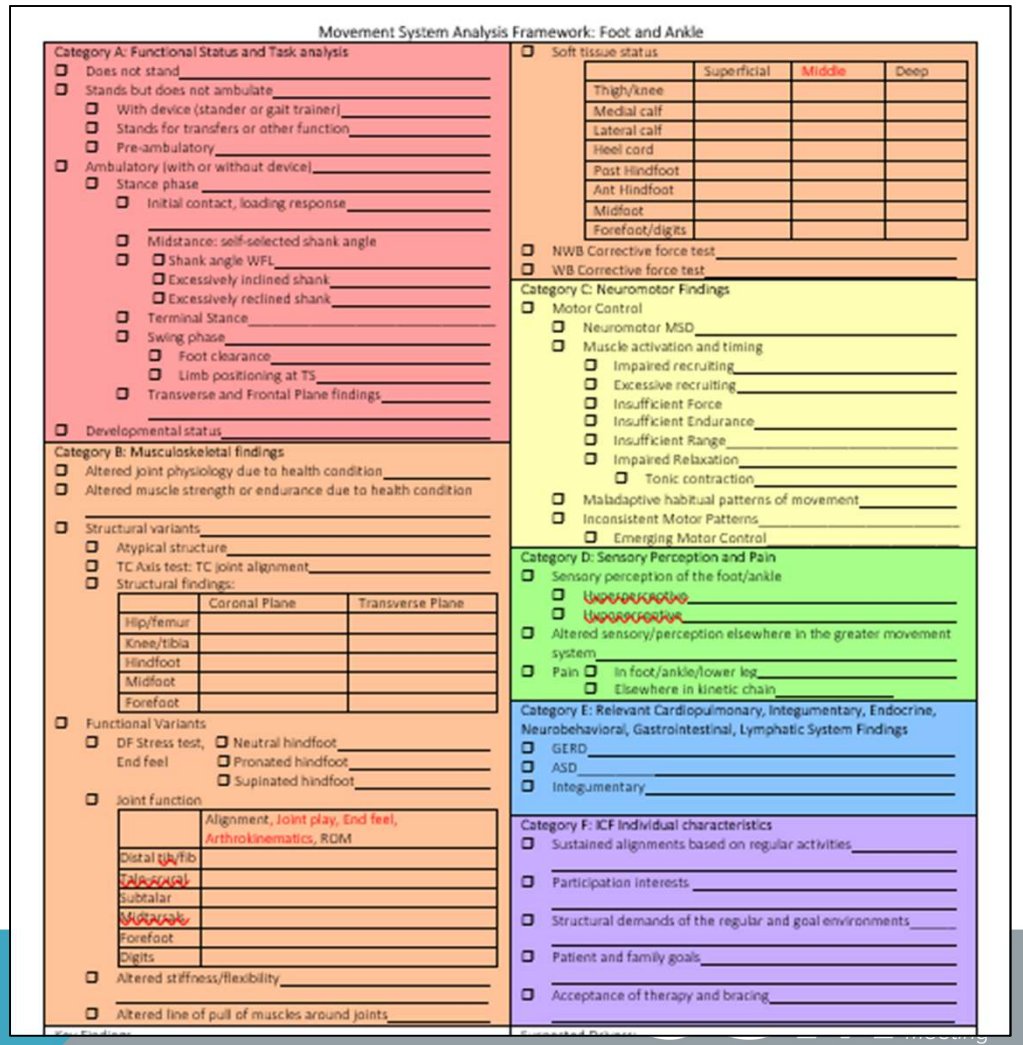




Examination of The Ankle

Special Tests

Movement System Analysis Framework: Foot and Ankle



Movement System Analysis Framework: Foot and Ankle

Category A: Functional Status and Task analysis

- ☐ Does not stand
- ☐ Stands but does not ambulate
  - ☐ With device (stander or gait trainer)
  - ☐ Stands for transfers or other function
  - ☐ Pre-ambulatory
- ☐ Ambulatory (with or without device)
  - ☐ Stance phase
    - ☐ Initial contact, loading response
    - ☐ Midstance: self-selected shank angle
    - ☐ ☐ Shank angle WFL
      - ☐ Excessively inclined shank
      - ☐ Excessively reclined shank
    - ☐ Terminal Stance
    - ☐ Swing phase
      - ☐ Foot clearance
      - ☐ Limb positioning at TS
    - ☐ Transverse and Frontal Plane findings
- ☐ Developmental status

Category B: Musculoskeletal findings

- ☐ Altered joint physiology due to health condition
- ☐ Altered muscle strength or endurance due to health condition
- ☐ Structural variants
  - ☐ Atypical structure
  - ☐ TC Axis test: TC joint alignment
  - ☐ Structural findings:

	Coronal Plane	Transverse Plane
Hip/femur		
Knee/tibia		
Hindfoot		
Midfoot		
Forefoot		

- ☐ Functional Variants
  - ☐ DF Stress test, End feel
    - ☐ Neutral hindfoot
    - ☐ Pronated hindfoot
    - ☐ Supinated hindfoot
  - ☐ Joint function

	Alignment, Joint play, End feel, Arthrokinematics, ROM
Distal tib/fib	
~~Talocrural~~	
Subtalar	
~~Midtarsal~~	
Forefoot	
Digits	

  - ☐ Altered stiffness/flexibility
  - ☐ Altered line of pull of muscles around joints

- ☐ Soft tissue status

	Superficial	Middle	Deep
Thigh/knee			
Medial calf			
Lateral calf			
Heel cord			
Post Hindfoot			
Ant Hindfoot			
Midfoot			
Forefoot/digits			

- ☐ NWB Corrective force test
- ☐ WB Corrective force test

Category C: Neuromotor Findings

- ☐ Motor Control
  - ☐ Neuromotor MSD
  - ☐ Muscle activation and timing
    - ☐ Impaired recruiting
    - ☐ Excessive recruiting
    - ☐ Insufficient Force
    - ☐ Insufficient Endurance
    - ☐ Insufficient Range
    - ☐ Impaired Relaxation
      - ☐ Tonic contraction
  - ☐ Maladaptive habitual patterns of movement
  - ☐ Inconsistent Motor Patterns
    - ☐ Emerging Motor Control

Category D: Sensory Perception and Pain

- ☐ Sensory perception of the foot/ankle
  - ☐ ~~Hyperperception~~
  - ☐ ~~Hyperception~~
- ☐ Altered sensory/perception elsewhere in the greater movement system
- ☐ Pain ☐ In foot/ankle/lower leg ☐ Elsewhere in kinetic chain

Category E: Relevant Cardiopulmonary, Integumentary, Endocrine, Neurobehavioral, Gastrointestinal, Lymphatic System Findings

- ☐ GERD
- ☐ ASD
- ☐ Integumentary

Category F: ICF Individual characteristics

- ☐ Sustained alignments based on regular activities
- ☐ Participation interests
- ☐ Structural demands of the regular and goal environments
- ☐ Patient and family goals
- ☐ Acceptance of therapy and bracing

Exam: Musculoskeletal

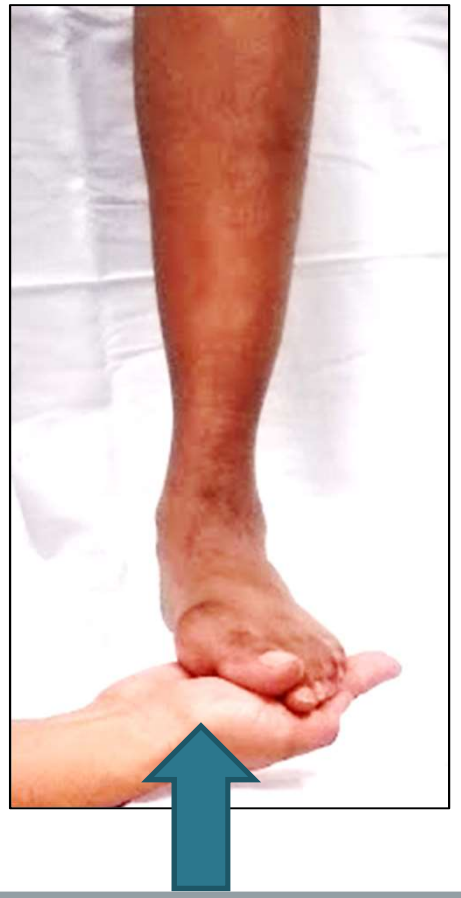
- ❒ Functional Variants
  - ❒ DF Stress test, End feel
    - ❒ 1-Neutral hindfoot _____
    - ❒ 2-Pronated hindfoot _____
    - ❒ 3-Supinated hindfoot _____
  - ❒ Joint function

	Alignment, Joint play, End feel, Arthrokinematics, ROM
Distal tib/fib	
Talo-crural	

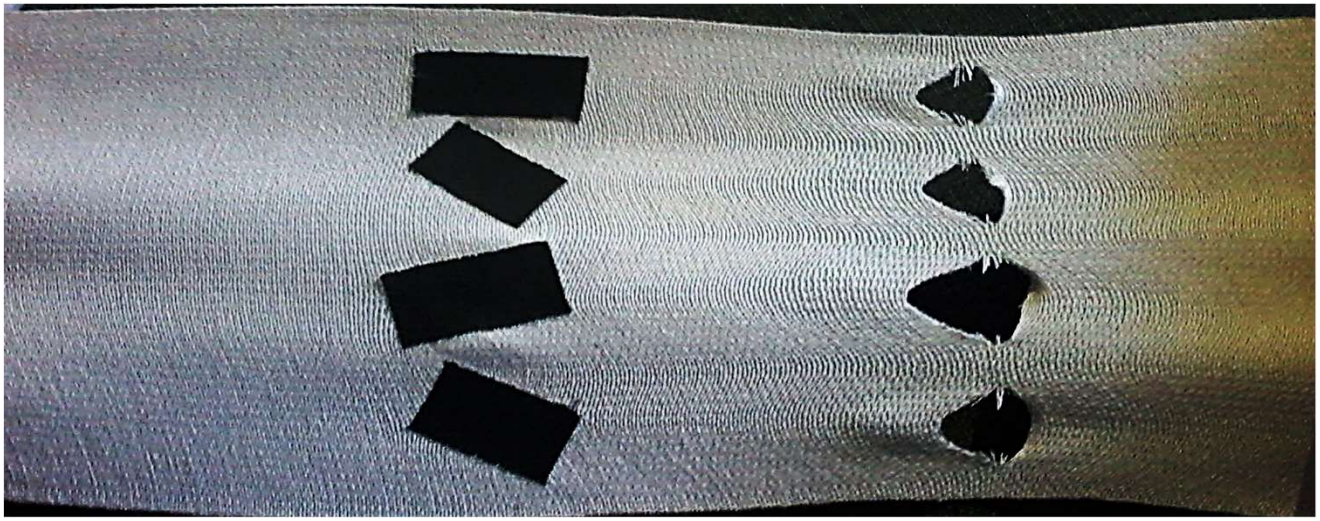
Dorsiflexion Stress Test

- ❒ Functional Variants
  - ❒ DF Stress test, End feel
    - ❒1-Neutral hindfoot_____
    - ❒2-Pronated hindfoot____
    - ❒3-Supinated hindfoot___

- Where does DF (foot towards tibia) occur when a general stress is applied?
- What structures limit further motion in the direction of foot toward tibia?



Dorsiflexion Stress Test



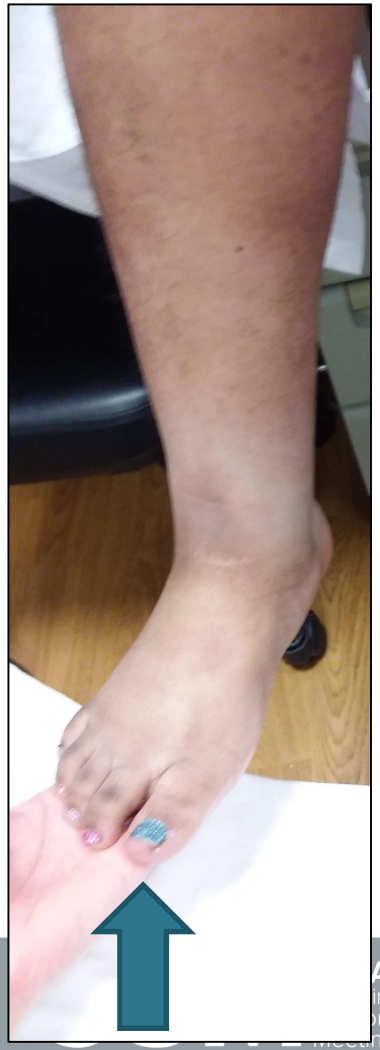
Dorsiflexion Stress Test

- ❒ Functional Variants
  - ❒ DF Stress test, End feel
    - ❒ 1-Neutral hindfoot_____
    - ❒ 2-Pronated hindfoot____
    - ❒ 3-Supinated hindfoot___

1. Neutral hindfoot

   End feel/location:

   - GS/Achilles tendon
   - TC joint restriction



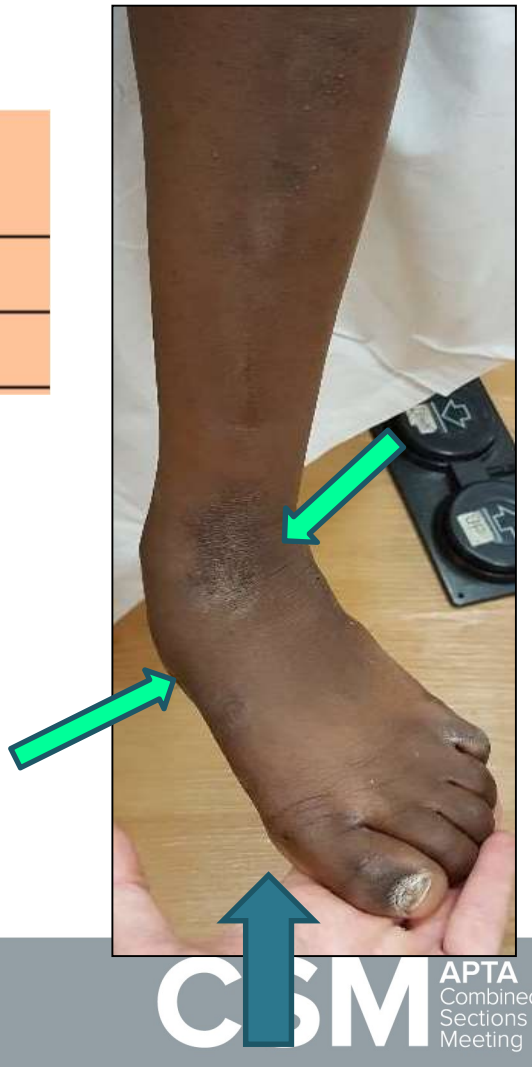
Dorsiflexion Stress Test

- ❒ Functional Variants
  - ❒ DF Stress test, End feel
    - ❒ 1-Neutral hindfoot_____
    - ❒ 2-Pronated hindfoot____
    - ❒ 3-Supinated hindfoot___

2. Pronated hindfoot

   End feel/location:

   - Anterior lateral talar impingement
   - Midfoot mush



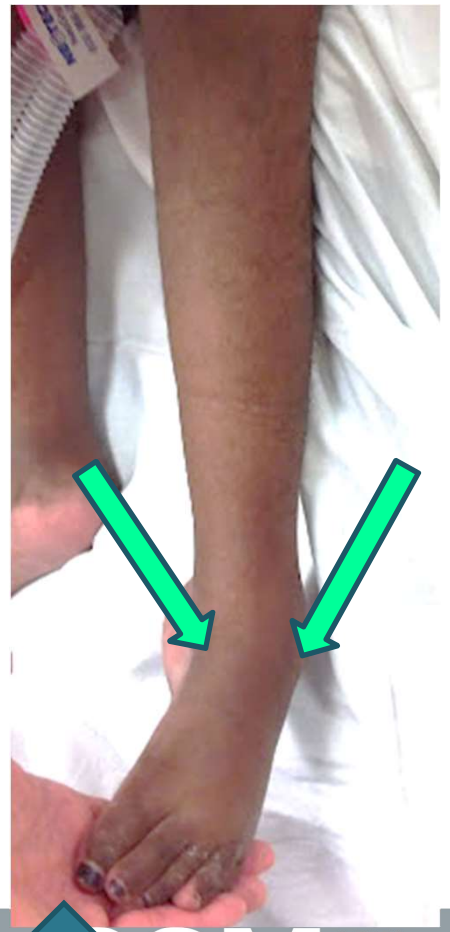
Dorsiflexion Stress Test

- ❒ Functional Variants
  - ❒ DF Stress test, End feel
    - ❒ 1-Neutral hindfoot_____
    - ❒ 2-Pronated hindfoot_____
    - ❒ 3-Supinated hindfoot____

3. Supinated hindfoot

   End feel/location:

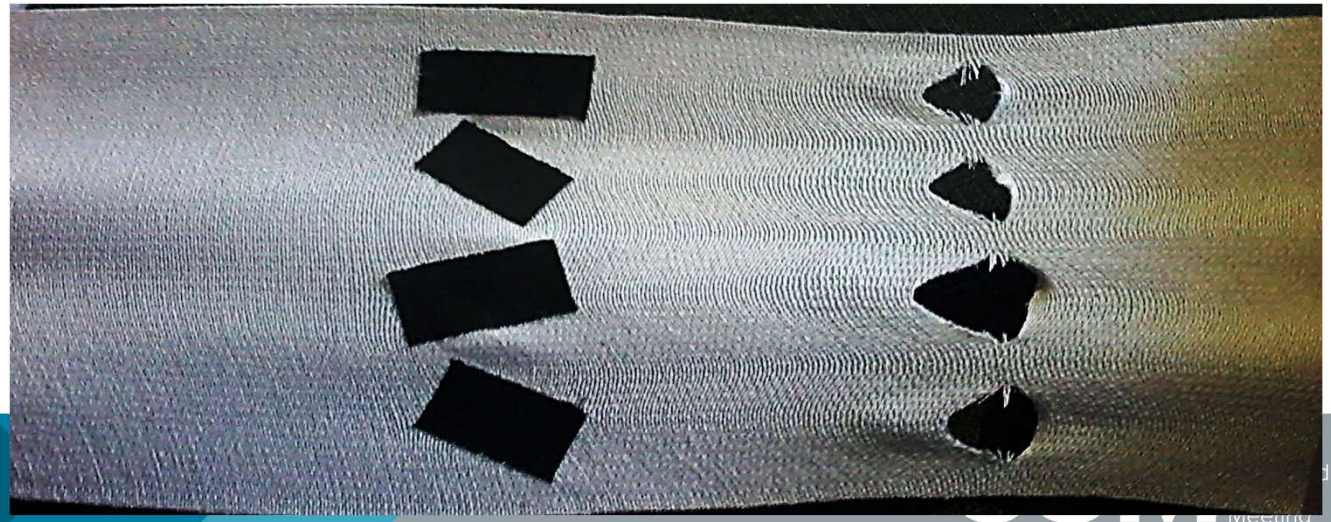
   - Anterior-medial talar impingement
   - Lateral talar subluxing



Dorsiflexion Stress Test

Helps to determine

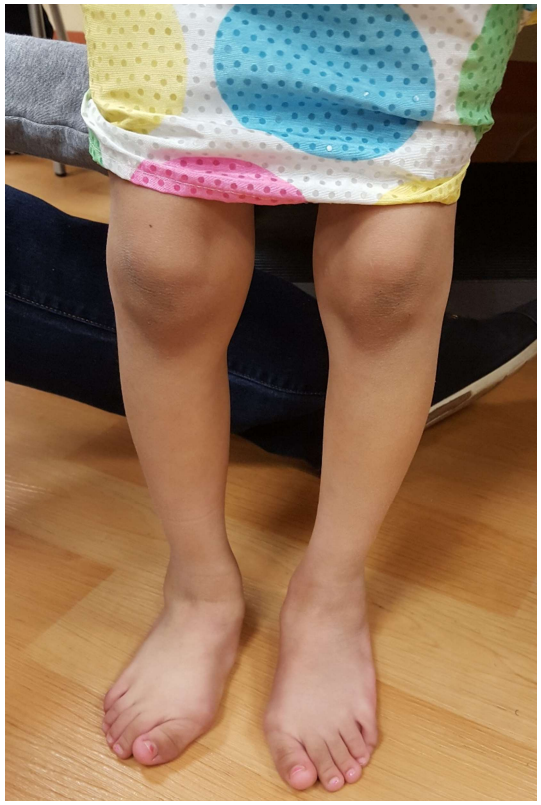
- path of least resistance for DF
- intra- and inter-joint relative flexibility
  - relative stiffness of muscle and connective tissue

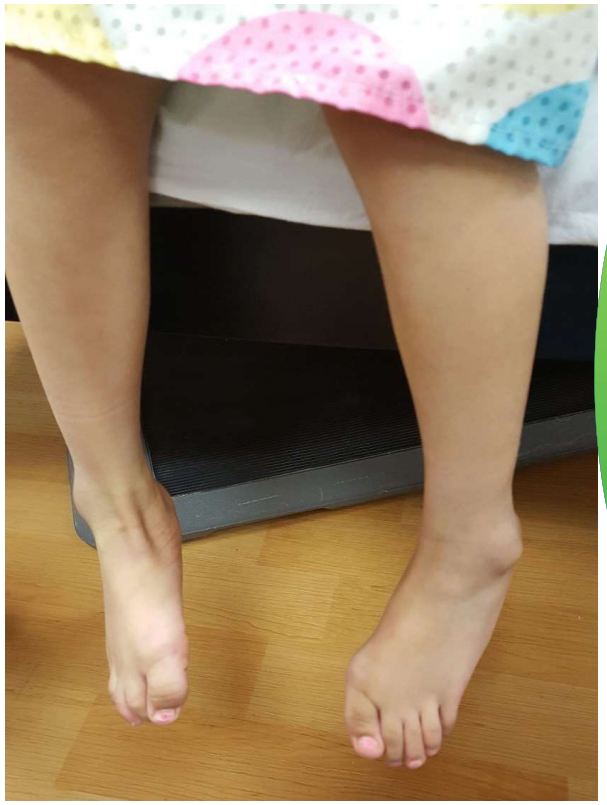


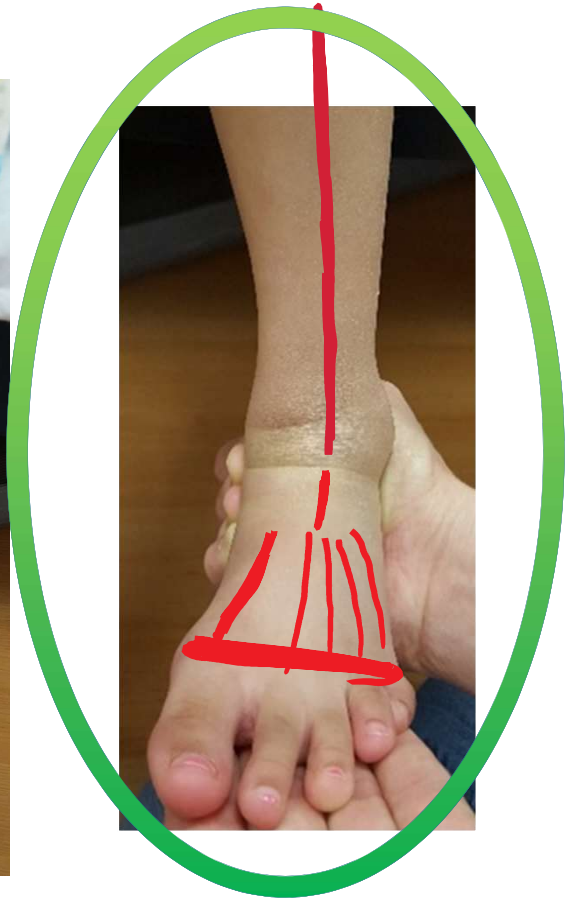
Talocrural Axis Test

- ❒ Structural variants_____
  - ❒ Atypical structure_____
  - ❒ TC Axis test: TC joint alignment_____
  - ❒ Structural findings:

	Coronal Plane	Transverse Plane
Hip/femur		
Knee/tibia		
Hindfoot		
Midfoot		
Forefoot		



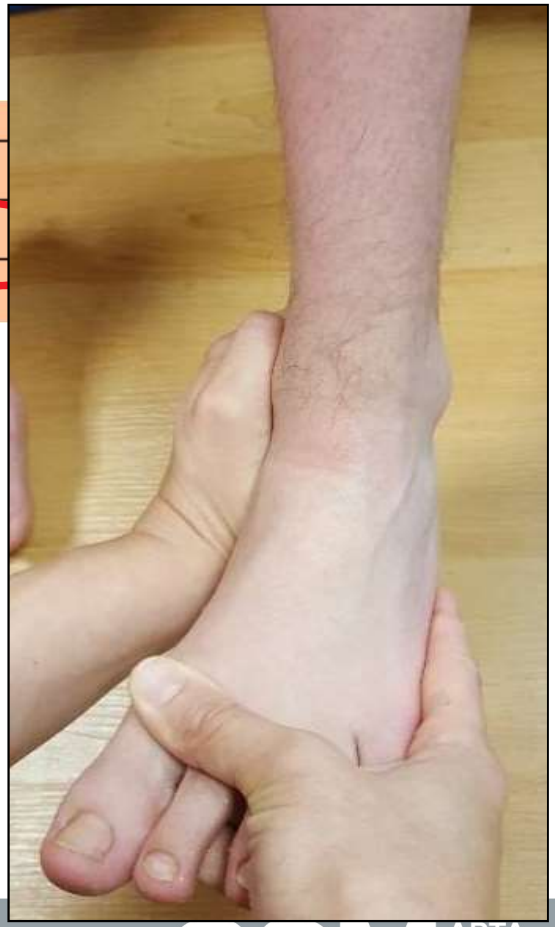




Talocrural Axis Test

- ❒ Structural variants_____
  - ❒ Atypical structure
  - ❒ TC Axis test: TC joint alignment_____
  - ❒ Structural findings:

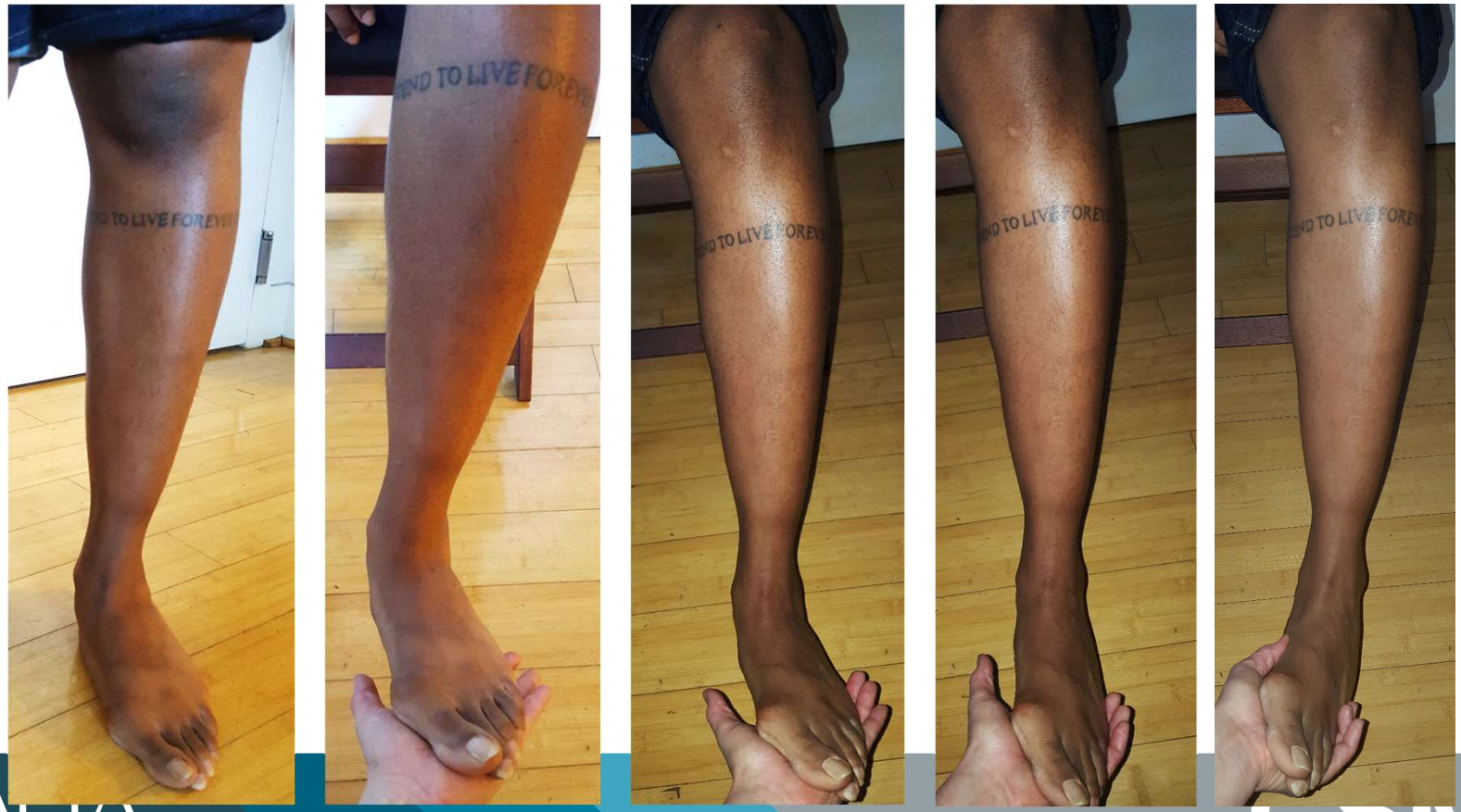
- Identifying the axis of the talo-crural joint
- "Pure" dorsiflexion without accessory joint motion



Talocrural Axis Test

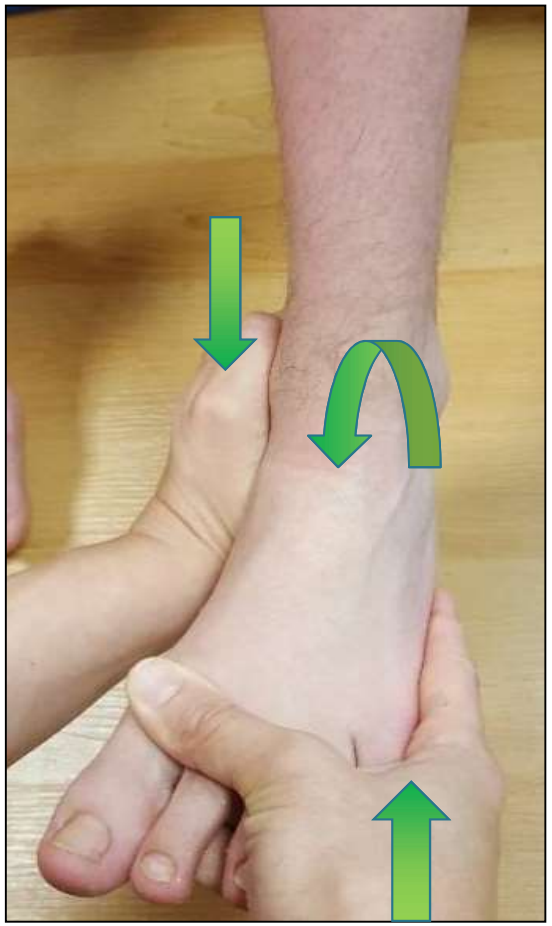
- Midfoot joints are taken into the close-packed position (full supination) to isolate motion at the TC

Talocrural Axis Test



Talocrural Axis Test

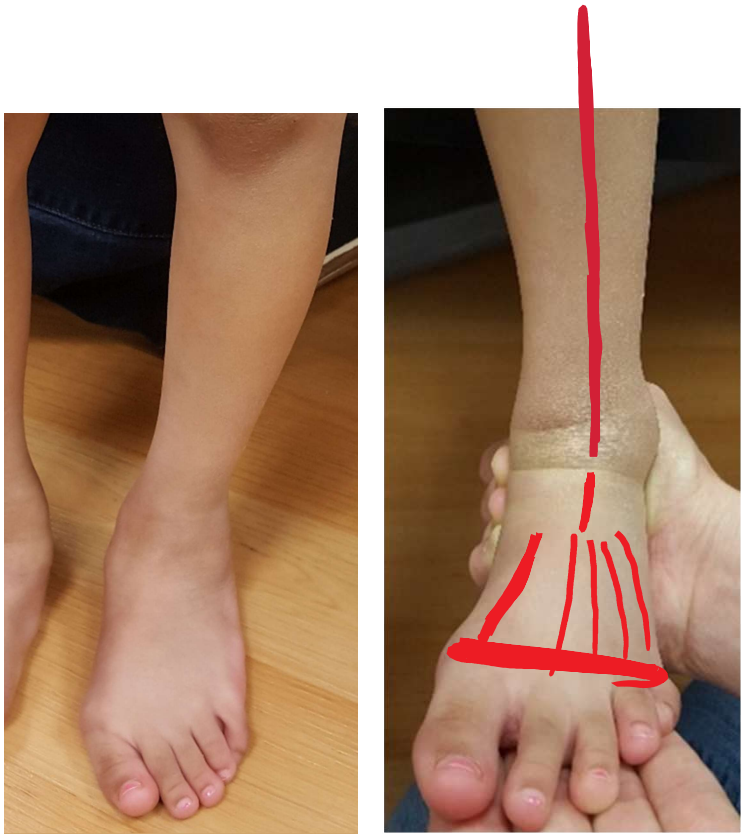
- Location of axis
- Range – DF *and* PF
- Quality of motion
- Limiting structures
- End feel
  - Location
  - Quality



Talocrural Axis Test

Helps to determine

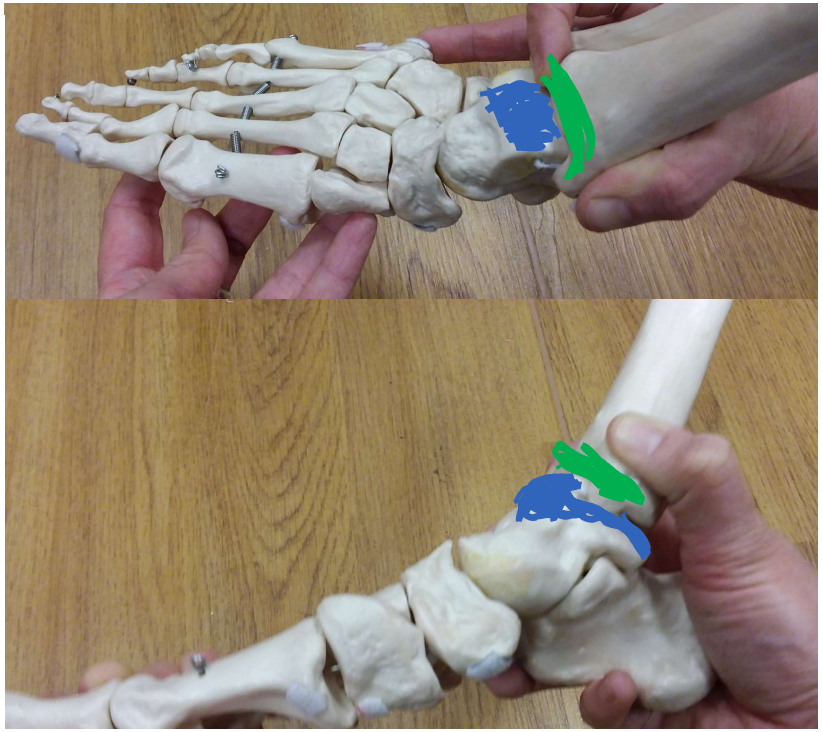
- Location of the axis of talo-crural motion
- Structural versus functional variants



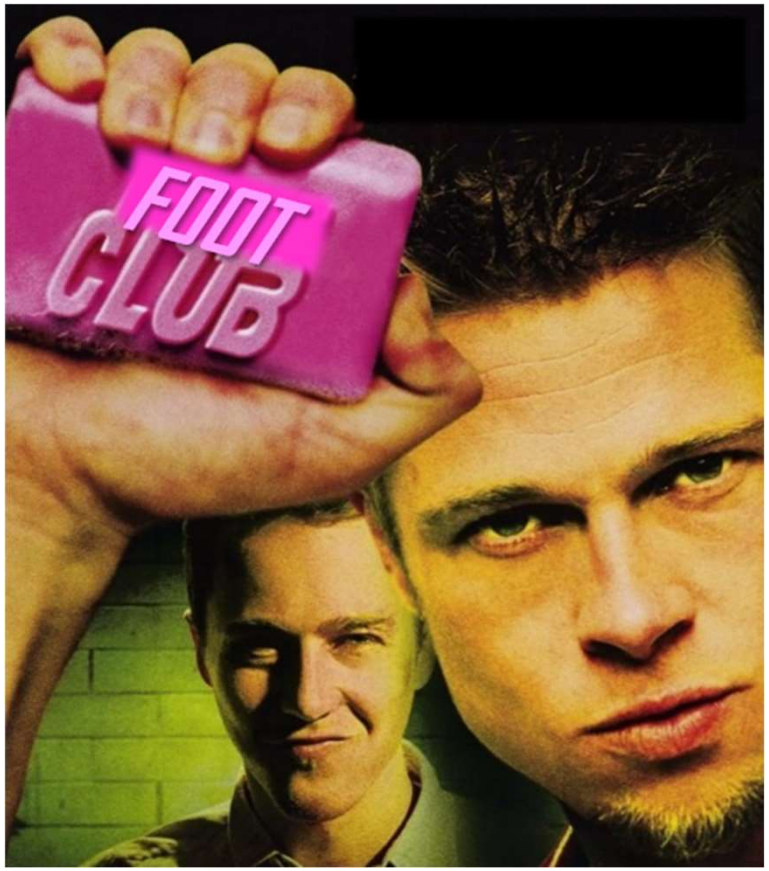
Talocrural Axis Test

Helps to determine

- Quality and quantity of motion specifically of the TC joint without contribution of accessory motion
- Limiting structures for TC DF to guide intervention



I. Introduction
II. Pediatric Ankle Impairments
III. Do We Need to Intervene?
    A. Evidence from adult literature
        1. Limited DF
        2. Excessive Pronation
        3. Weakness
        4. Neuroplastic Changes
    B. Impact on Developing Systems
IV. How Should We Intervene?



Theories of Intervention

The **Roast** and the **Parachute**

Theories of Intervention:

The Parable of the Roast

No White After Labor Day

No Red Wine With Fish

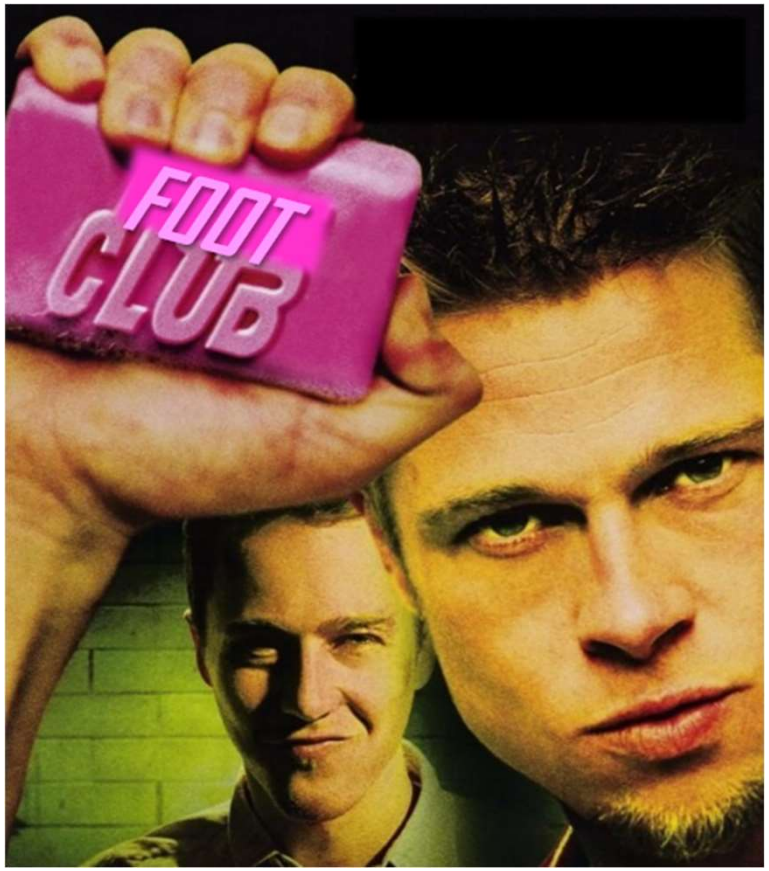
Theories of Intervention:

The Systematic Review of the Parachute

Parachute use to prevent death and major trauma related to gravitational challenge: *systematic review* of randomised controlled trials. (Smith 2003)

- Authors were unable to identify any randomized controlled trials of parachute intervention.
- "The basis for parachute use is purely observational, and its apparent efficacy could potentially be explained by a 'healthy cohort' effect".
- "As with many interventions intended to prevent ill health, the effectiveness of parachutes has not been subjected to rigorous evaluation by using randomised controlled trials. Advocates of evidence based medicine have criticised the adoption of interventions evaluated by using only observational data.

I. Introduction
II. Pediatric Ankle Impairments
III. Do We Need to Intervene?
    A. Evidence from adult literature
        1. Limited DF
        2. Excessive Pronation
        3. Weakness
        4. Neuroplastic Changes
    B. Impact on Developing Systems
IV. How Should We Intervene?



Impacts of Limited DF: Athletes

- The association of dorsiflexion flexibility on knee kinematics and kinetics during a drop vertical jump in healthy female athletes. (Malloy 2015)
- Predictors of frontal plane knee excursion during a drop land in young female soccer players. (Sigward 2008)

Impacts of Limited DF: Neurotypical adults with chronic ankle stability:

- Ankle dorsiflexion range of motion influences dynamic balance in individuals with chronic ankle instability. (Basnett 2013)

Impacts of Limited DF: Neurotypical controls

- The effect of reduced ankle dorsiflexion on lower extremity mechanics during landing: A systematic review. (Mason-Mackay 2017)
- Ankle DF range of motion and landing biomechanics. (Fong 2011)
- Effects of ankle dorsiflexion limitation on lower limb kinematic patterns during a forward step-down test: A reliability and comparative study. (Lebleu 2018)
- Effect of limiting ankle-dorsiflexion range of motion on lower extremity kinematics and muscle-activation patterns during a squat. (Macrum 2012)

Impact of Limited DF Range

Asymptomatic controls & athletes:

- Increased vertical ground reaction force
- Decreased shock absorption

Impact of Limited DF Range

Asymptomatic controls & athletes:

- Increased coronal and transverse plane displacement
  - Greater peak **knee abduction** angles
  - Greater peak **knee abduction** moments
  - Increased **medial rotation of hip**
  - Increased **adduction of hip**

Impact of Limited DF Range

Asymptomatic controls & athletes:

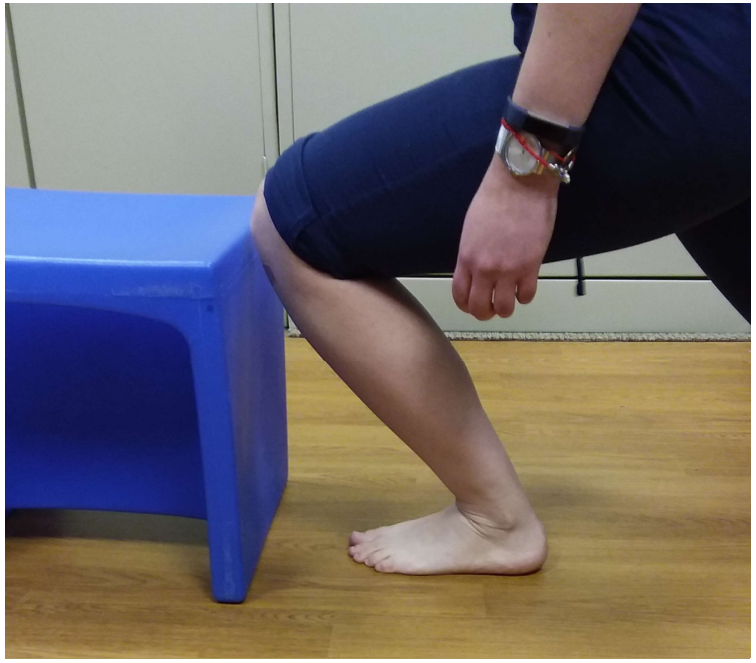
- Increased coronal and transverse plane displacement
  - Greater peak **knee abduction** angles
  - Greater peak **knee abduction** moments
  - Increased **medial rotation of hip**
  - Increased **adduction of hip**

Impact of Limited DF Range

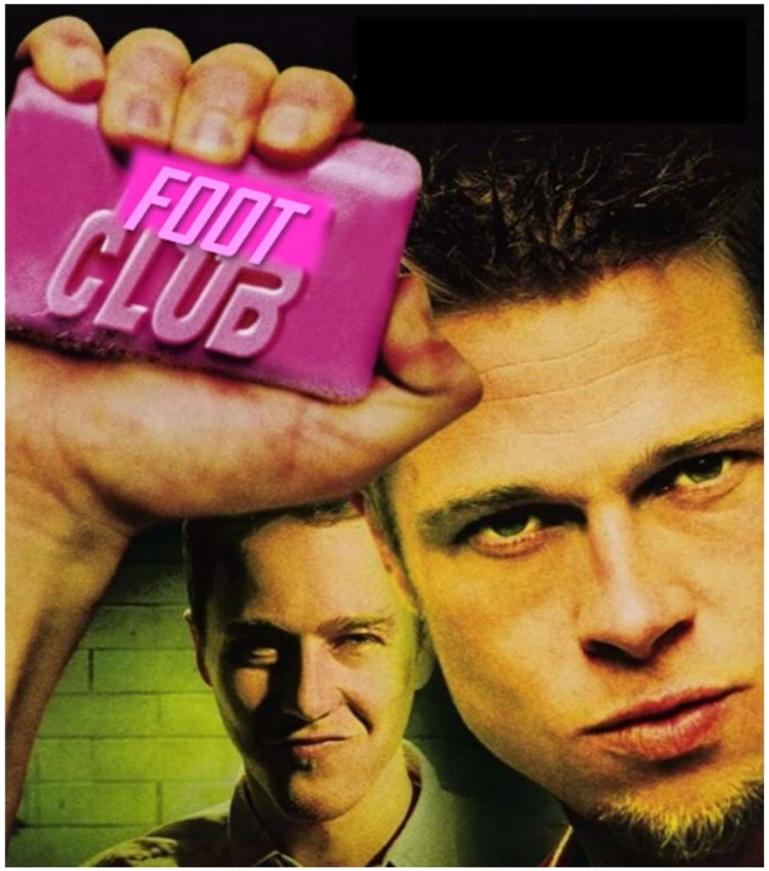
Neurotypical adults with chronic ankle stability:

- Decreased performance on *balance* testing

- What indicates “limited” DF?



I. Introduction
II. Pediatric Ankle Impairments
III. Do we need to intervene?
    A. Evidence from adult literature
        1. Limited DF
        2. Excessive Pronation
        3. Weakness
        4. Neuroplastic Changes
    B. Impact on Developing Systems
IV. How Should We Intervene?



Impact of Excessive Pronation in Asymptomatic controls, runners

- The relationship between foot posture and lower limb kinematics during walking: A systematic review (Buldt 2014)
- Increased unilateral foot pronation affects lower limbs and pelvic biomechanics during walking. (Resende 2015)
- Risk factors associated with medial tibial stress syndrome in runners: a systematic review and meta-analysis.(Newman 2013)

Impact of Excessive Pronation:

Asymptomatic controls, runners:

- Increased medial tibial rotation
- Increased ipsilateral pelvic drop
- Increased medial stress

Impact of Excessive Pronation:

Asymptomatic controls, runners:

- Increased tibial medial rotation
- Increased ipsilateral pelvic drop
- Increased medial stress

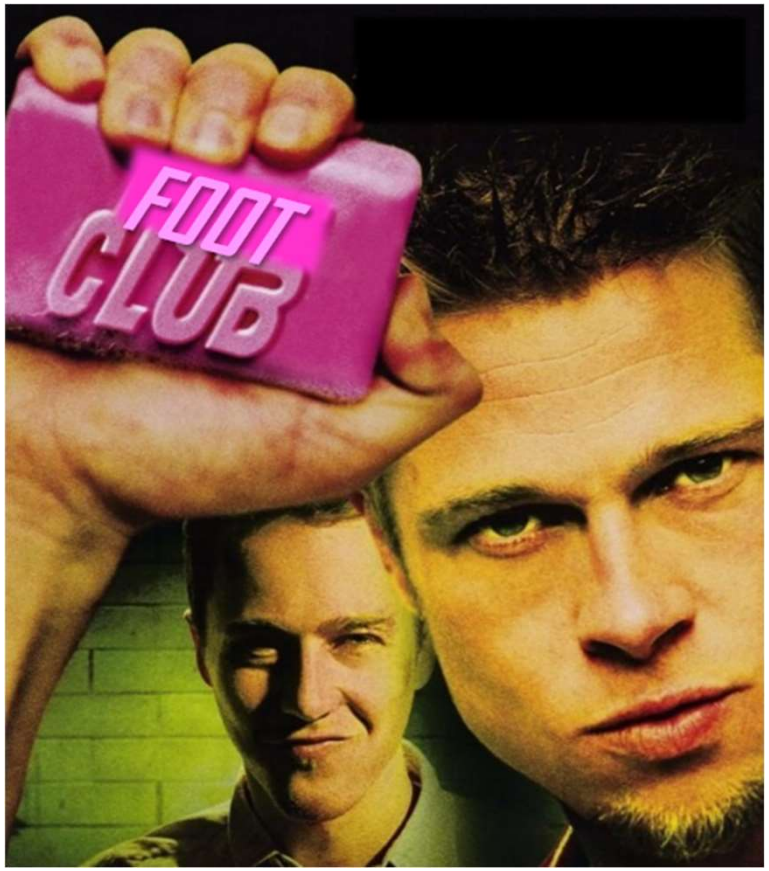
Impact of Excessive Pronation:

Elite baseball players

- Increased shoulder involvement (surgery)

The association of foot arch posture and prior history of shoulder or elbow surgery in elite-level baseball pitchers. (Feigenbaum 2013)

I. Introduction
II. Pediatric Ankle Impairments
III. Do We Need to Intervene?
    A. Evidence from adult literature
        1. Limited DF
        2. Excessive Pronation
        3. Weakness
        4. Neuroplastic Changes
    B. Impact on Developing Systems
IV. How Should We Intervene?



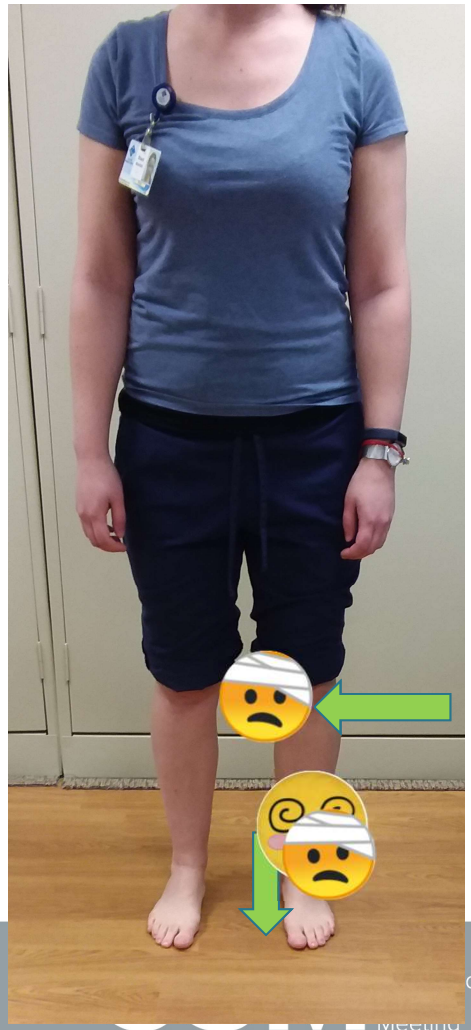
Impact of Impaired Strength in Neurotypical Adults:

- Lower extremity muscle strength after anterior cruciate ligament injury and reconstruction. (Thomas 2013)
- Muscle strength and flexibility characteristics of people displaying excessive medial knee displacement. (Bell 2008)
- Eccentric plantar-flexor torque deficits in participants with functional ankle instability. (Fox 2008)
- Fatigue of the plantar intrinsic foot muscles increases navicular drop. (Headlee 2008)

Impact of Insufficient Plantar Flexor Strength:

Neurotypical adults :

- Increased medial knee displacement
- Functional ankle instability
- Increased medial arch loading
- Increased incidence of ankle and knee injury



Impact of Insufficient Plantar Flexor Strength:

Neurotypical adults :

- Increased medial knee displacement
- Functional ankle instability
- Increased medial arch loading
- Increased incidence of ankle and knee injury

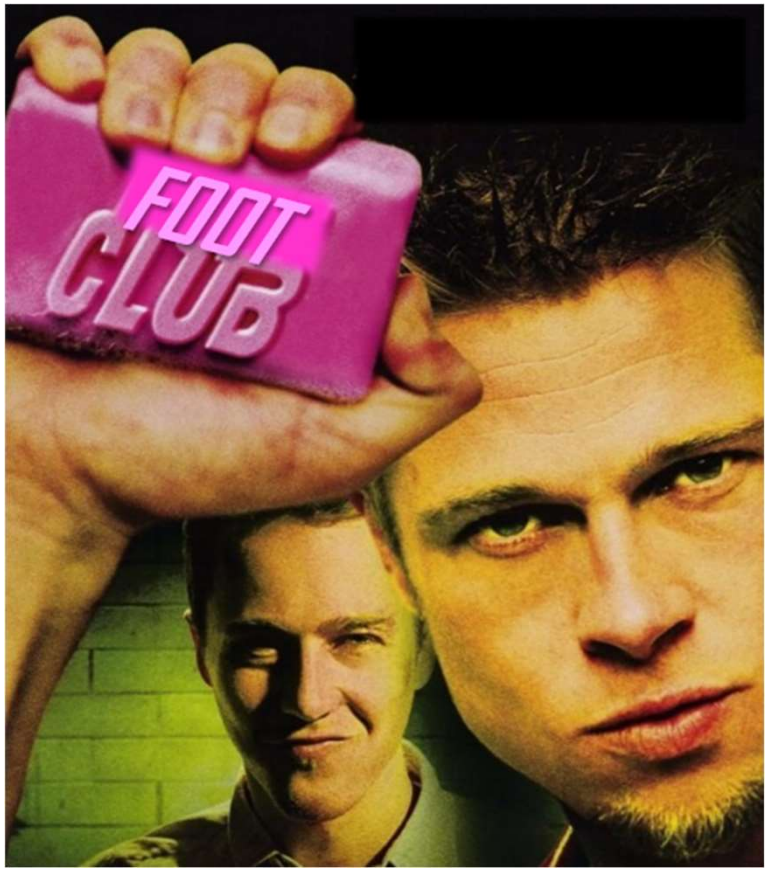
Impact of Fatigue of Intrinsic Foot Muscles (Foot Core!):

Neurotypical controls :

- Navicular drop

.

I. Introduction
II. Pediatric Ankle Impairments
III. Do We Need to Intervene?
    A. Evidence from adult literature
        1. Limited DF
        2. Excessive Pronation
        3. Weakness
        4. Neuroplastic Changes
    B. Impact on Developing Systems
IV. How Should We Intervene?



Cortical-Body Matrix (Body Map)

The cortex's multisensory representation of the body and peripersonal space.

(Moseley 2012, Melzack 2005)

Cortical-Body Matrix

- develops in a predictable manner, but development and continued function is **based on experience**
- is highly plastic based on experience, even after development is complete

Cortical mapping changes have been observed in:

- CRPS
- UE pain
- Stroke/CVA
- ACL injury
- Back pain
- Pregnancy
- Aging
- Obesity
- Surgery
- Immobilization
- Frozen shoulder
- Arthritis
- Dystonia

Flor 2000, Maihöfner 2003, Moseley 2008, Stenekes 2009, Moseley 2012, *Toussaint 2013, Meugnot 2014, Louw 2015, Beales 2016, Falling 2016*

Neuroplastic Changes

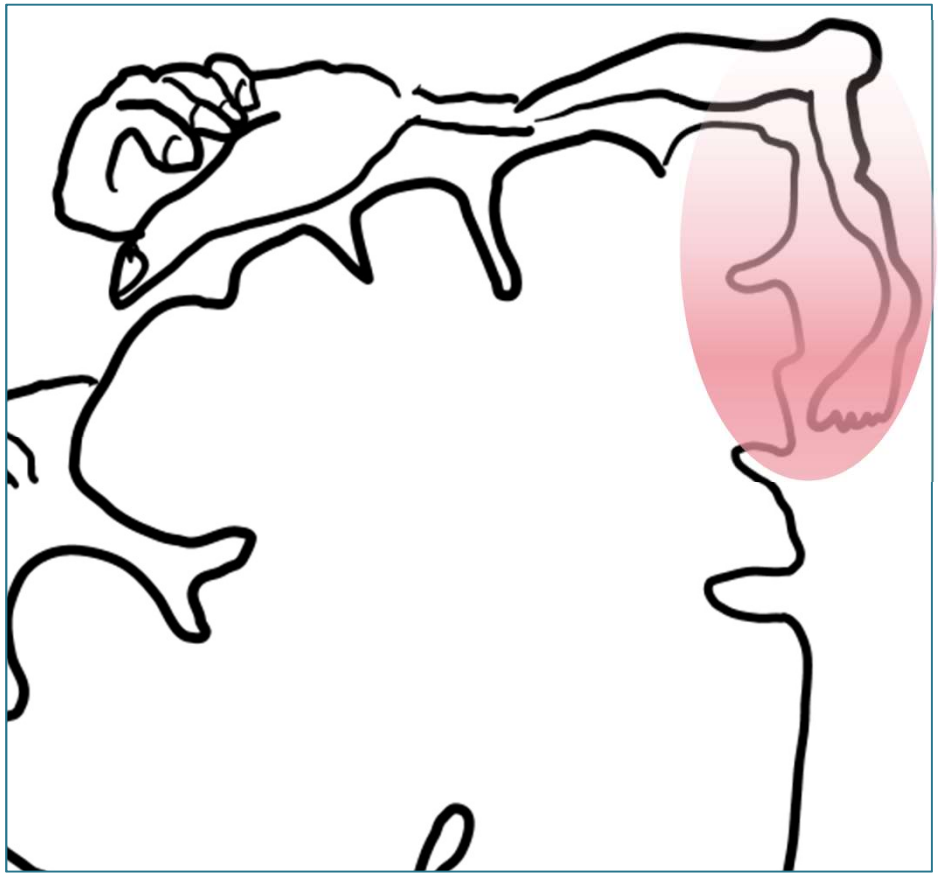
Neglect and Smudging

- Dampened perception of afferent information
- Decreased awareness of area
- Decreased ability to differentiate afferent information from area

Neuroplastic Changes

Hyperperception

- Amplified perception of afferent information
- Hypervigilance of area
- Decreased ability to differentiate types of afferent information



Neuroplastic Changes

Changes Impact:

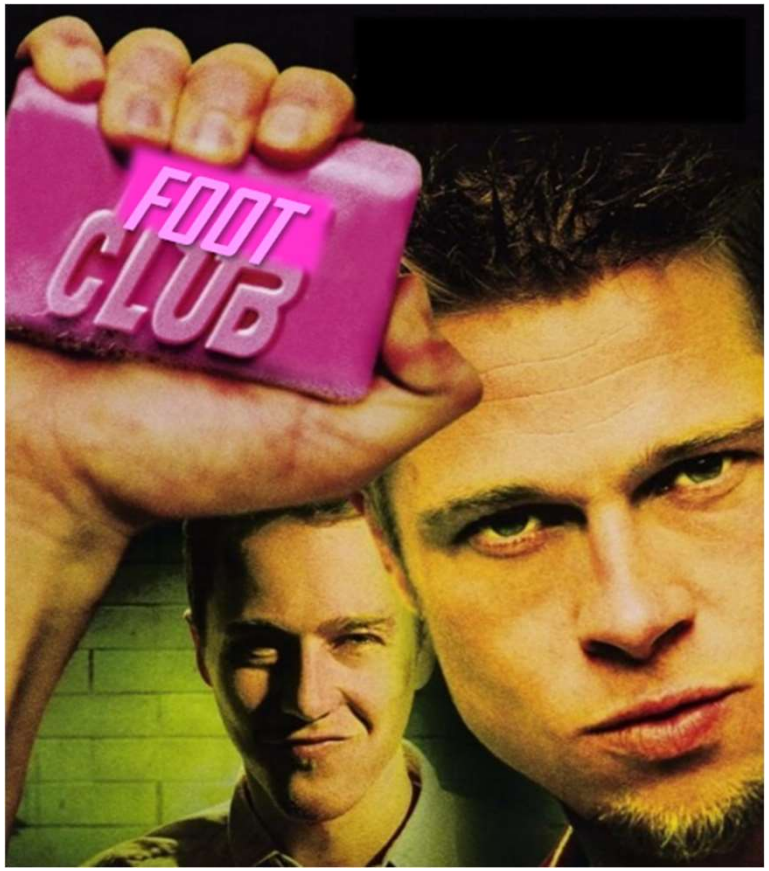
- Sensory accuracy
- Motor control
- Perception of pain
- Readiness for motor learning

Functional Impact of Neuroplastic Changes:

In neurotypical systems:

- Altered somatosensory input and processing
- Altered proprioception
- Altered motor response
- Altered postural control
- Altered neuromotor control

I. Introduction
II. Pediatric Ankle Impairments
III. Do We Need to Intervene?
    A. Evidence from adult literature
        1. Limited DF
        2. Excessive Pronation
        3. Weakness
        4. Neuroplastic Changes
    B. Impact on Developing Systems
IV. How Should We Intervene?



Do we need to intervene?

B. Impact on Developing Systems

- Do children with pediatric health conditions have special protections against the forces that impact adult movement systems?

Do we need to intervene?

B. Impact on Developing Systems

Kinesiopathological Model

- Repeated movements and sustained alignments influence structure and function

Developmental Kinesiopathological Model

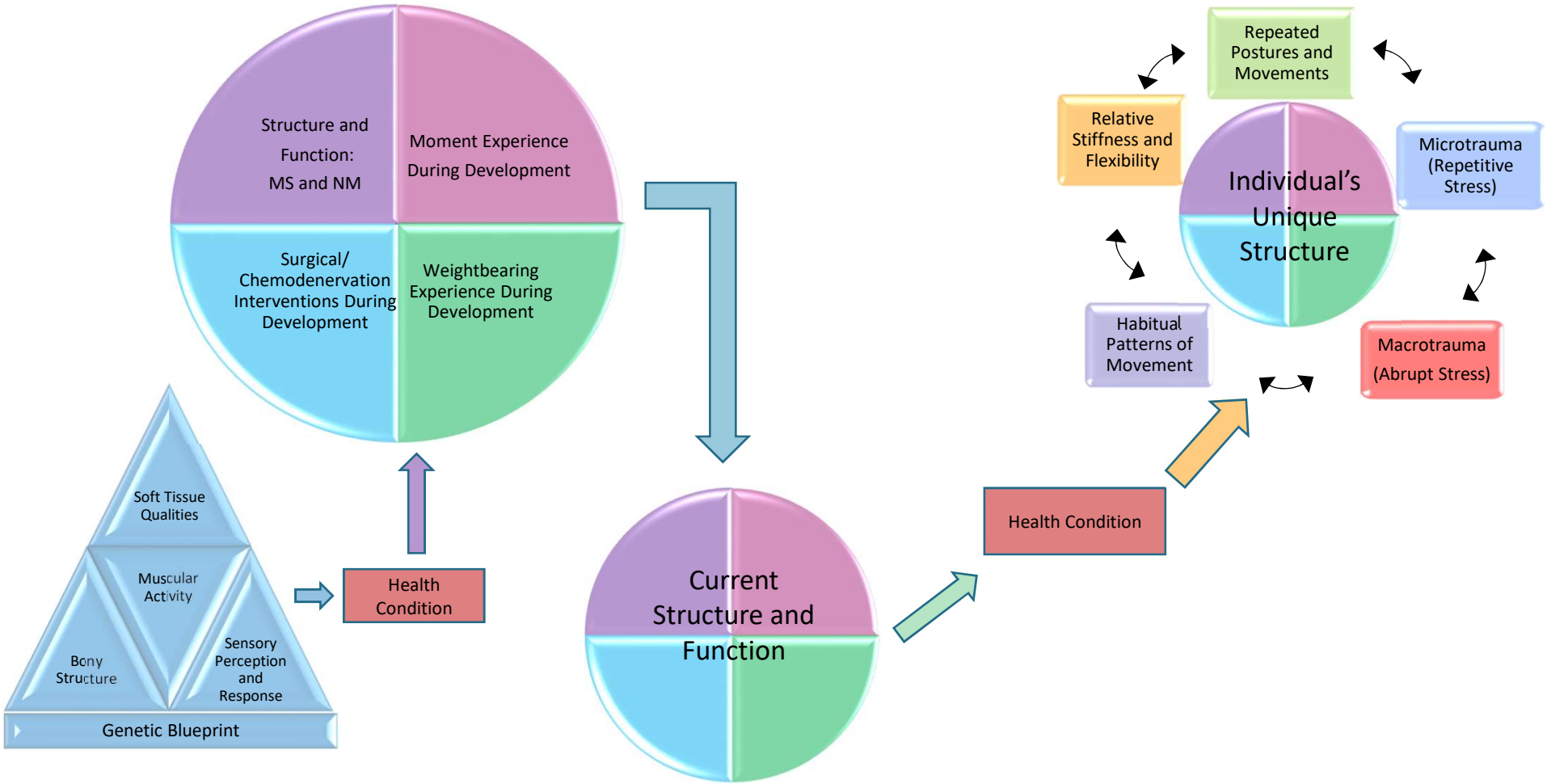
- Repeated movements and sustained alignments during development will influence structural and functional outcomes

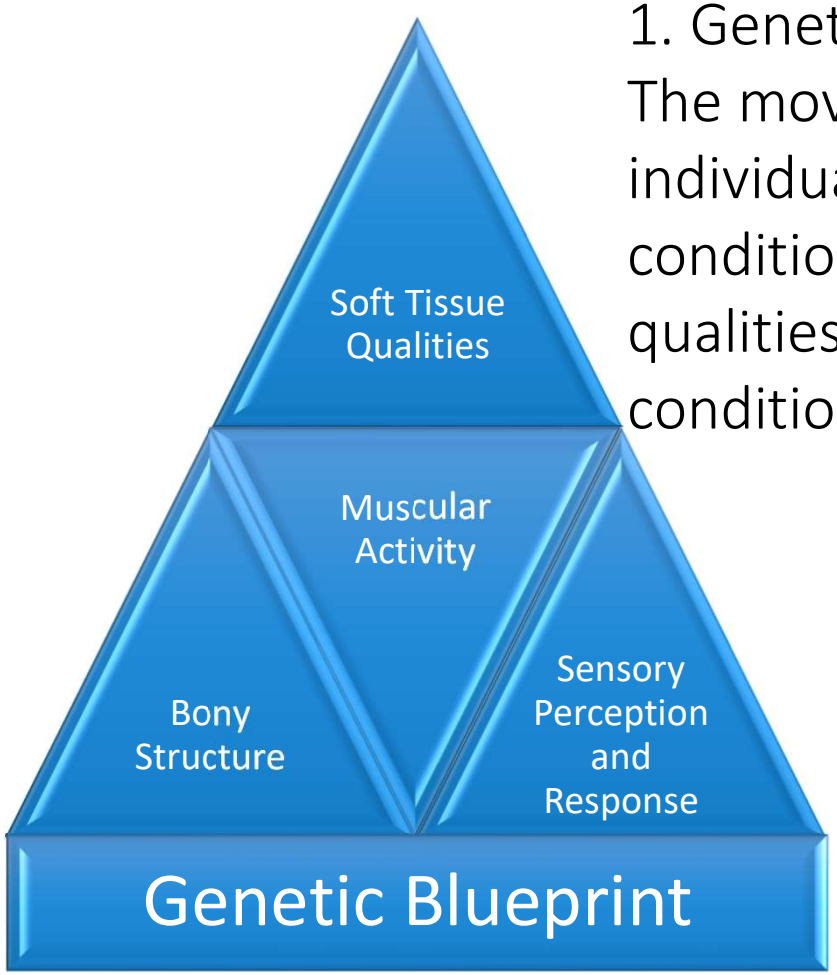
Developmental Kinesiopathologal Model

New Paradigm:

- Function of the movement system is multifactorial and depends not just the health condition, but influence of multiple internal and external factors.
- The structure and function of the mature movement system will be impacted by movement experiences during development.

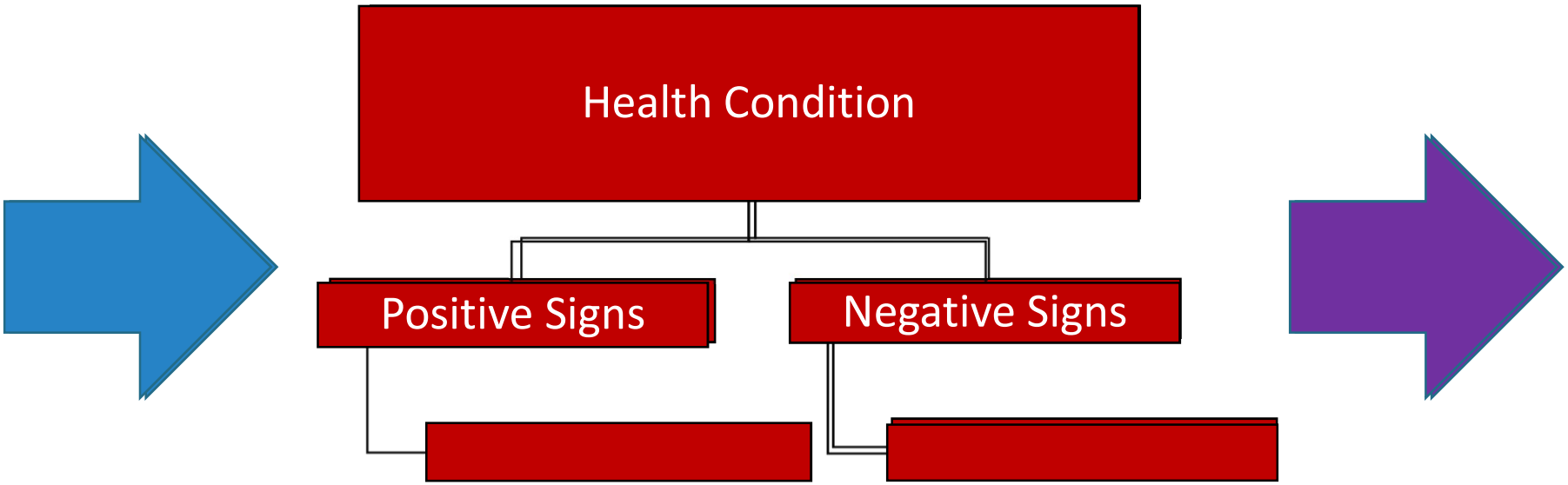
Developmental Kinesiopathological Model (DKM)

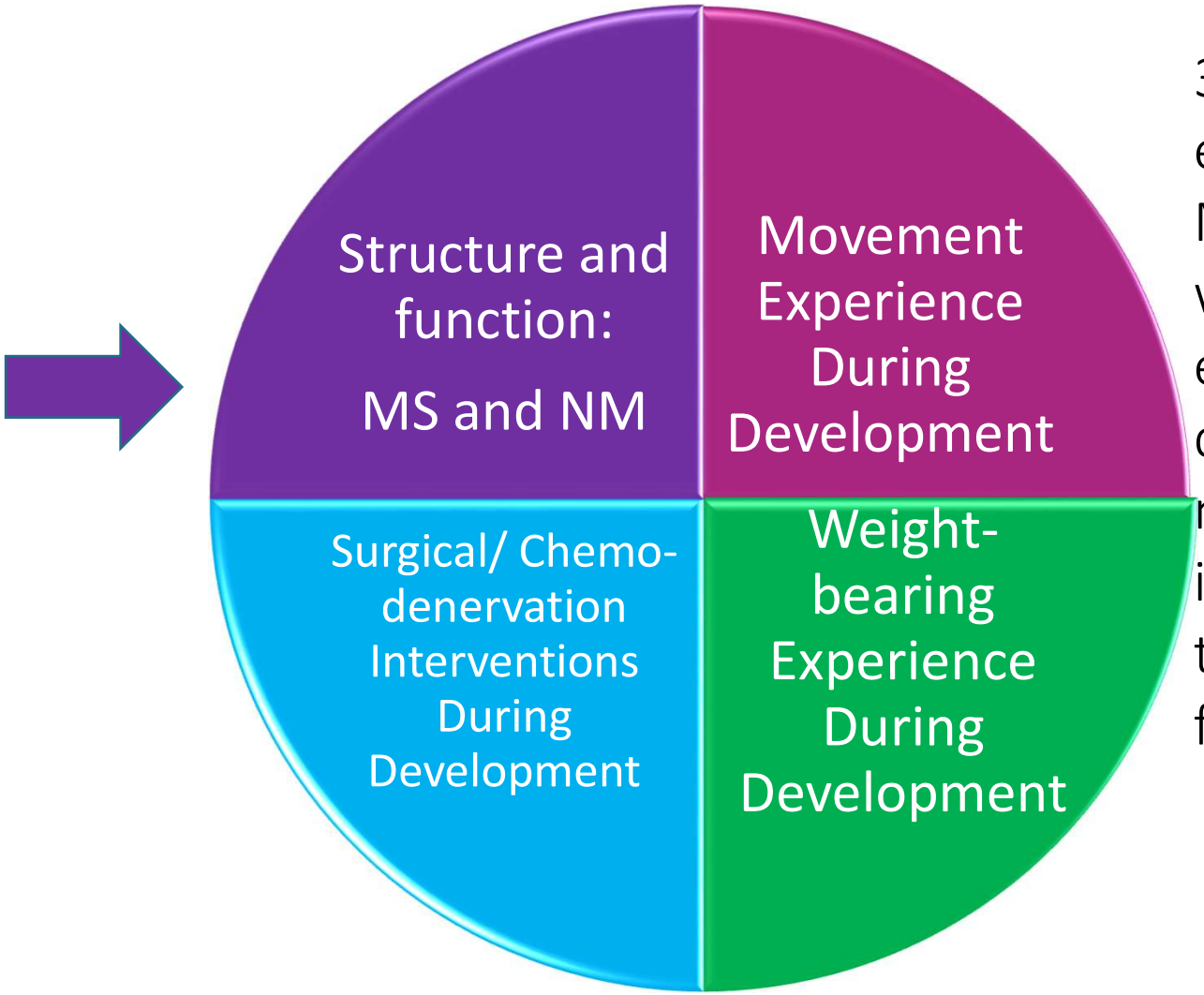




1. Genetic heterogeneity:
The movement system of each individual with a pediatric health condition also has a unique set of qualities, unrelated to the health condition.

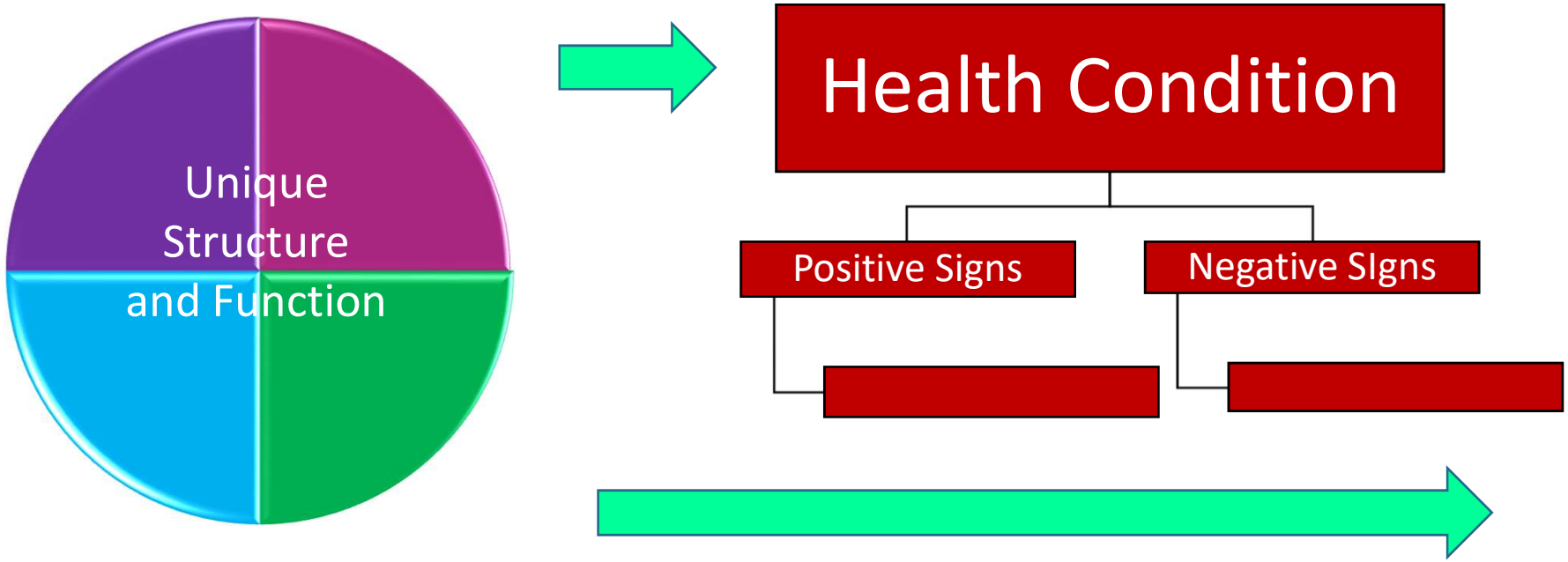
2. Heterogeneity of health conditions:
Health conditions are not homogeneous in their impact on individuals.



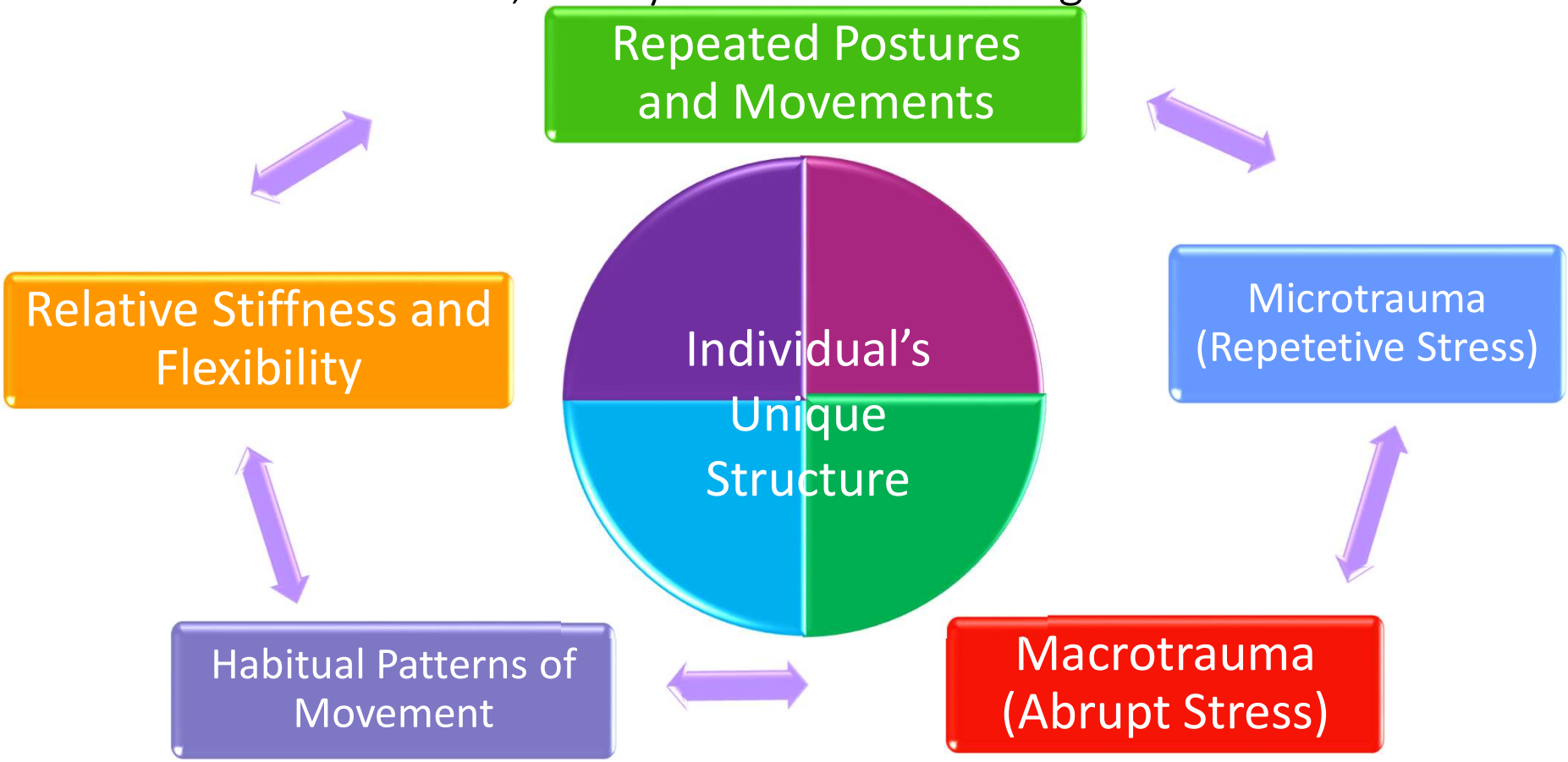


3. Heterogeneity of experience: Movement and weightbearing experiences during development of the movement system impact short- and long-term structure and function.

4. Continued influence of health conditions:
Some health conditions continue to contribute primary negative or positive signs during development.



The movement system, with unique qualities from development in the context of these forces, at any time is functioning in the context of:



Developmental Kinesiopathologal Model

If movement and weightbearing experiences during development of the movement system impact long-term structure and function

then

we will influence long-term kinesiopathology with interventions during development.

Developmental Kinesiopathologal Model

Musculoskeletal Development

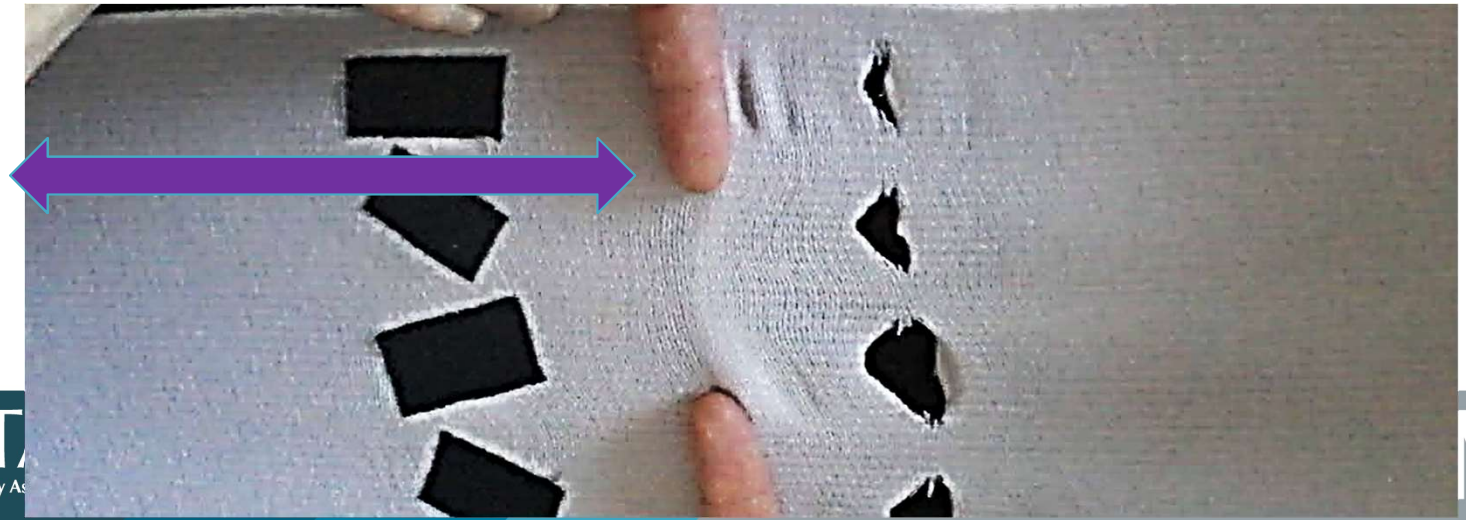
By guiding forces during repetitive movement and sustained alignments, we can:

- provide stress and strain that encourage tissues to form in a manner compatible with healthy movement patterns.
- reduce the system's tendency to experience microtrauma and macrotrauma in the future.

Musculoskeletal Development

For a system that is experiencing atypical stresses during development:

- Goal of interventions might be to **normalize the stresses on the movement system to maximize MS development in the context of a health condition.**



Developmental Kinesiopathologal Model

Neuromotor Development

- Neuroplasticity is greatest before specialization.
- There are critical windows for developing motor patterns.
- Mass practice is required for motor skill development.
- The body becomes efficient in the patterns it performs in mass practice.
- It can be difficult to access new patterns once regular patterns are established.

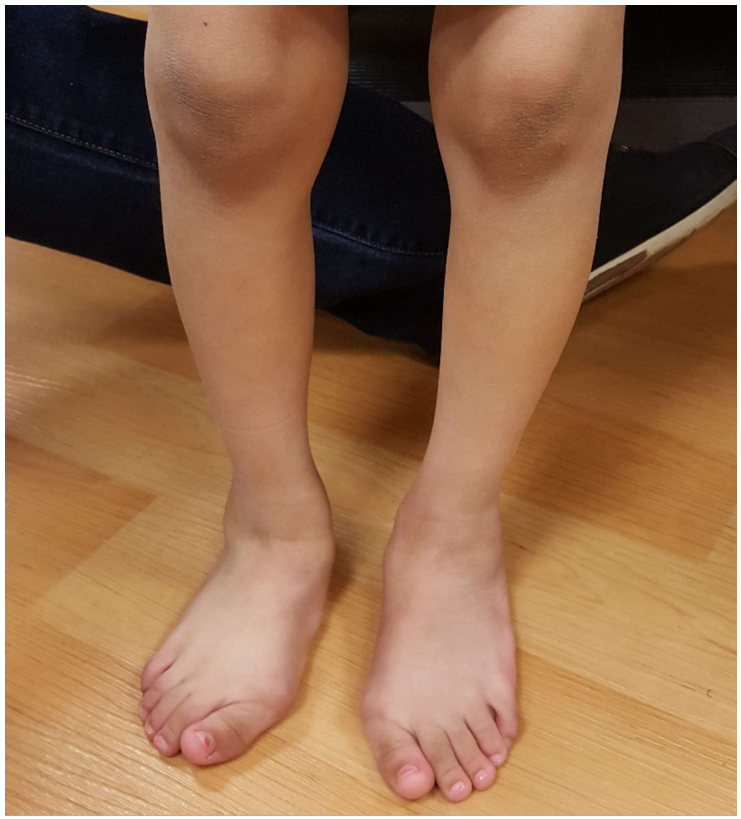
Developmental Kinesiopathologal Model

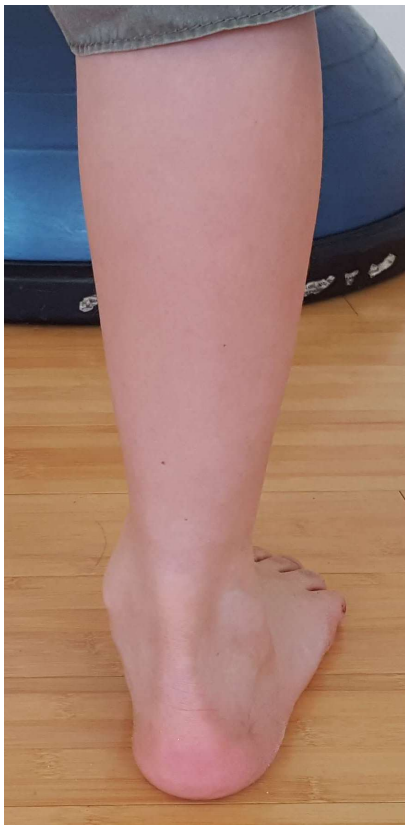
Sensory-Perceptual Development

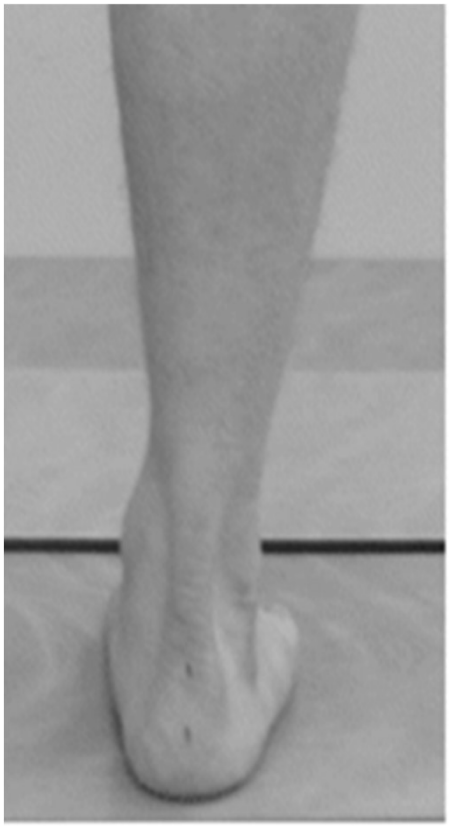
Foot core: neural subsystem

- Loss of alignment of the foot during development impacts the *development of the perception of this information*
- Biasing the foot intrinsics to develop with typical alignment allows for this information to be available

How are the foot intrinsics in each of these feet able to provide information for the development of the cortical matrix for balance?





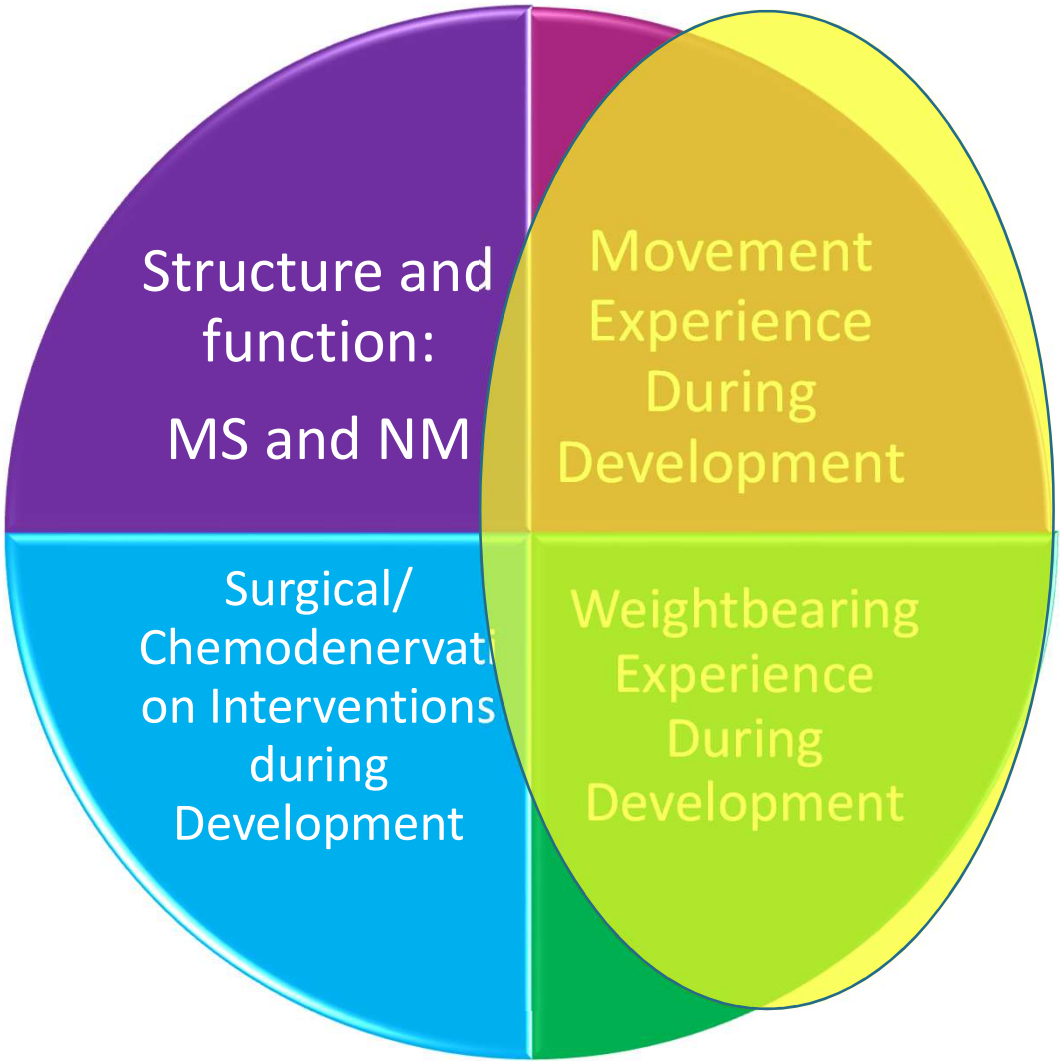


Developmentally Therapeutic Gait

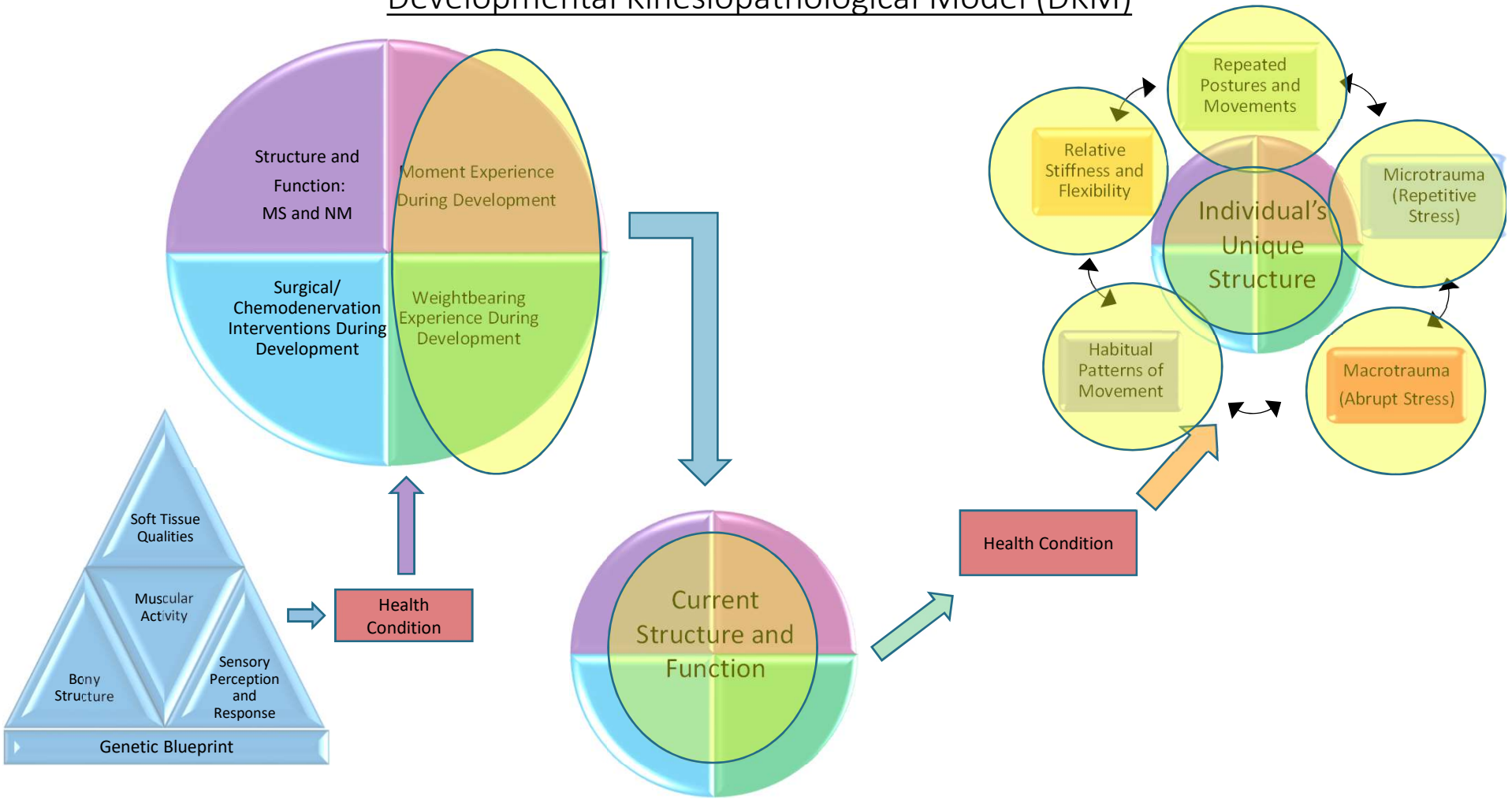
Developmental Kinesiopathologal Model

Developmentally Therapeutic Gait

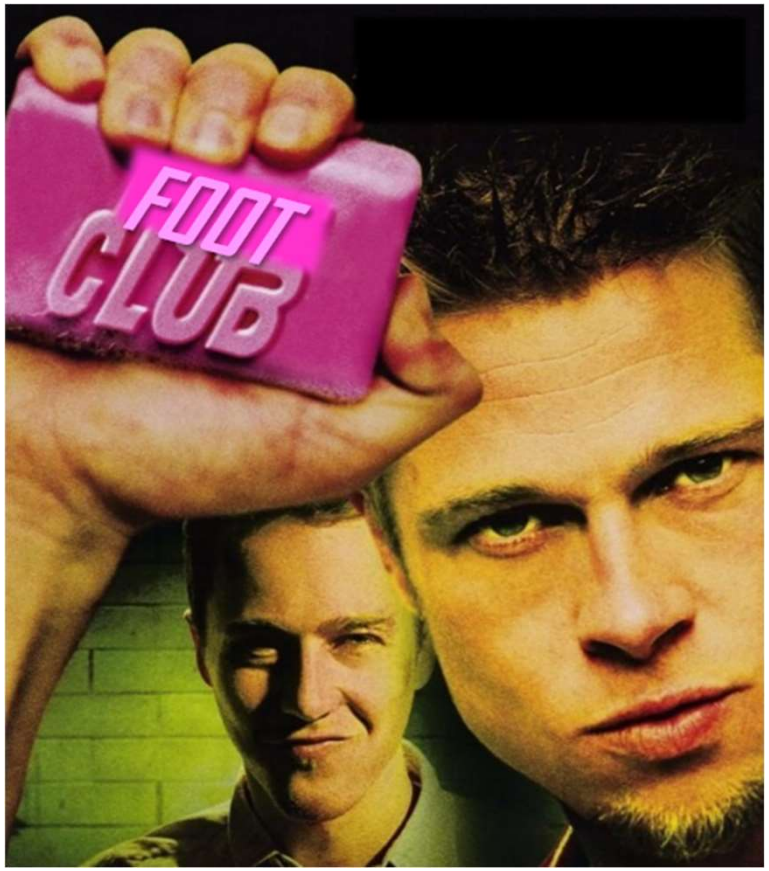
- Right things happening at the right places at the right times
- Preventing damage
- Providing the conditions for best possible structural development


Structure and function:
MS and NM
Movement Experience During Development
Surgical/ Chemodenervation Interventions during Development
Weightbearing Experience During Development

Developmental Kinesiopathological Model (DKM)



I. Introduction
II. Pediatric Ankle Impairments
III. Do We Need To Intervene?
IV. How Should We Intervene?
    A. #Goals
    B. Motion
    C. Functional Strength
    D. Neuroplasticity
    E. Education
    F. External Supports



A. Goals

What is the goal of intervention?

Goals of Intervention:

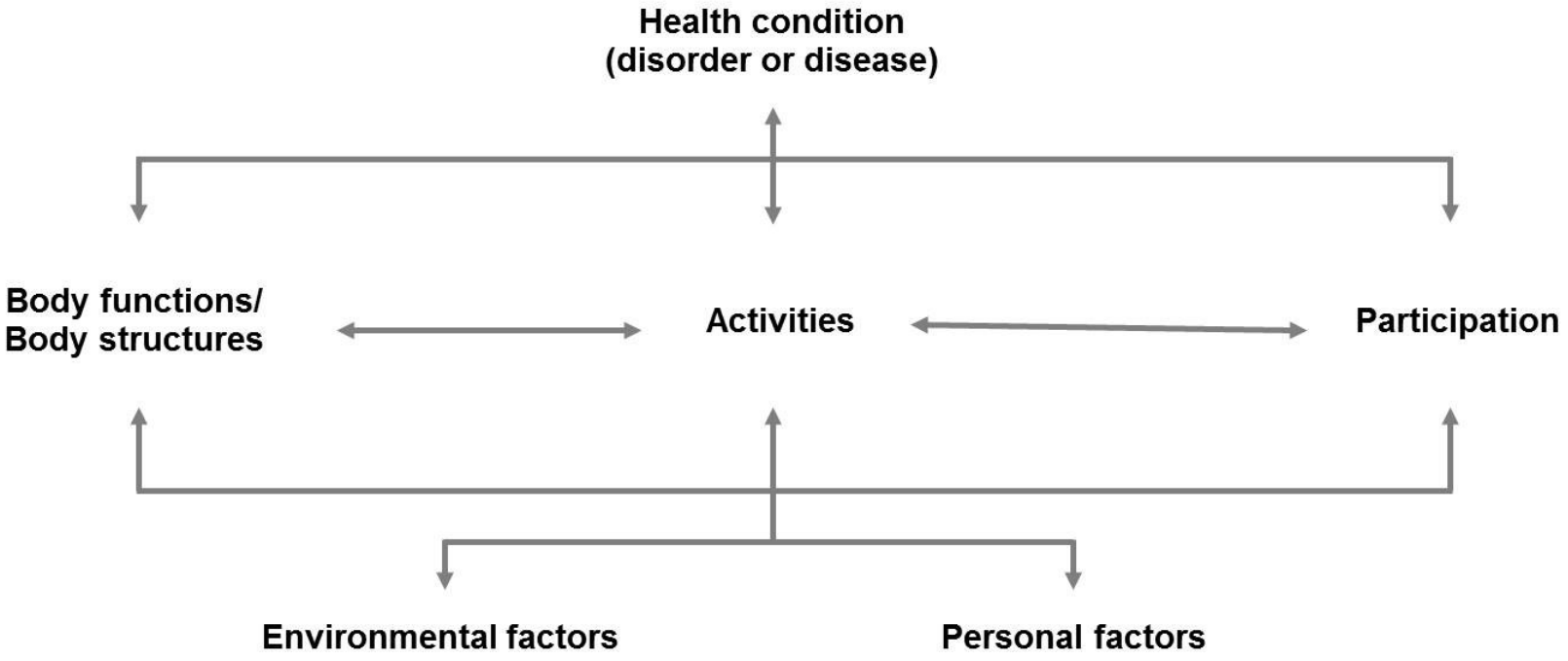
PT's goal:

Patient's goal:

Family's goal:

Other team member's goals:

Goals: Organizing with the ICF Model



Goals

Body Structure and Function

- Lessen the impact of cumulative micro-trauma due to sustained alignments or repeated movements
- Externally support hypermobile structures in the movement system which have become the path of least resistance for ground reaction forces
- Direct forces toward target structures to increase their relative flexibility

Goals

Body Structure and Function

- Restrict or resist motions in planes not compatible for healthy biomechanics
- Influence neuromuscular activation patterns during gait and other weightbearing activities

Goals

Activities

- Improve
  - Function
  - Efficiency
  - Safety

Goals

Environment

- Increase *direct access* to goal environments and structures

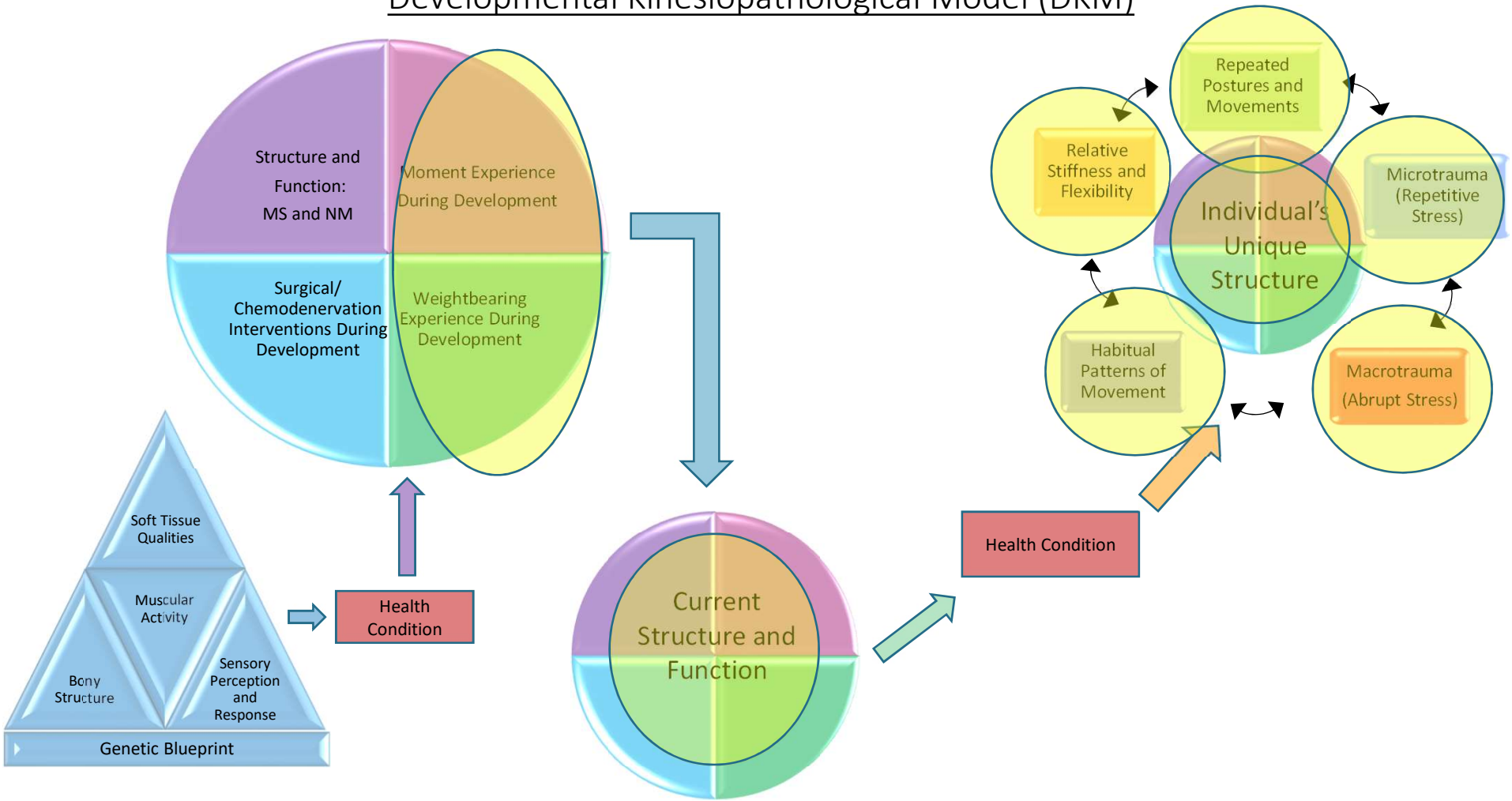
Goals

Participation & Personal Factors

- Social acceptance
- Self acceptance

- Fit in
- Stand out
- Appear neurotypical
- Celebrate differences
- Be cool

Developmental Kinesiopathological Model (DKM)



Goals

Developmental Kinesiopathological Model

For the patient as an **adult**:

- Minimize negative sequelae of developing in the context of a pediatric health condition
- Minimize **pain**
- Maximize **structural resilience** of the movement system
- Maximize neuromotor function and **access to varied movement** options

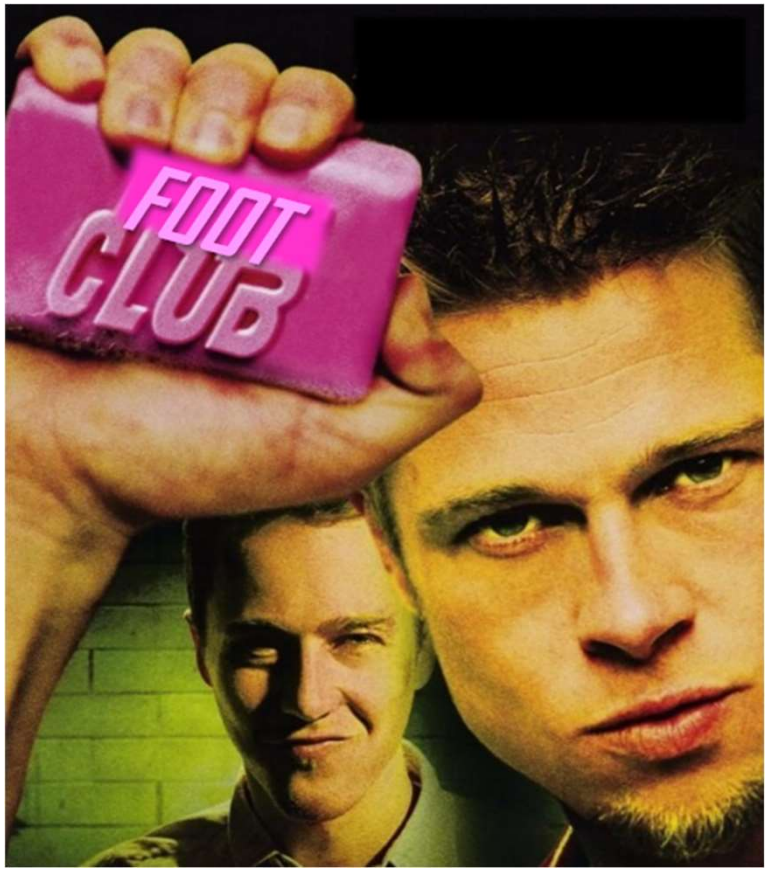
Goals

Developmental Kinesiopathological Model

For the patient as an adult:

- Maximize the **environments and activities** the patient can access with their movement system
- Maximize **acceptance** of individual differences
- Maximize the ability to **self-advocate** and access appropriate resources
- Maximize work and social **engagement** as an adult

I. Introduction
II. Pediatric Ankle Impairments
III. Do We Need To Intervene?
IV. How Should We Intervene?
    A. #Goals
    B. Motion
    C. Functional Strength
    D. Neuroplasticity
    E. Education
    F. External Supports



Interventions

Limited Range of Motion

Manual therapy of ankle joints and soft tissues has been shown to improve:

- DF range
- Balance
- Functional goals

Stanek 2018, An 2017, Marrón-Gómez 2015, Zicenzino 2006, Chevutschi 2015, Grieve 2013, Capobianco 2018, Capobianco 2019, Yoon 2014, Weerasekara 2018, Silveira 2016, Lee 2017, Kang 2015, Johanson 2014, Kim 2018, Kwon 2015

Interventions

Limited Range of Motion

Manual Therapy

- Used to address:
  - Hypomobilities/excessive stiffness
  - Maladaptive intra- and inter-joint relative stiffness/ flexibility

Interventions

Limited Range of Motion

Populations

- Acute and chronic ankle instability in orthopedic/neurotypical population
- Athletes
- Adult stroke

Interventions

Limited Range of Motion

- ……..Pediatric health conditions?

Passive muscle properties are altered in children with cerebral palsy before the age of 3 years and are difficult to distinguish clinically from spasticity. (Willerslev-Olsen 2013)

- Change in passive muscle properties was present in the majority of subjects.

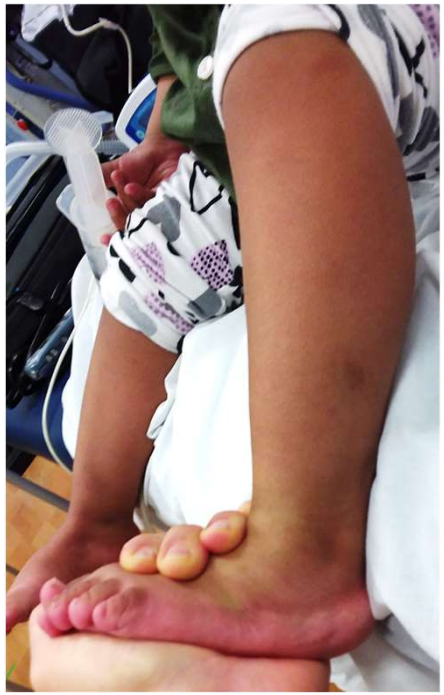
Interventions

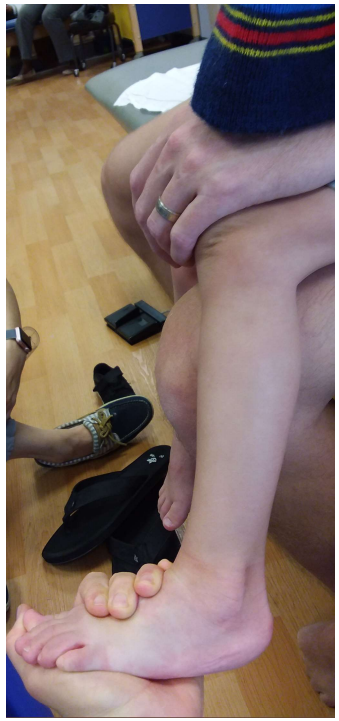
Manual Therapy: Posterior Talar Glide

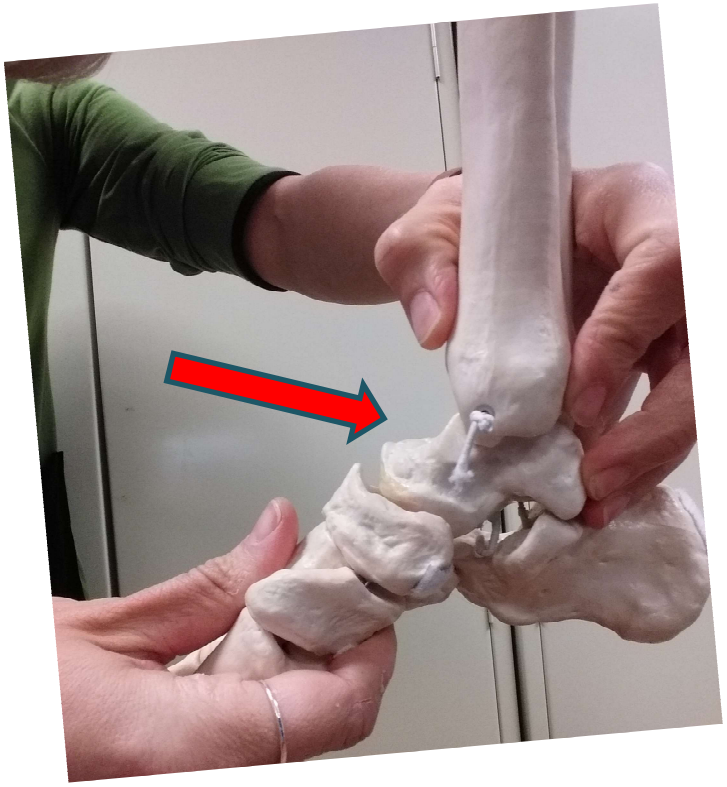
Interventions

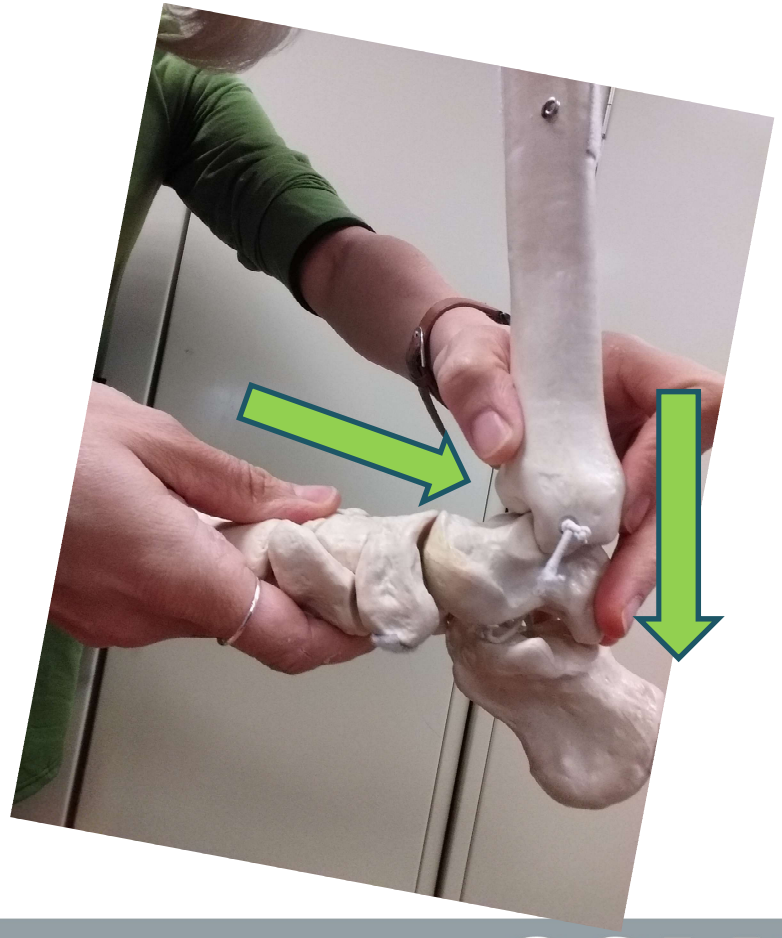
Manual Therapy: Posterior Talar Glide

With inferior glide of calcaneous/talar complex





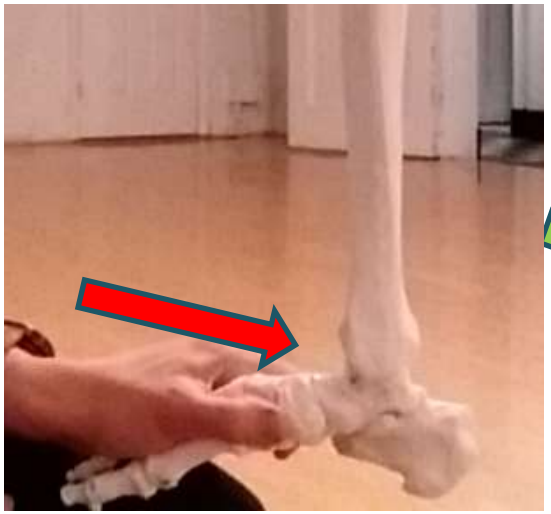


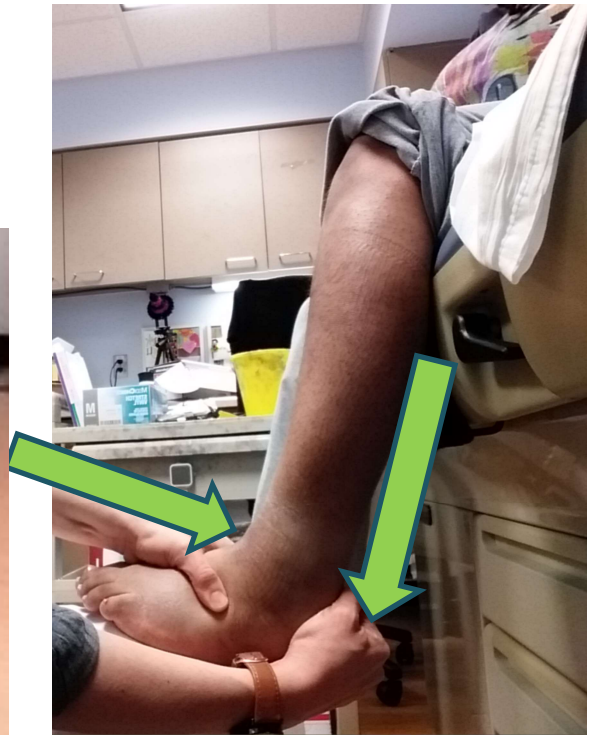


Interventions

Manual Therapy: Posterior Talar Glide

With inferior glide of calcaneous/talar complex



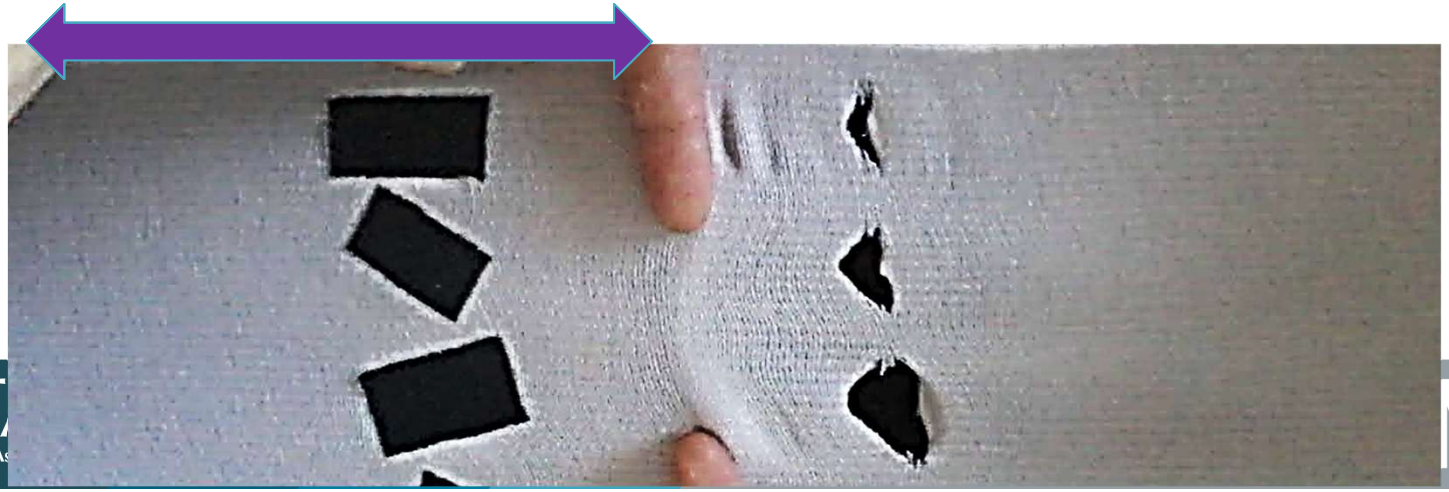


Interventions

Manual Therapy: Posterior Talar Glide

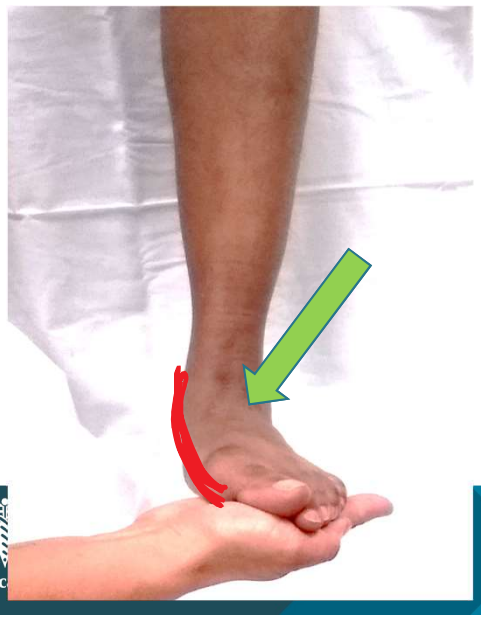
Mobilizing the talo-crural joint within in context of the ankle movement system

- Protecting over-stretched structures
- Guiding forces to target structures



Talo-crural mobilization for the pronated hindfoot

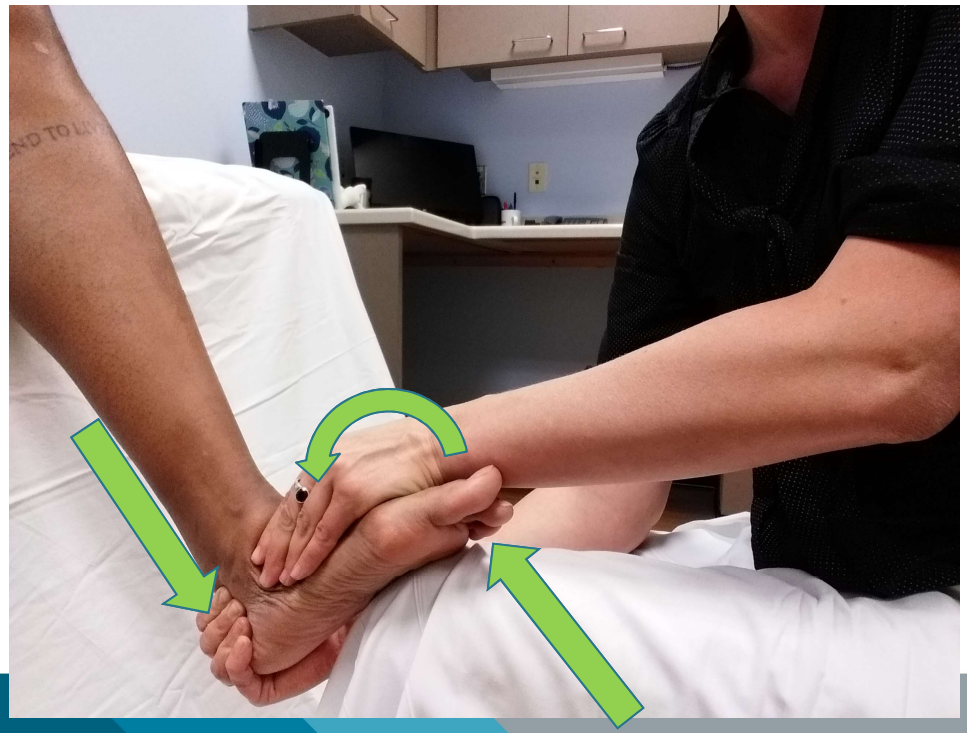
- Midfoot and forefoot in close-packed position to overcome relative flexibility



Interventions

Posterior Talar Glide with:

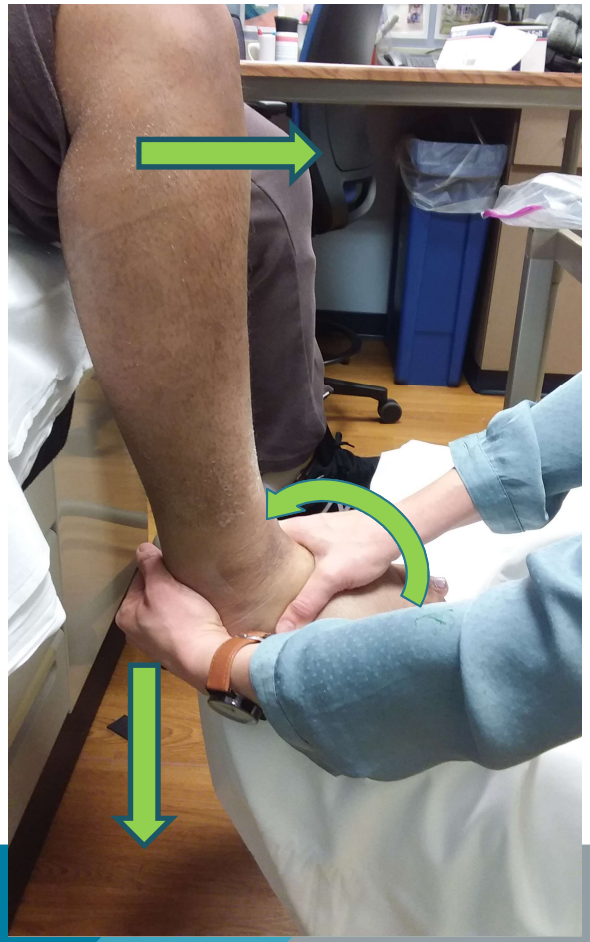
Calcaneal inferior glide and triplanar guidance

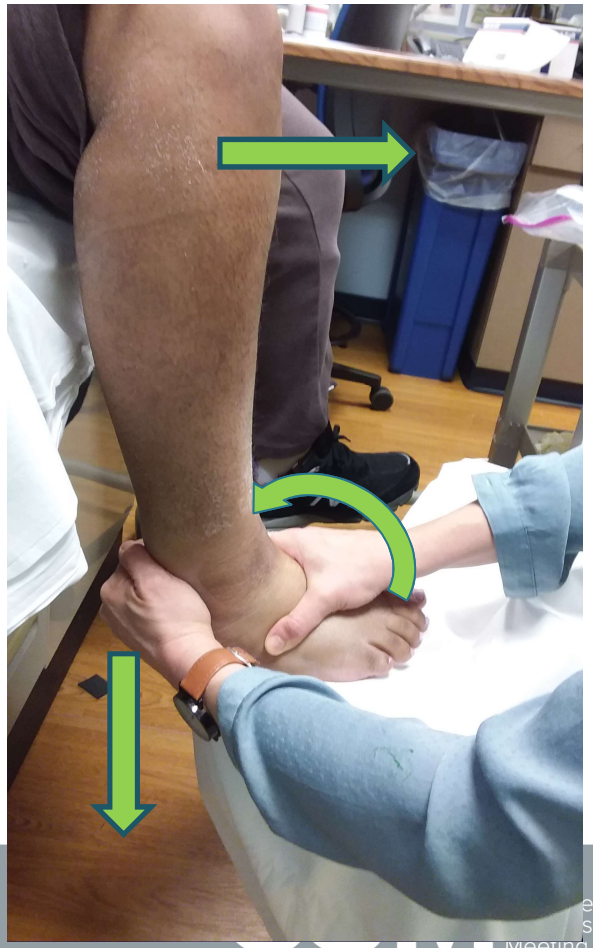


Mobilization With Movement (MWM)

HEP:

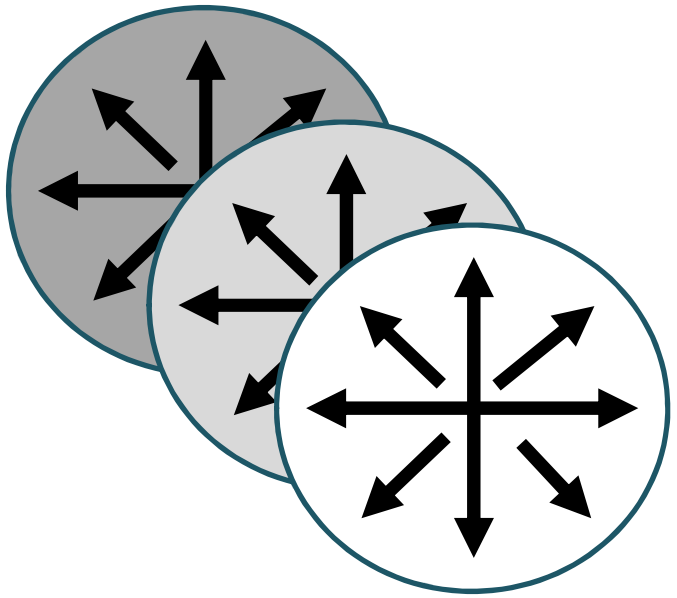
- Taping
- Therapeutic casting





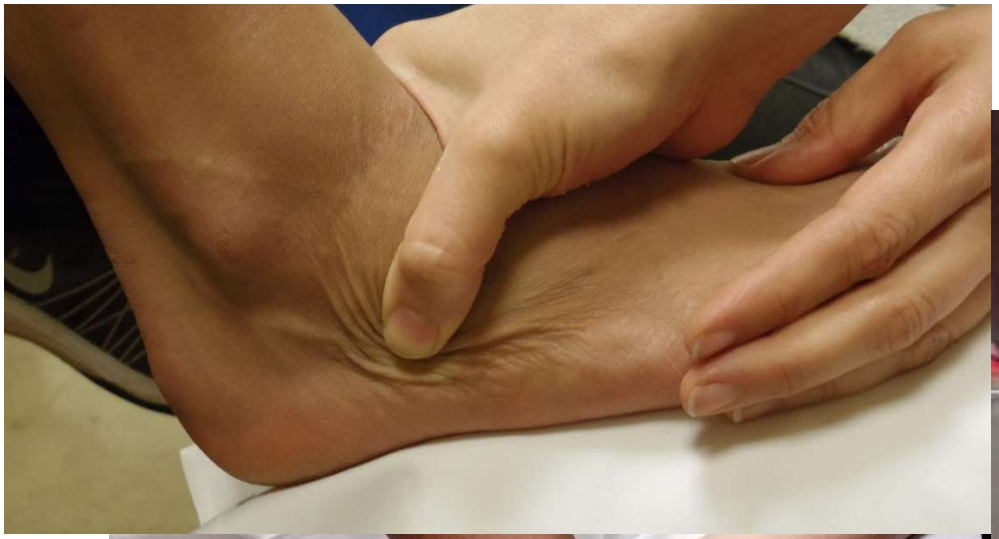
Soft Tissue Mobilization to Increase DF

- Ability of tissues to lengthen, shorten, fold, glide and slide
- Multi-layer
- Multi-directional

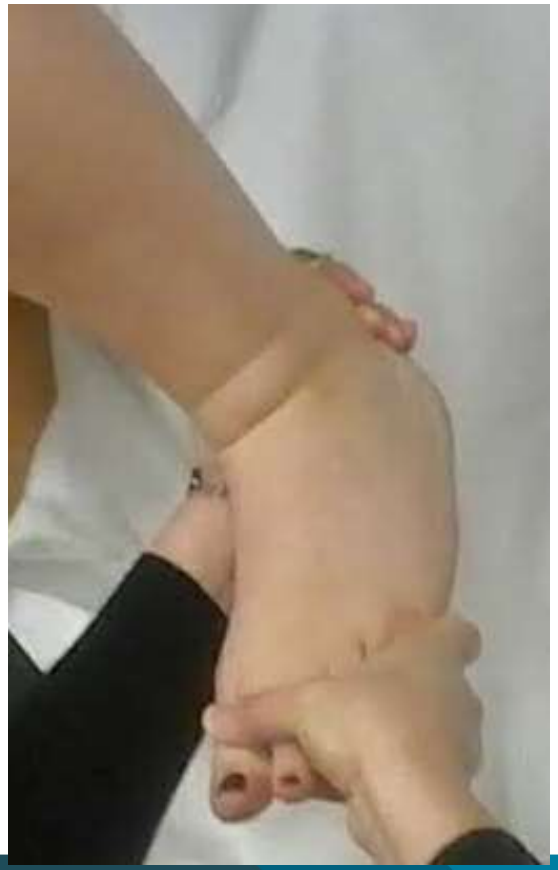


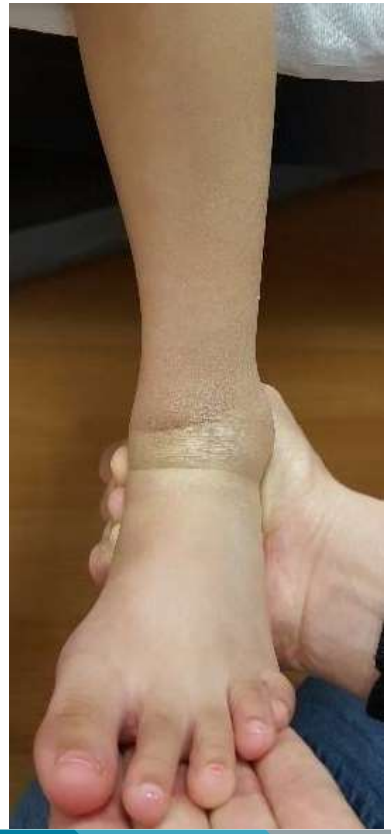
Soft Tissue Mobilization to Increase DF

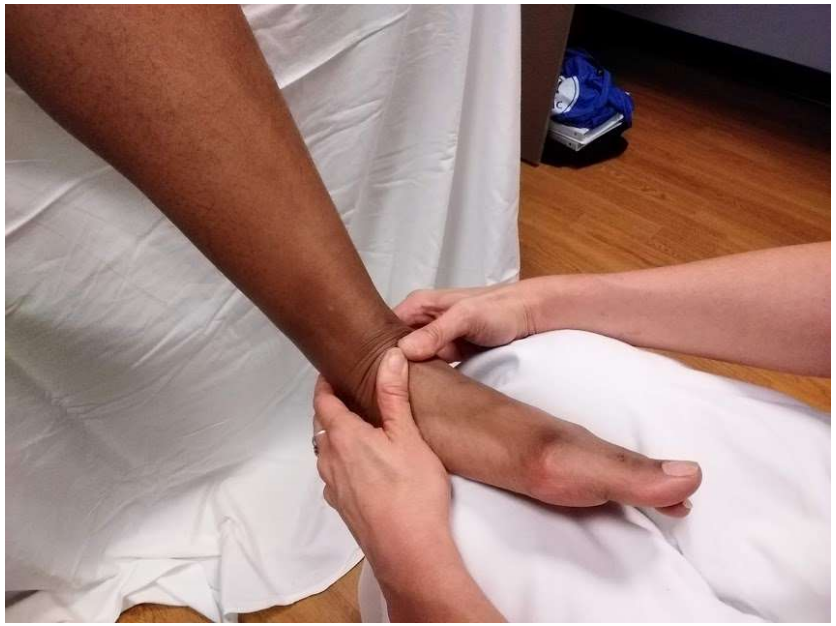
Soft Tissue Mobilization to Increase DF



Soft Tissue Mobilization to Increase DF

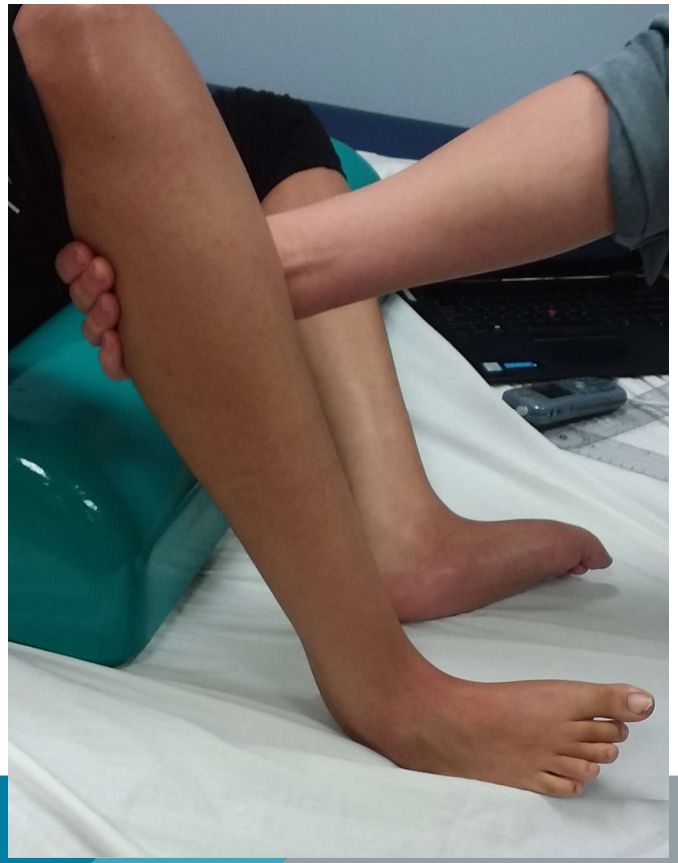


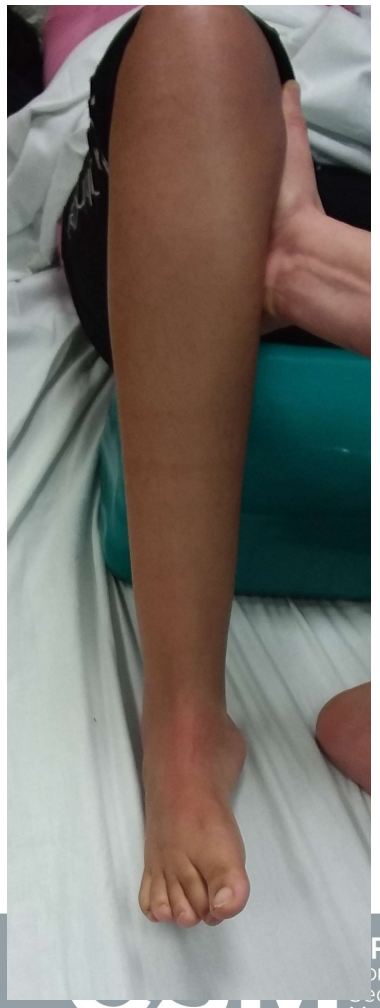




Manual Therapy Progression

Supinated Posture

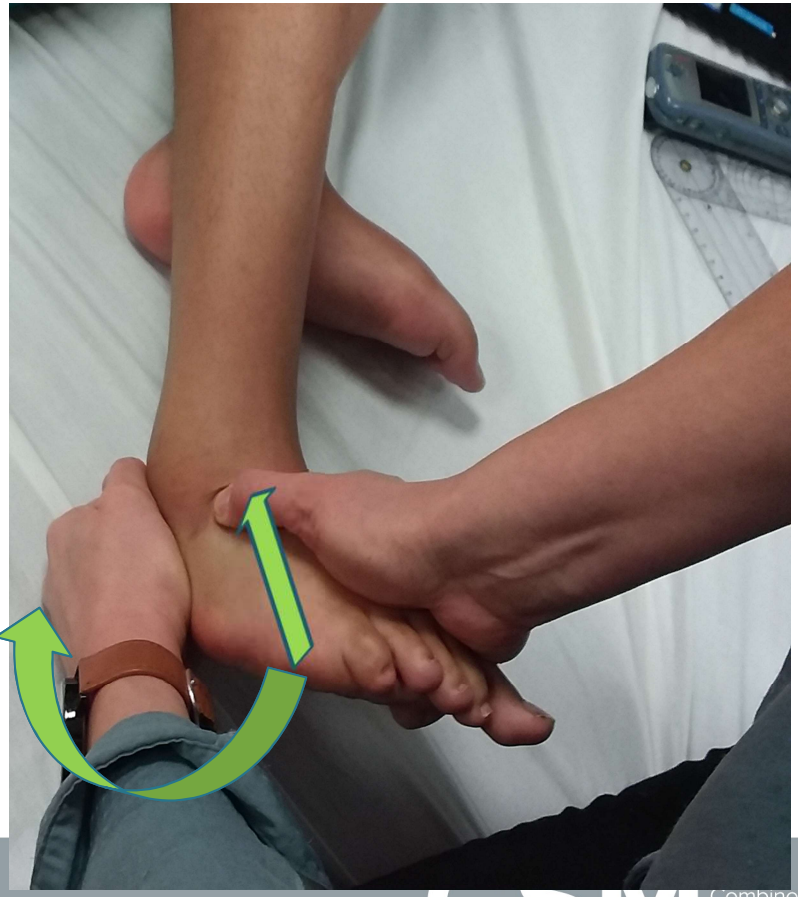




Manual Therapy Progression

Supinated Posture

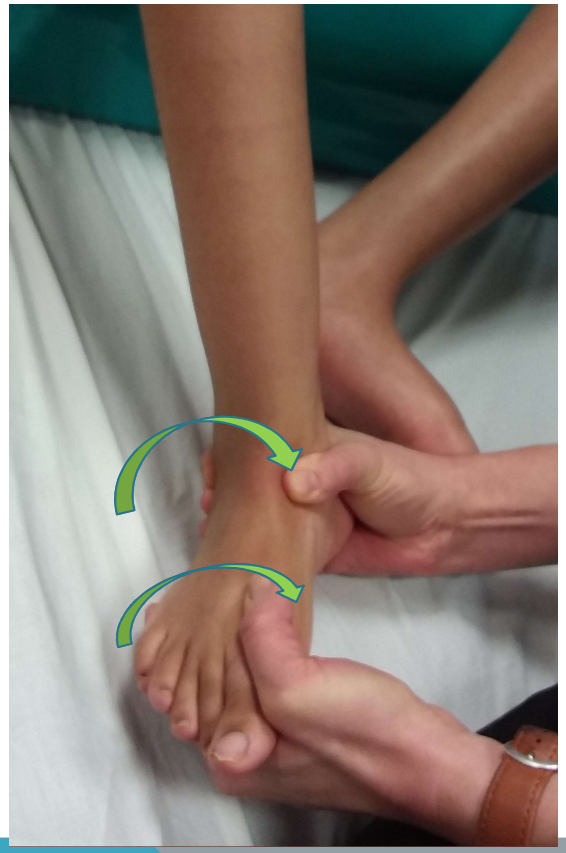
- Calcaneal inferior glide with eversion
- Posterior-medial talar mobilization

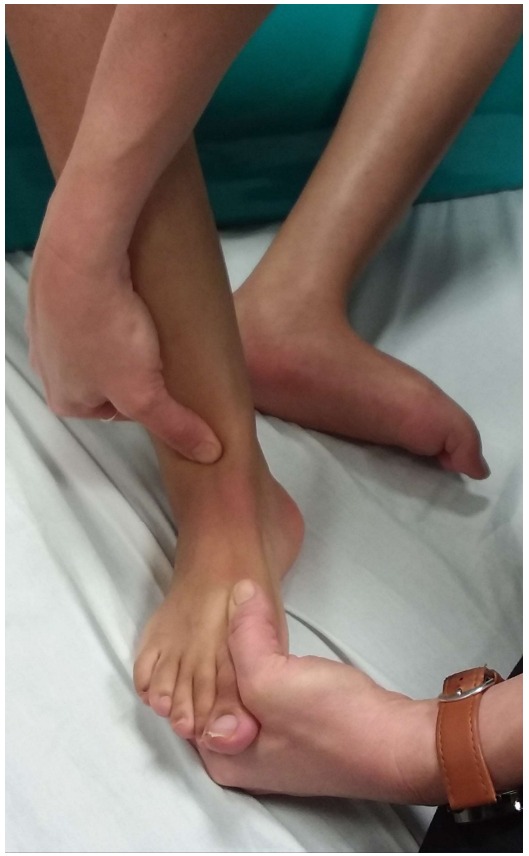


Manual Therapy Progression

Supinated Posture

- Anterior hindfoot – medial soft tissue mobilization
- 1st ray: plantarflexion mob
- TC plantarflexion with elongation of TA/EHL

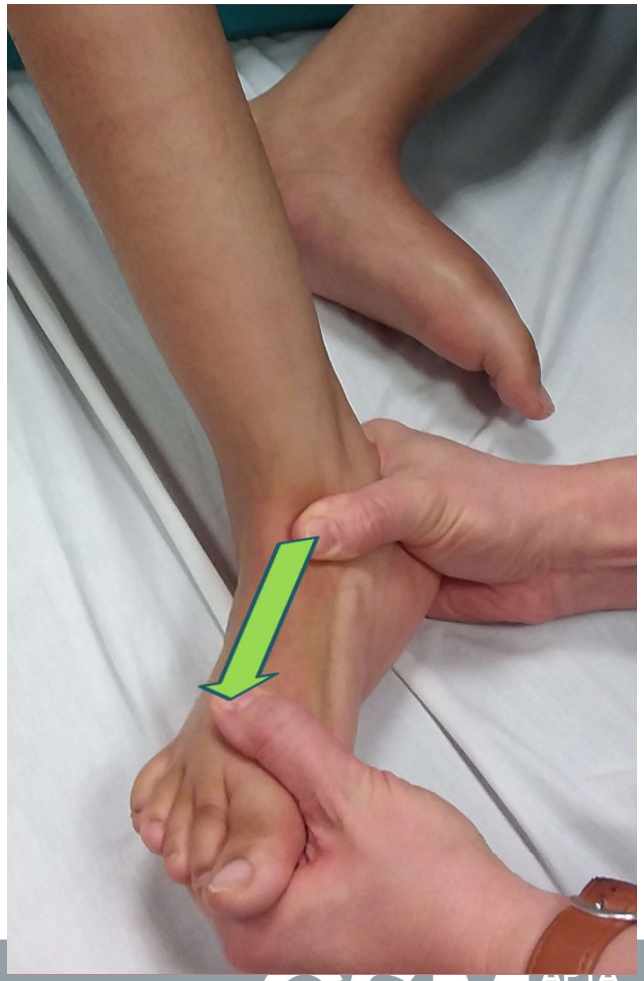




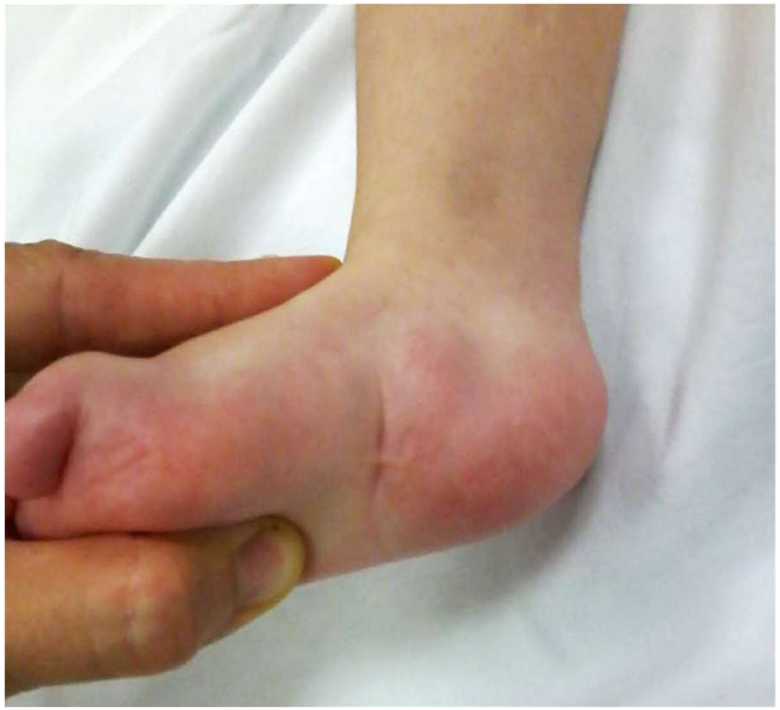
Manual Therapy Progression

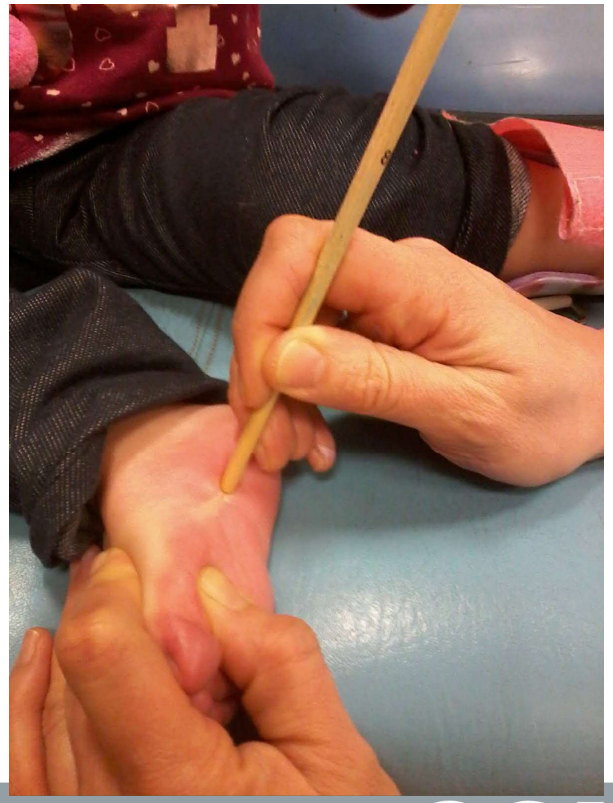
Supinated Posture

- Distraction with PF mobilization for midfoot and first ray
- Extension of MTPs
- Elongation of plantar fascia



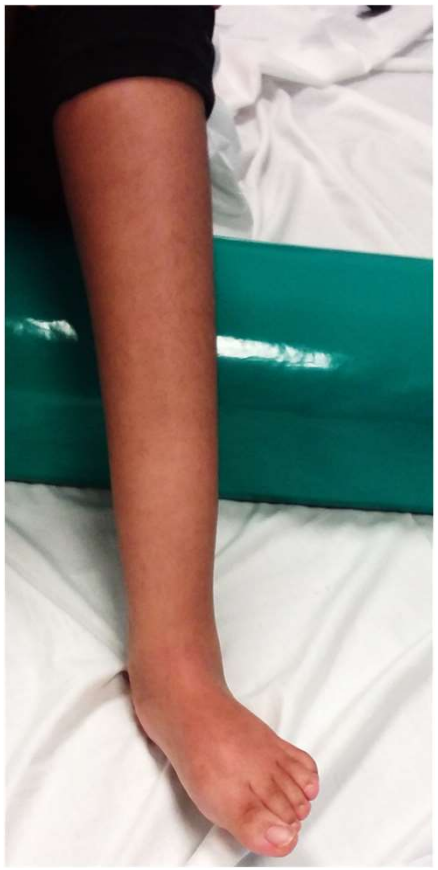
Instrument Assisted Soft Tissue Mobilization (IASTM)





Manual Therapy Progression

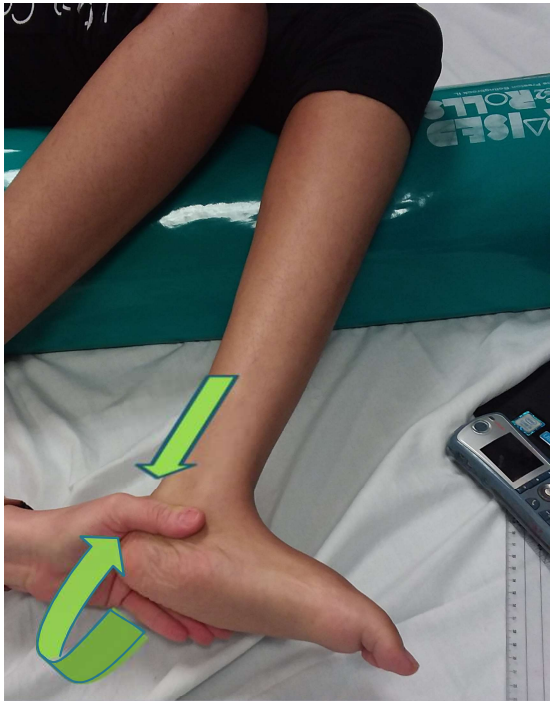
Pronated Posture

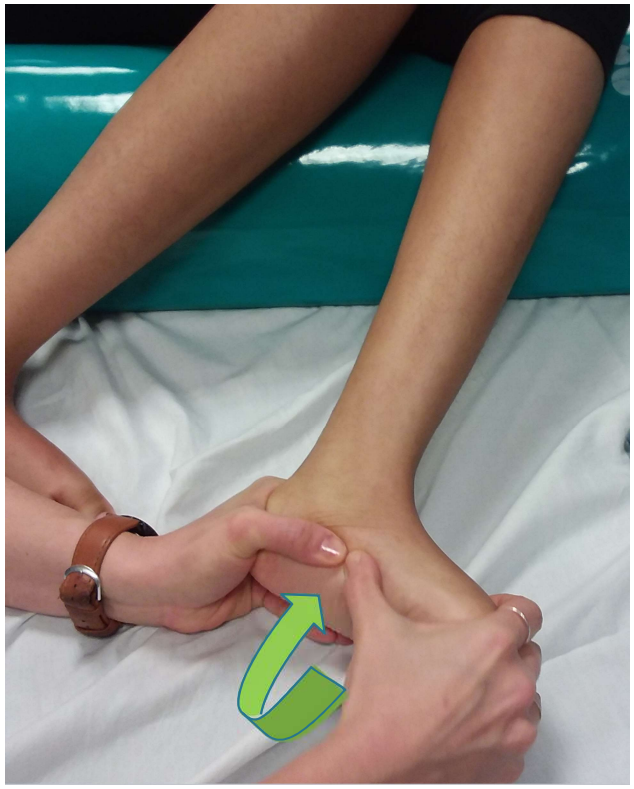


Manual Therapy Progression

Pronated Posture

- Inferior/ inversion mobilization of calcaneus
- Medial/superior mobilization of navicular

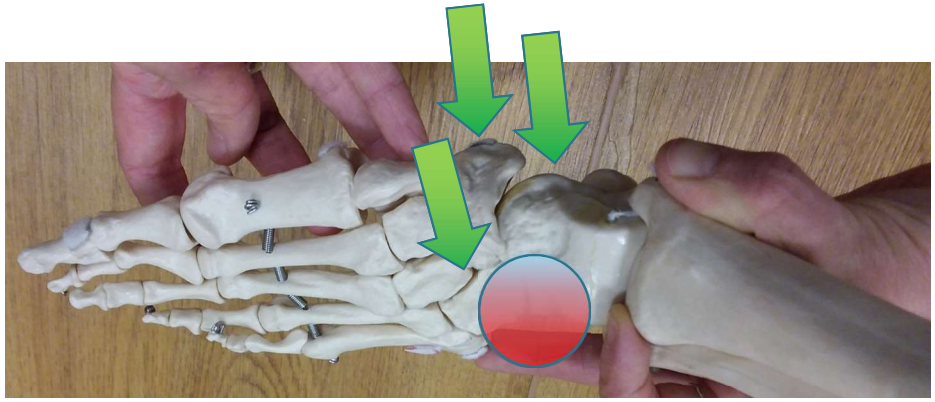


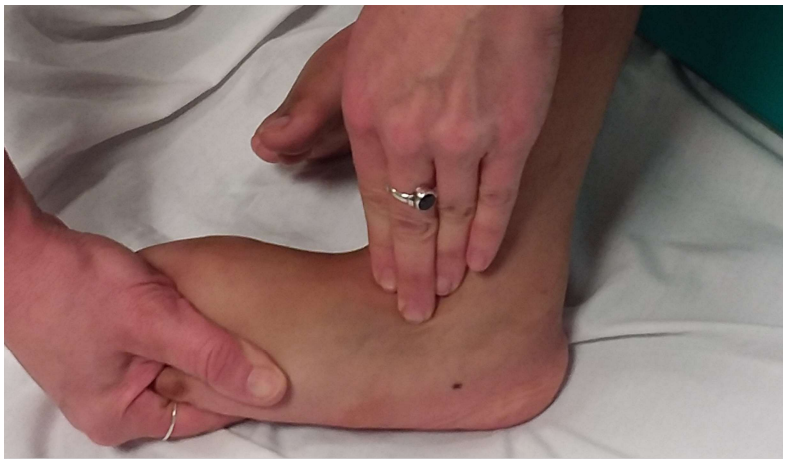


Manual Therapy Progression

Pronated Posture

- Release of soft tissue at lateral talar head to allow for talus to move laterally





Manual Therapy Progression

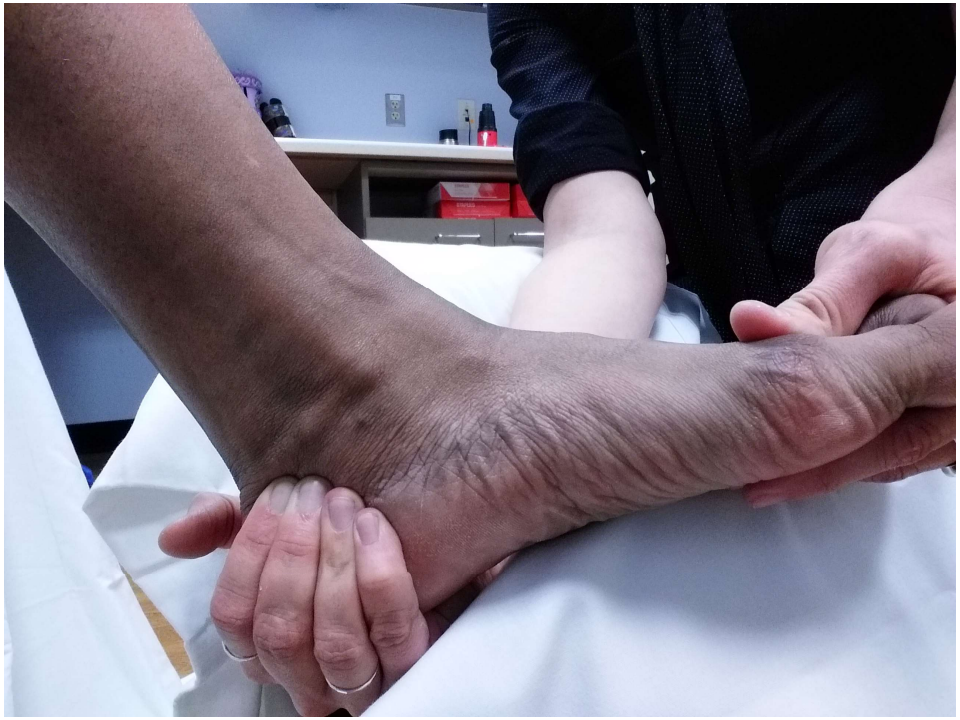
Pronated Posture

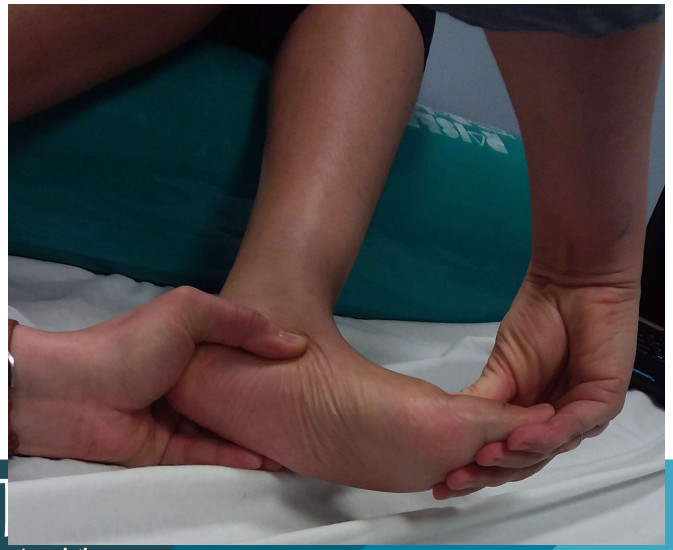
- PF of 1st ray and midfoot with hindfoot stablized

Manual Therapy Progression

Pronated Posture

- PF of 1st ray and midfoot with hindfoot stabilized

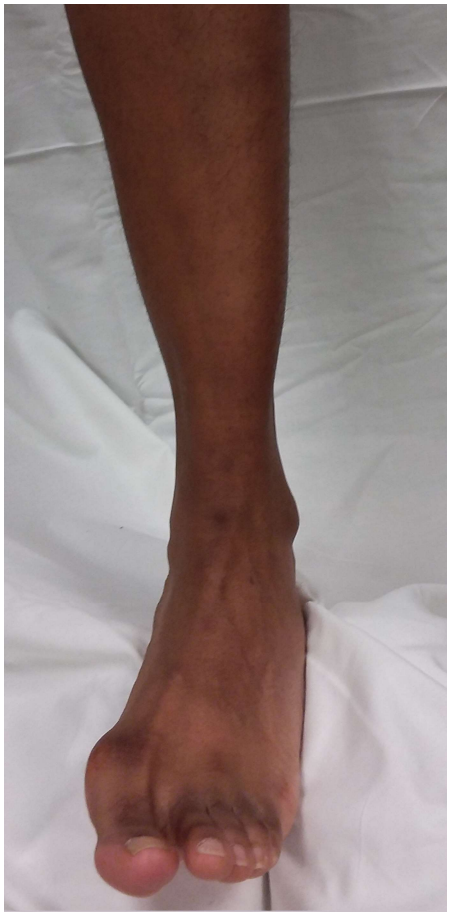


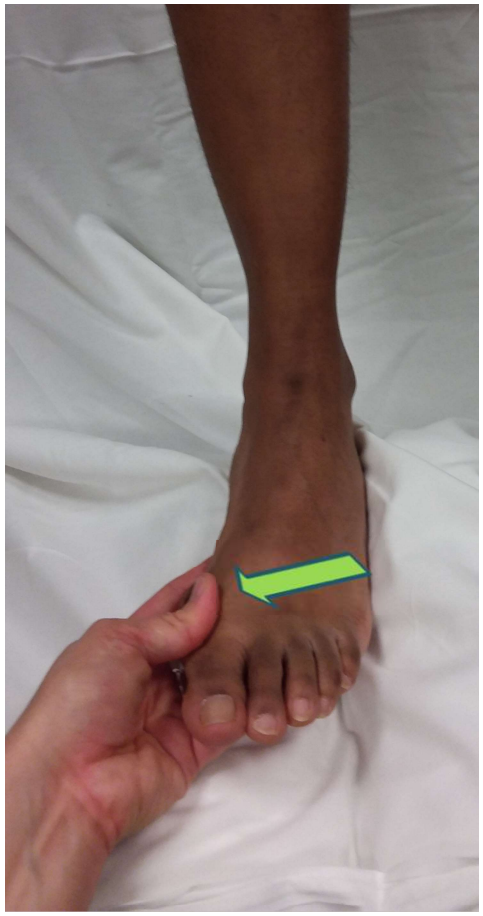


Manual Therapy Progression

Pronated Posture

- Joint and soft tissue mobilization of abducted digits





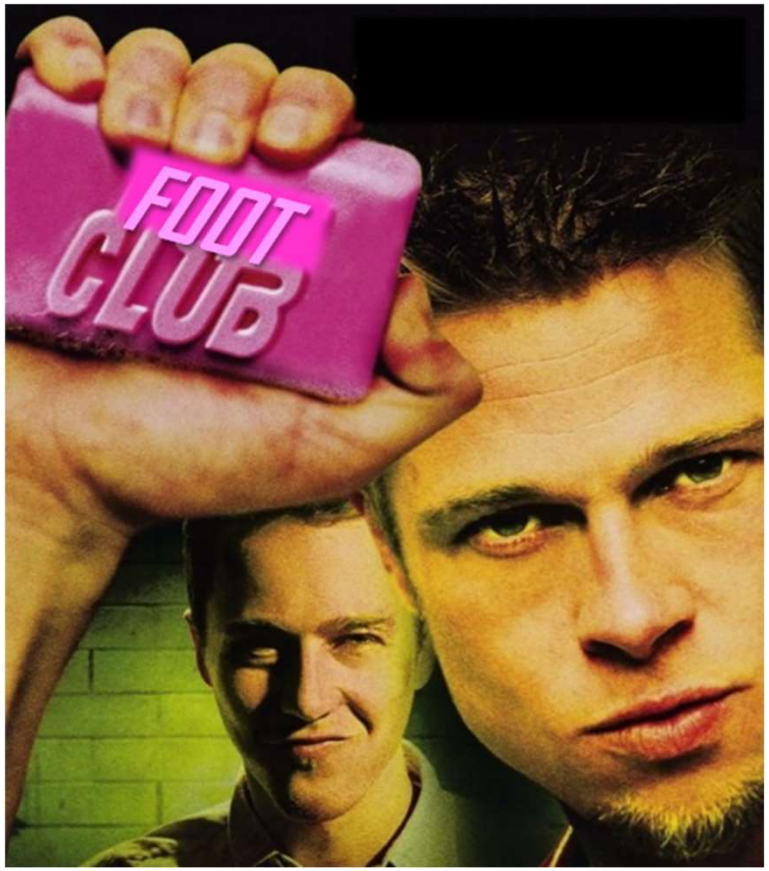
Mobilizations:

"Frozen Ankle" Hypothesis

- The Frozen Shoulder Has A Brain. A. Low, S. Schmidt, P. Mintken (CSM 2019--AHUEPT)
- Might stiffness be adaptive?

- We must provide the system with an adaptive path to stability if we are to add degrees of freedom.

I. Introduction
II. Pediatric Ankle Impairments
III. Do We Need To Intervene?
IV. How Should We Intervene?
    A. #Goals
    B. Motion
    C. Functional Strength
    D. Neuroplasticity
    E. Education
    F. External Supports

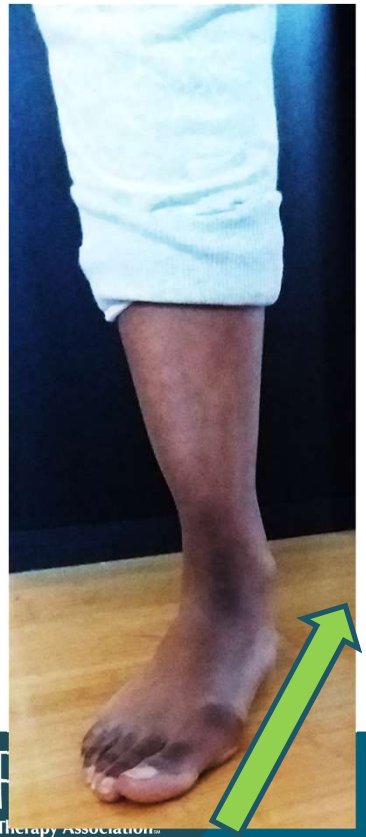


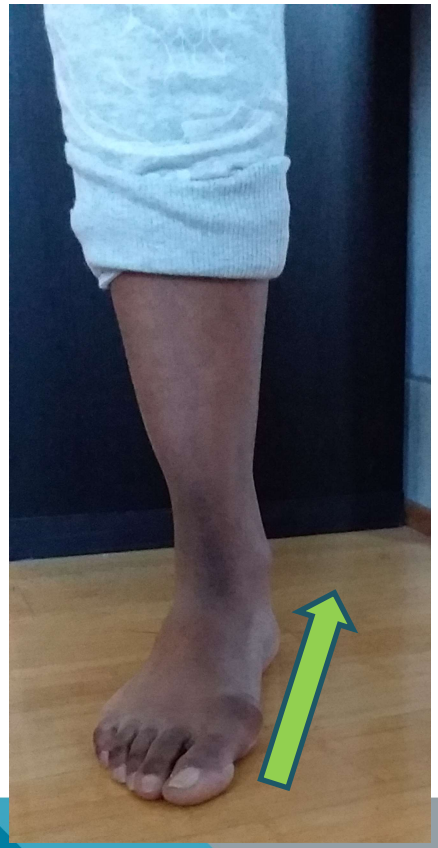
Improving Intrinsic Stability Through Progressive Strengthening

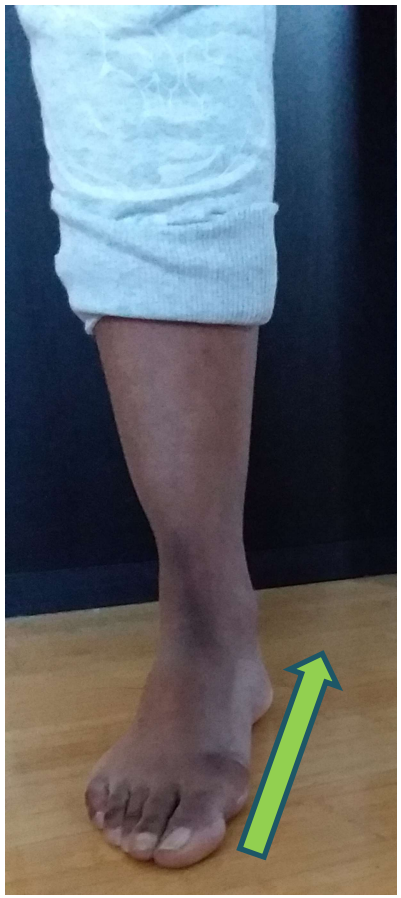
- Immediate effect of short-foot exercise on dynamic balance of subjects with excessively pronated feet. (Moon 2014)
- The effects of short foot exercises and arch support insoles on improvement in the medial longitudinal arch and dynamic balance of flexible flatfoot patients. (Kim 2016)
- Effect of plantar intrinsic muscle training on medial longitudinal arch morphology and dynamic function. (Mulligan 2013)
- Strength training for plantar fasciitis and the intrinsic foot musculature: a systematic review. (Huffer 2017)

Progressive Exercise

Short Foot

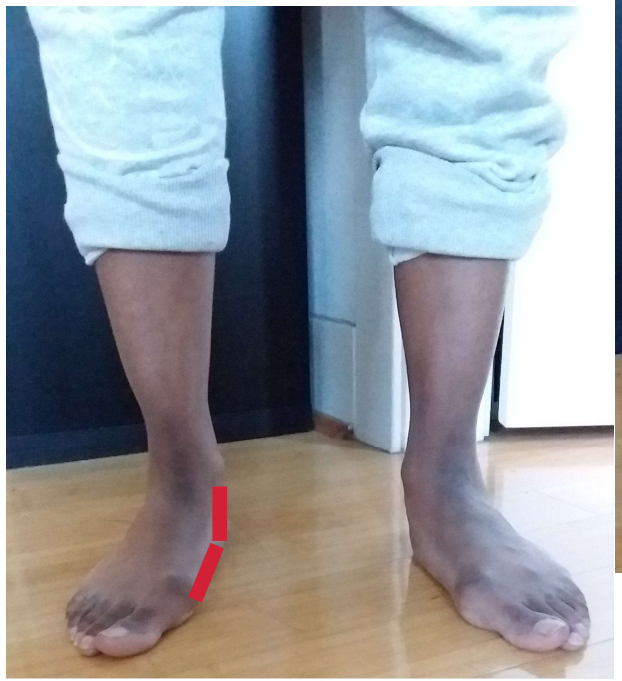


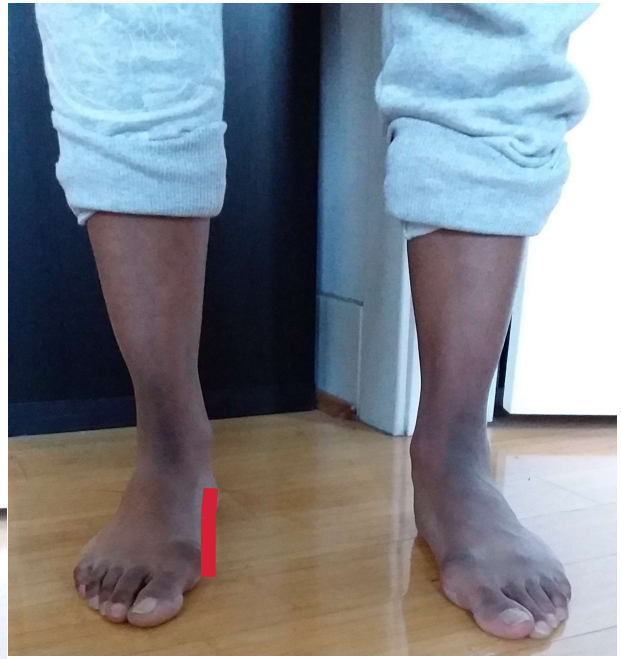


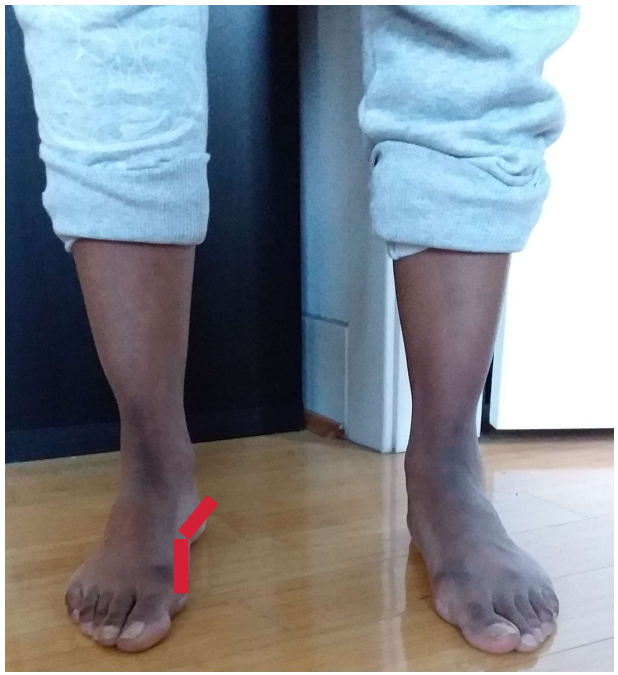


Progressive Exercise

Short Foot

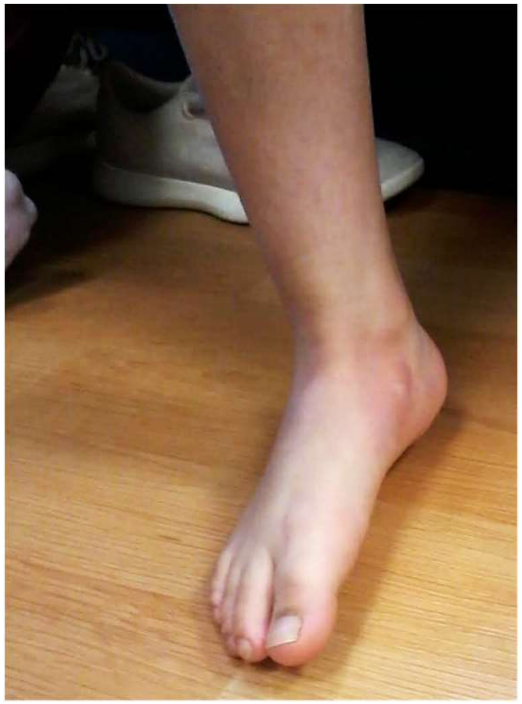


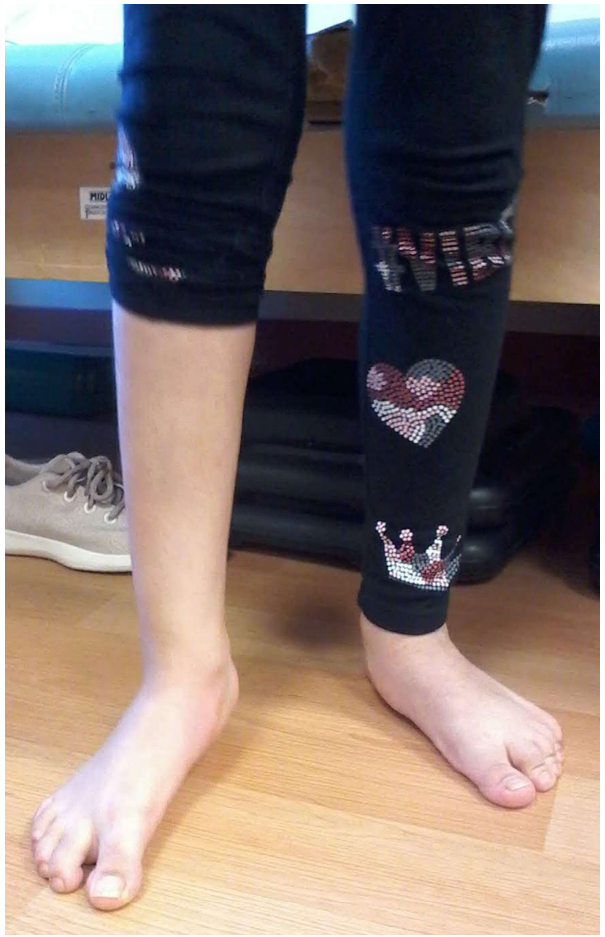




Progressive Exercise

Short Foot





Progressive Exercise

Short Foot

- But….

Improving Motor Control: Observation and Imagery

- Graded motor imagery for patients with stroke: a non-randomized controlled trial of a new approach. (Polli 2017)
- Training the motor cortex by observing the actions of others during immobilization. (Bassolino 2014)
- Best practice for motor imagery: a systematic literature review on motor imagery training elements in five different disciplines. (Schuster 2011
- Clinical assessment of motor imagery after stroke. (Malouin 2008)
- Mental practice for relearning locomotor skills. (Malouin 2010)
- Graded motor imagery for pathologic pain: a randomized controlled trial. (Moseley 2006)

Improving Motor Control: Observation and Imagery

Progression

- Action observation
- Motor imagery
- Motor performance

Improving Motor Control: Observation and Imagery

Observation

- Adult model
- *Peer* model
  - Live
  - Video

Improving Motor Control: Observation and Imagery

Transitioning from observation to visualization

- *Self* model

Improving Motor Control: Observation and Imagery

Self model for visualization:

- Mirror therapy

Mirror Therapy

- Mirror therapy for improving motor function after stroke--Cochrane Review (Thieme 2018)
- Mirror Box Training in Hemiplegic Stroke Patients Affects Body Representation. (Tosi 2017)
- Effect of Mirror Therapy on Recovery of Stroke Survivors: A Systematic Review and Network Meta-analysis. (Yang 2018)
- The Activation of the Mirror Neuron System during Action Observation and Action Execution with Mirror Visual Feedback in Stroke: A Systematic Review. (Zhang 2018)
- The effect of tactile discrimination training is enhanced when patients watch the reflected image of their unaffected limb during training. (Moseley 2009)

Mirror Therapy

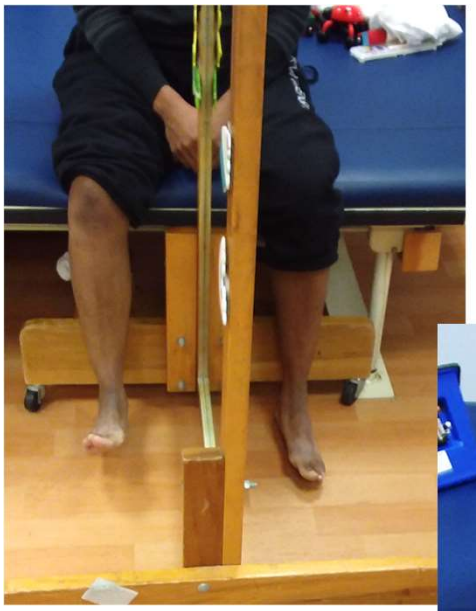
- Visualization: self-model

Mirror Therapy

With visual attention to reflection of stronger side in mirror

Progression (involved side)

- No movement
- Imagine movement
- Imitate, minimal effort
- Imitate, full effort

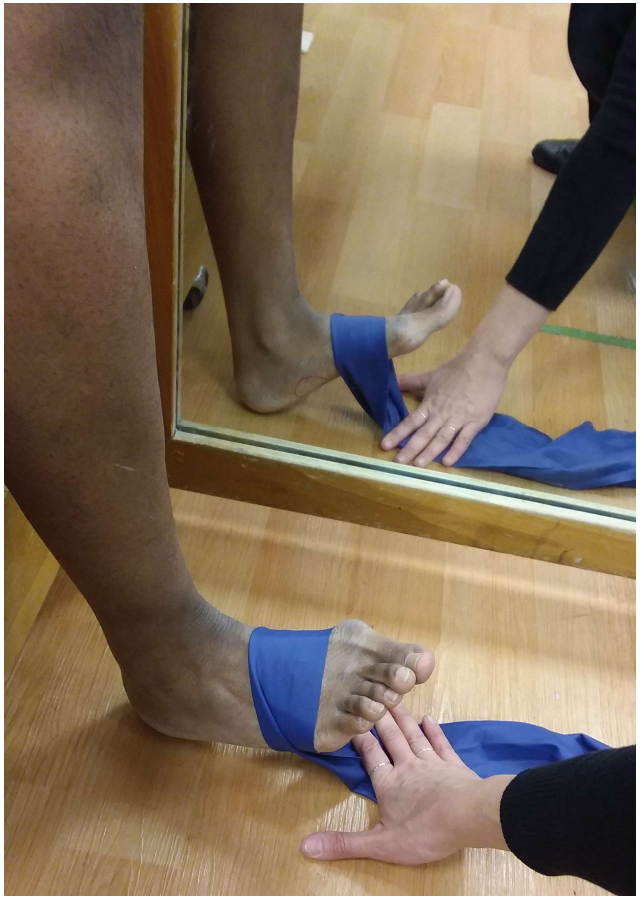


Mirror Therapy

With attention to reflection of stronger side in mirror

Progression

- Imitate, full effort
- Resistance to stronger side
- Resistance to involved side



Mirror Therapy

With attention to reflection of stronger side in mirror

Progression

- Foot doming in mirror for visual feedback

Observation + Mirror Therapy

- Adult model with self-model
- Neglect: cues to attend to image

Visualization

Improving Foot and Ankle Motor Control

Electric Stimulation

Impact of e-stim training to “foot core”

- Decreased navicular drop and decreased vertical GRF

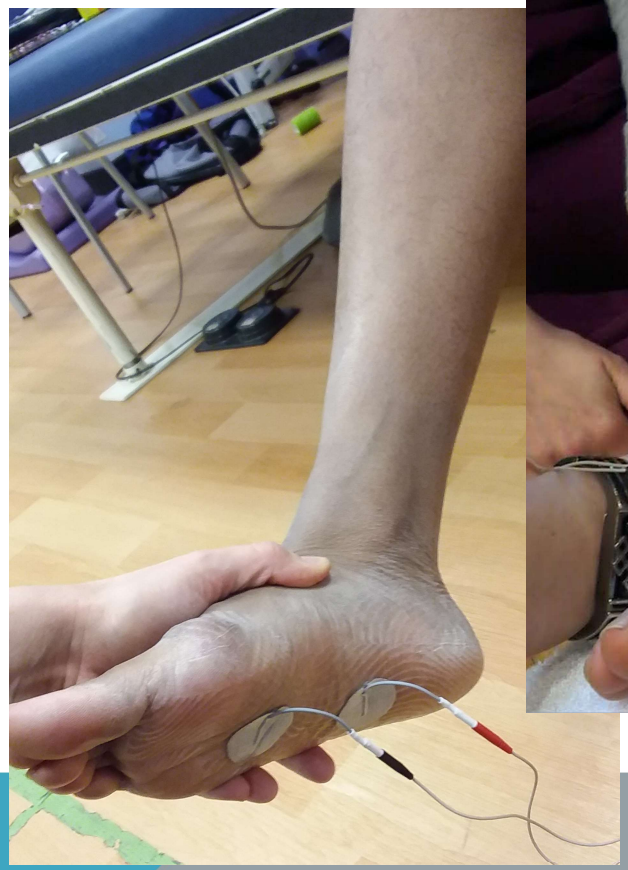
The effect of additional activation of the plantar intrinsic foot muscles on foot dynamics during gait. (Okamura 2018)

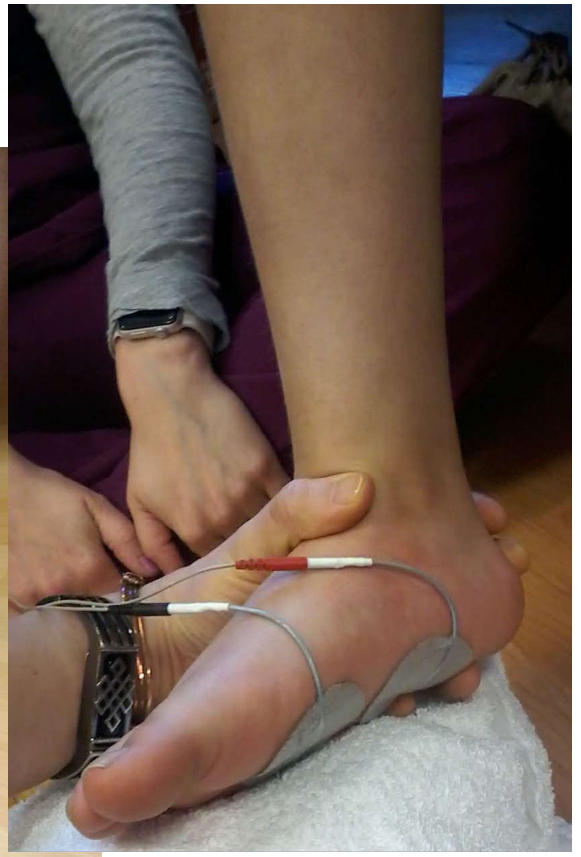
Improving Foot and Ankle Motor Control

Electric Stimulation

Progression

- Non-weightbearing



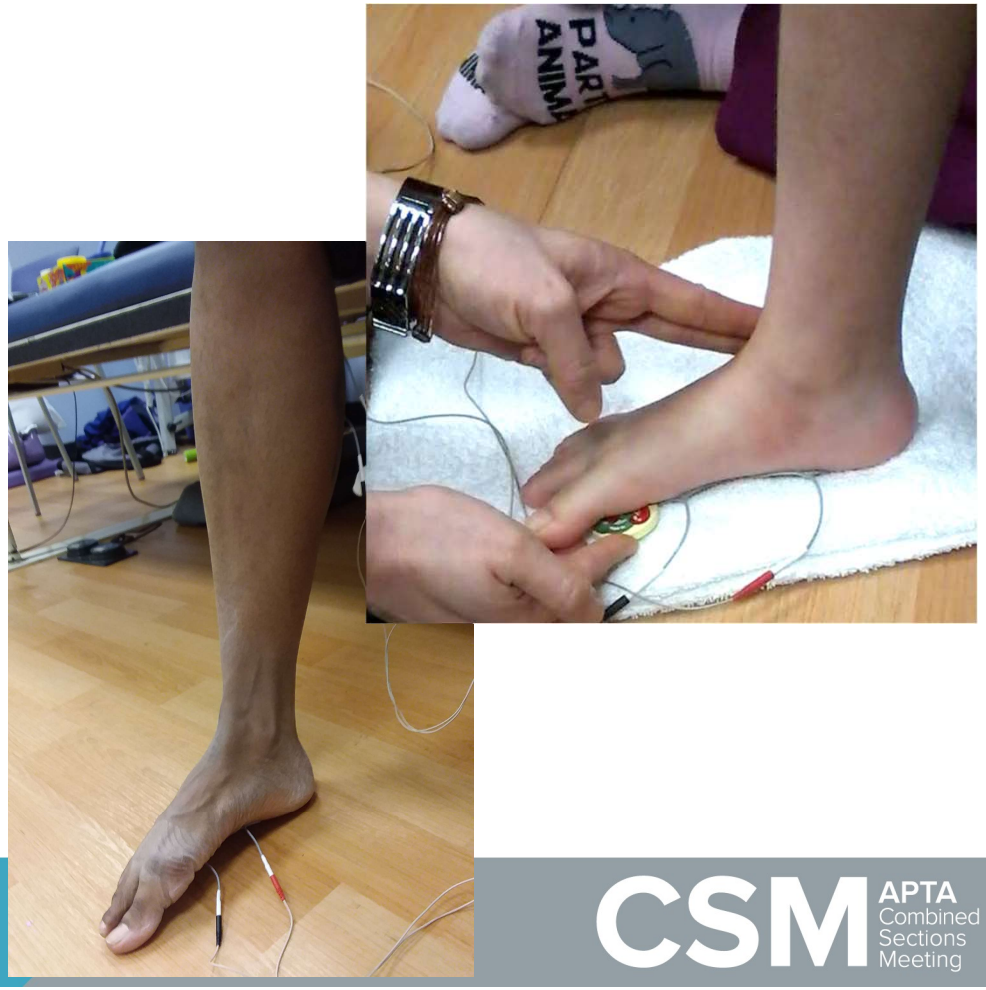


Improving Foot and Ankle Motor Control

Electric Stimulation

Progression

- Weightbearing in sitting
- Semi-standing



Improving Foot and Ankle Motor Control

Electric Stimulation

Progression

- Sit to stand
  - Progression within controlled range

Electric Stimulation

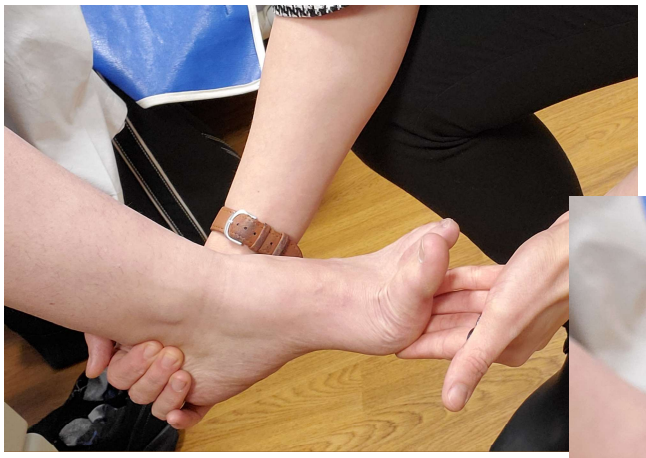
Progression

- Gait training
  - Verbal cues
  - Mirror
  - No feedback
  - Remove e-stim

Improving Foot and Ankle Motor Control

Welcome to The Resistance

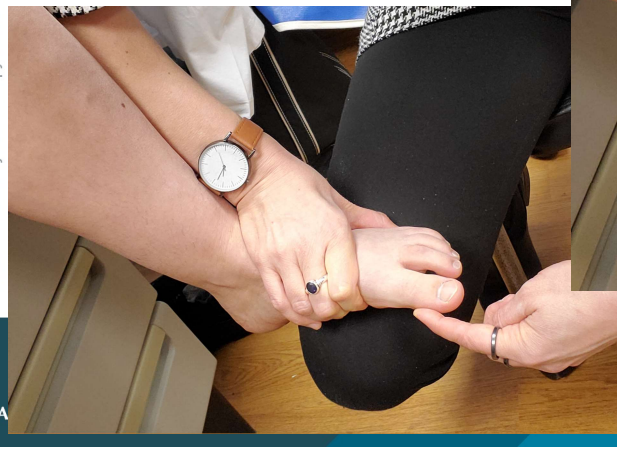
Use of resistance to improve motor response

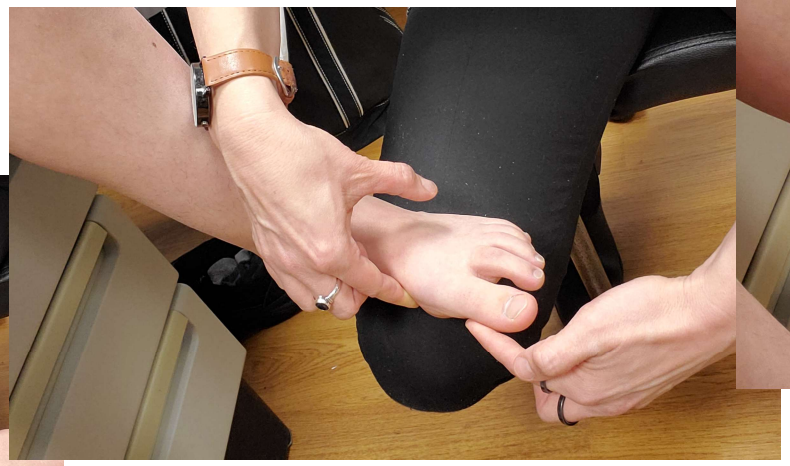


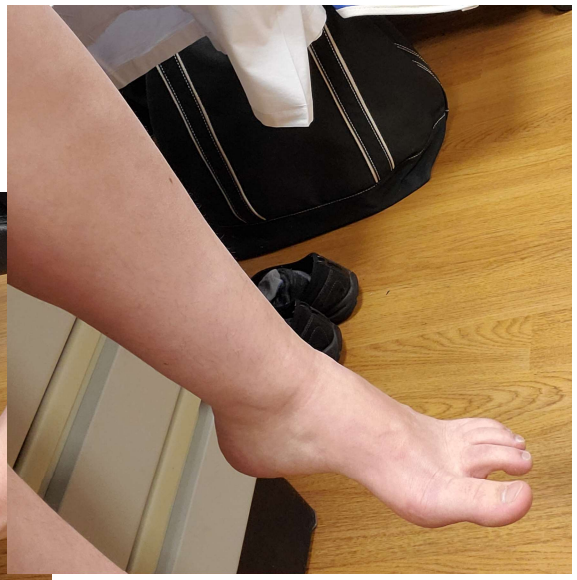
Improving Foot and Ankle Motor Control

Welcome to The Resistance

Use of resistance to improve motor response

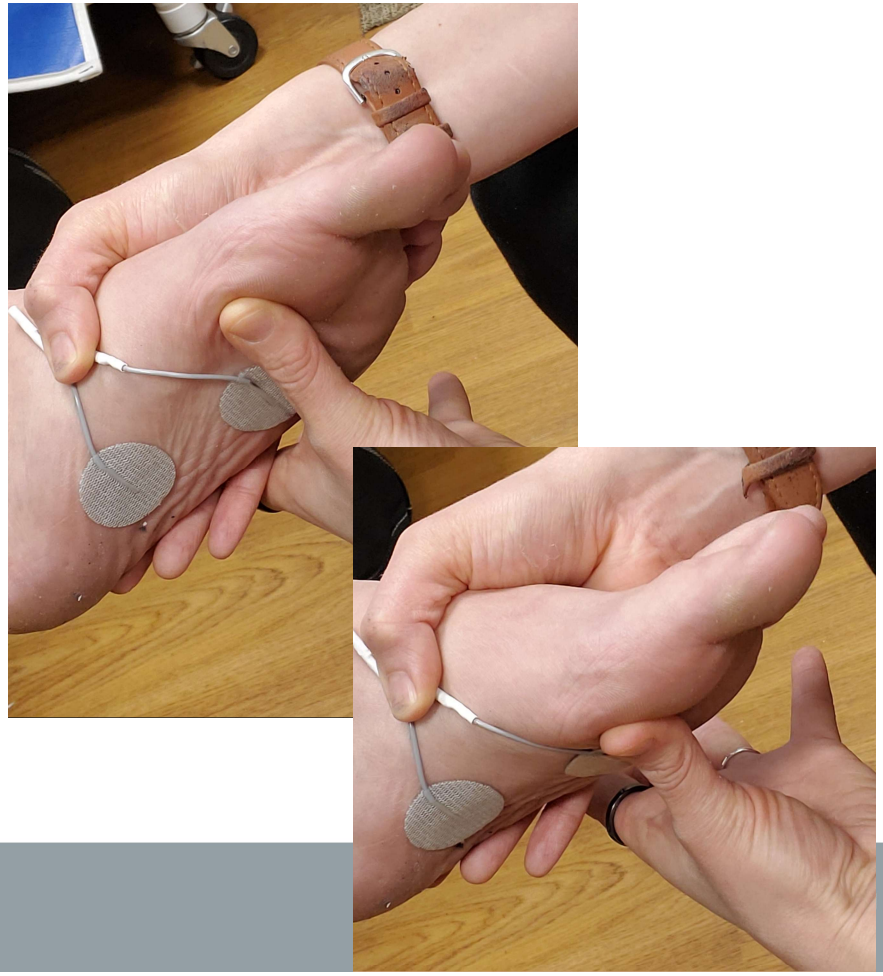






Improving Foot and Ankle Motor Control

Electric Stimulation + Resistance



Improving Foot and Ankle Motor Control

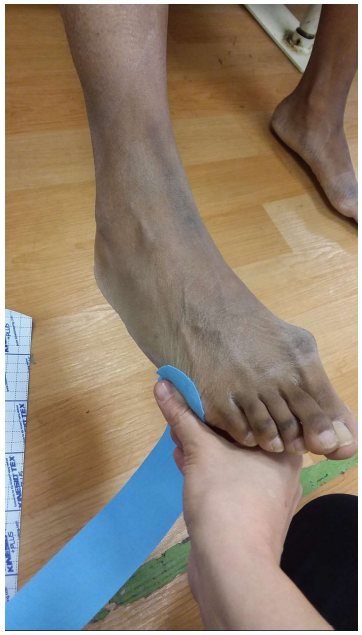
Taping

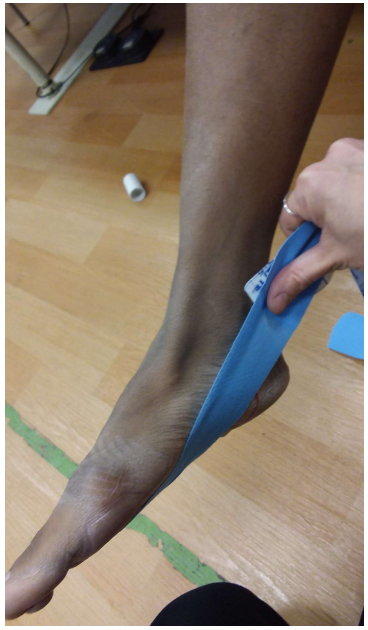
1. Longitudinal foot core

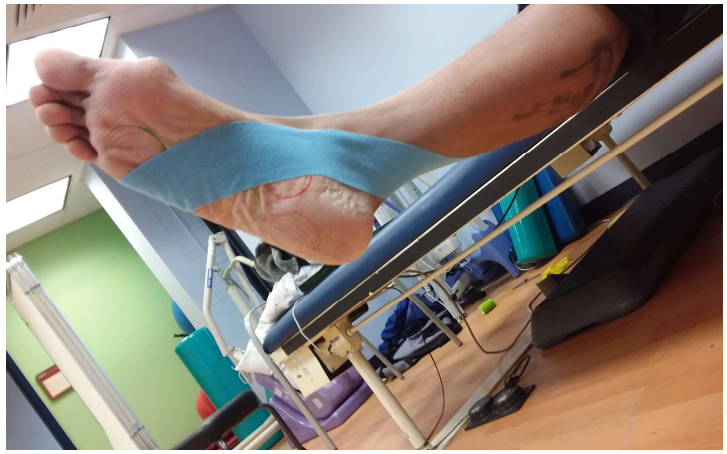
Improving Foot and Ankle Motor Control

Taping

2. Spiral foot core



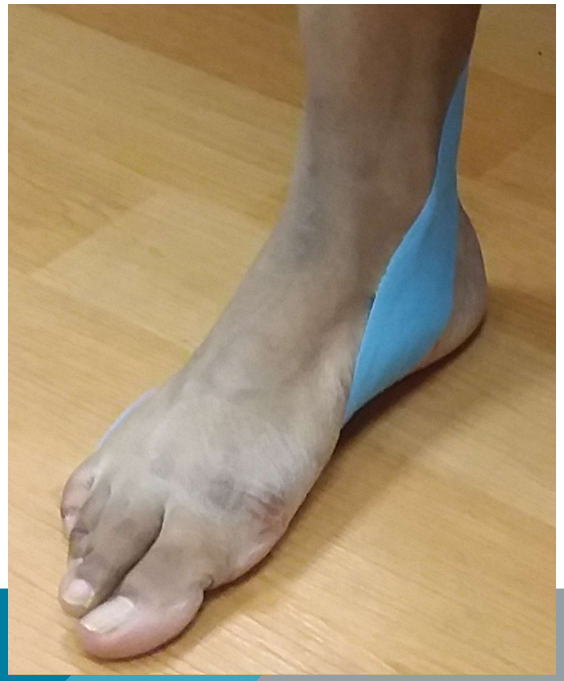


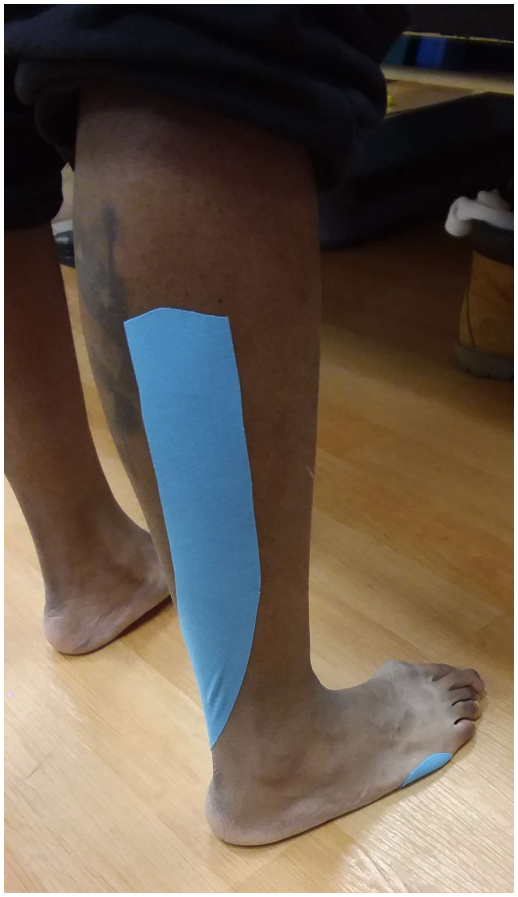


Improving Foot and Ankle Motor Control

Taping

2. Spiral foot core



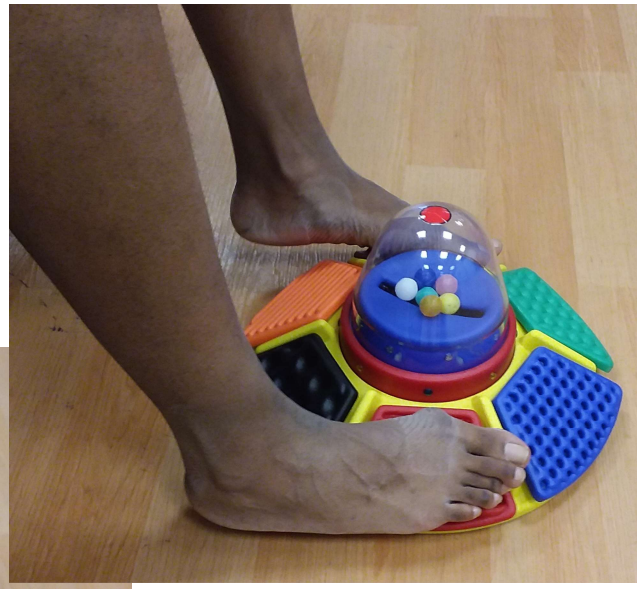


Improving Foot and Ankle Motor Control

Enhanced Feedback for Motor Exploration

Use of technology to increase:

- Feedback
- Opportunities for success

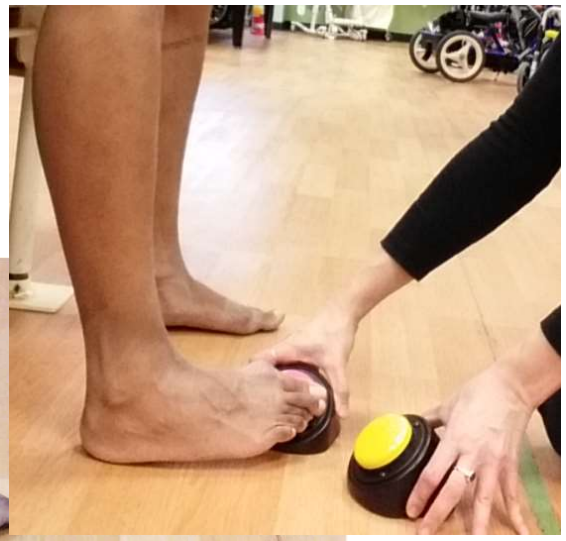


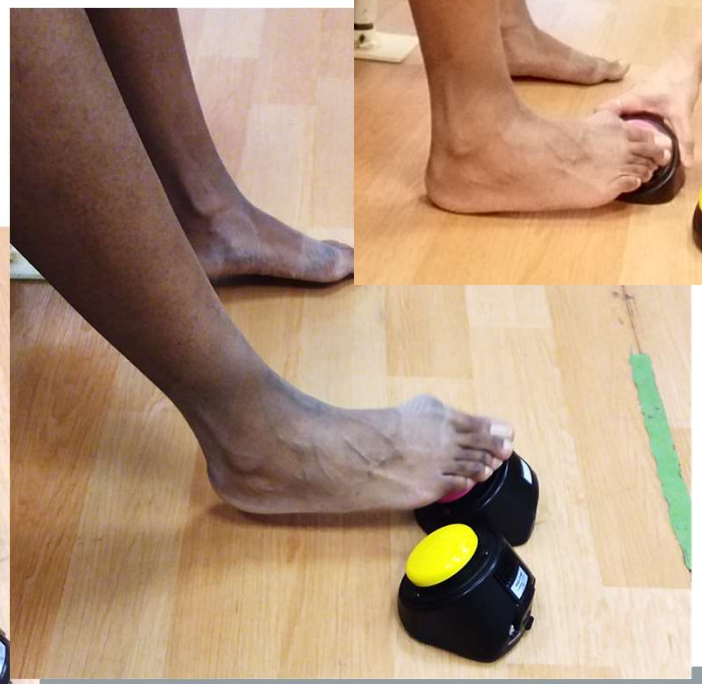
Improving Foot and Ankle Motor Control

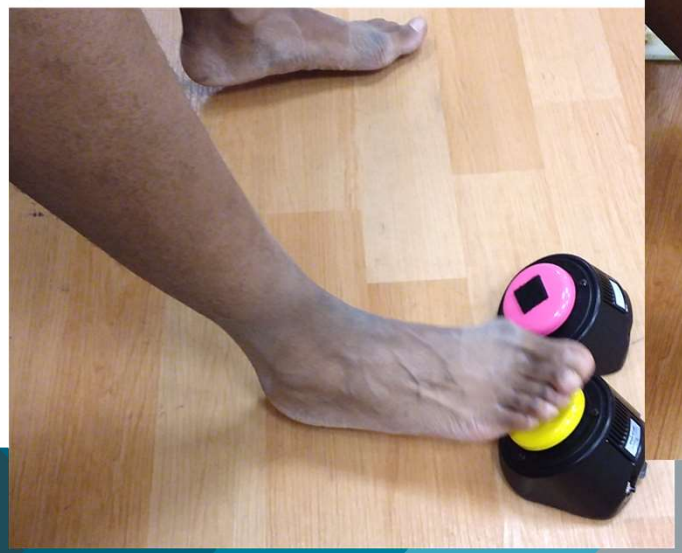
Enhanced Feedback for Motor Exploration

Novel activities **Feopardy**

- Placement
- Timing



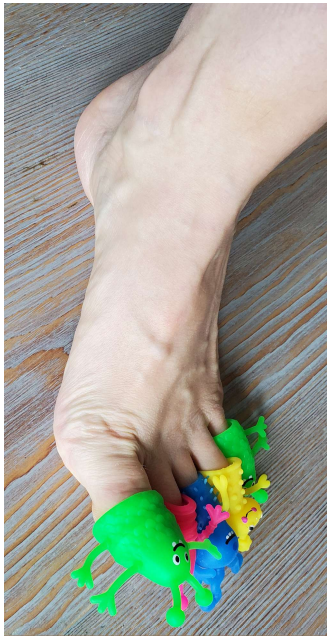


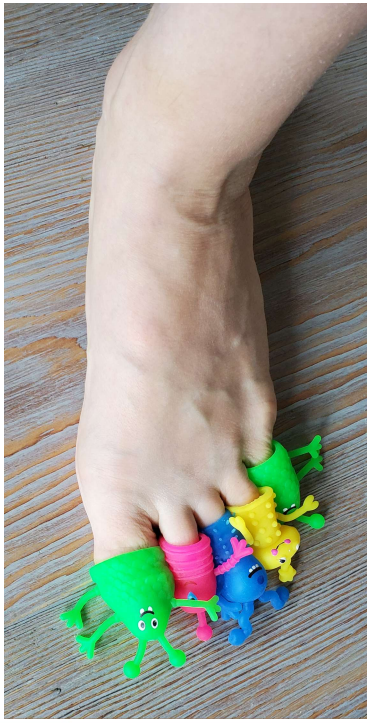


Improving Foot and Ankle Motor Control

Enhanced Feedback for Motor Exploration

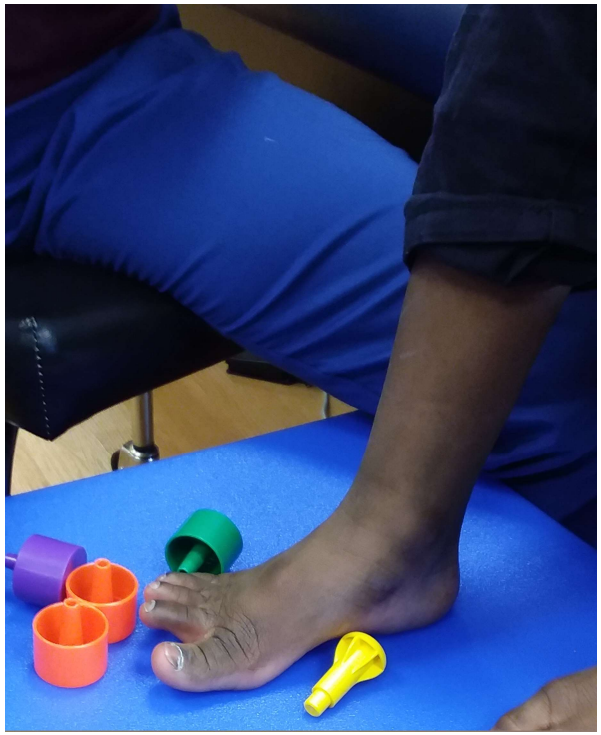
Low tech





Improving Foot and Ankle Motor Control

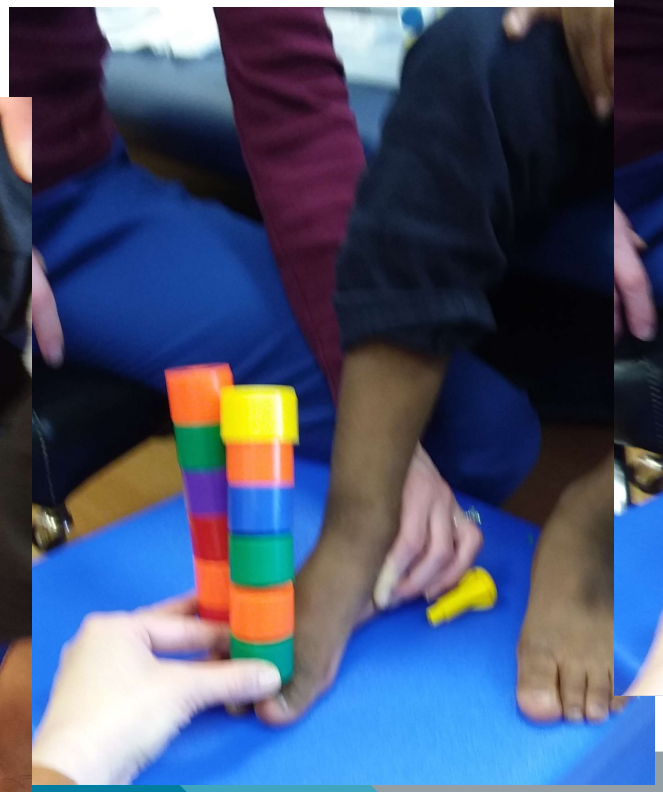
Partial Weightbearing With Motor Task



Improving Foot and Ankle Motor Control

Partial Weightbearing With Motor Task

Toe Tower

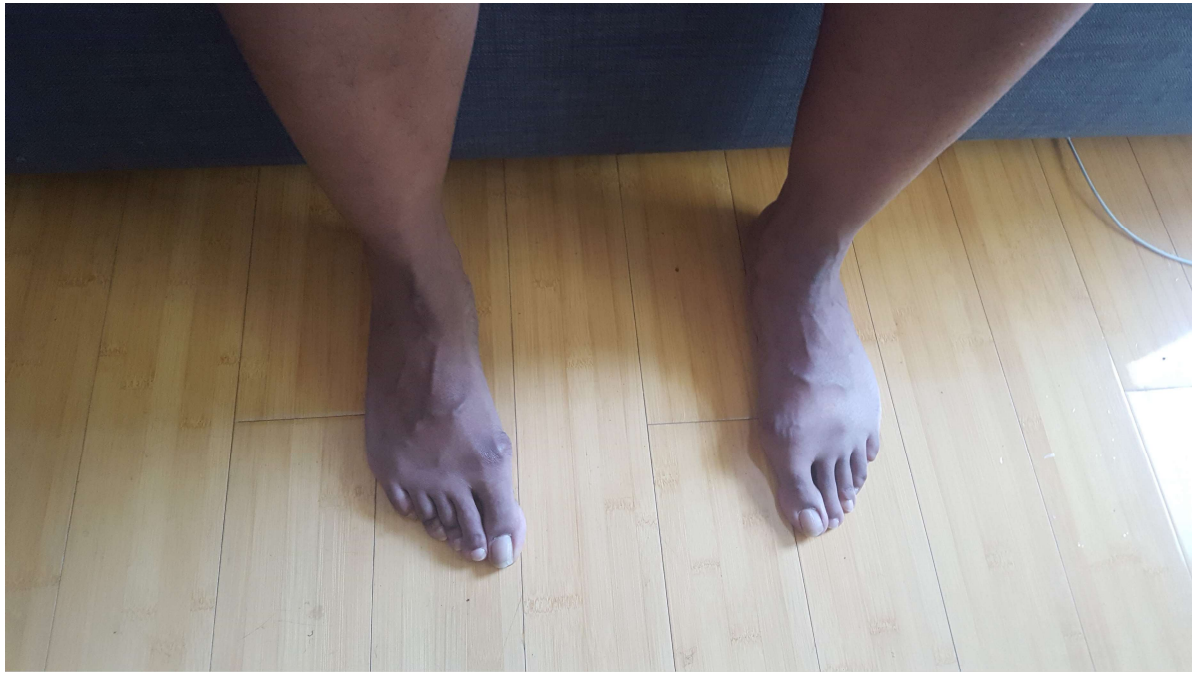


Improving Foot and Ankle Motor Control

Progressive Exercise

Short foot

- Sitting
- Semi-standing



Improving Foot and Ankle Motor Control

Progressive Exercise

Short foot

- With visual feedback

Improving Foot and Ankle Motor Control

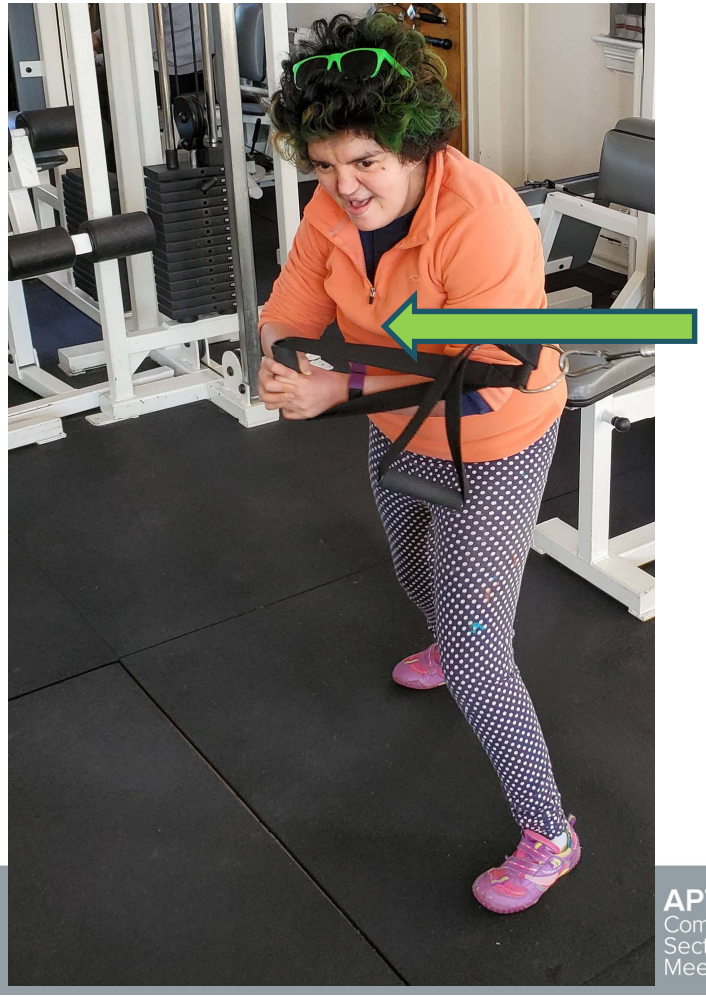
Progressive Exercise

Resisted rotation in split stance

Improving Foot and Ankle Motor Control

Progressive Exercise

- Resisted rotation in split stance



Improving Foot and Ankle Motor Control

Progressive Exercise

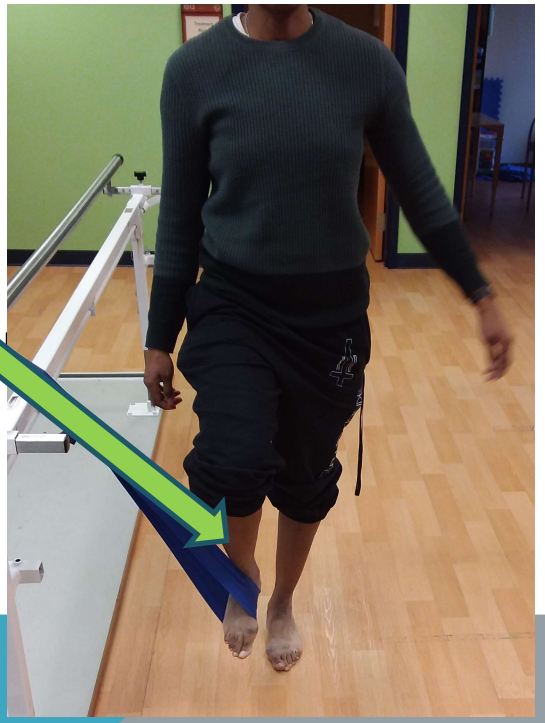
Resisted side step

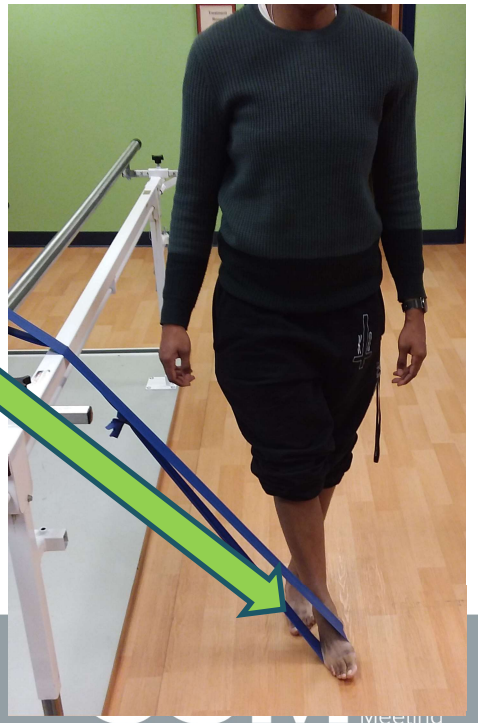
Improving Foot and Ankle Motor Control

Progressive Exercise

Resisted diagonal step-down*

- Progression:
  - Sitting
  - Semi-standing
  - Standing with UE s
  - SLS





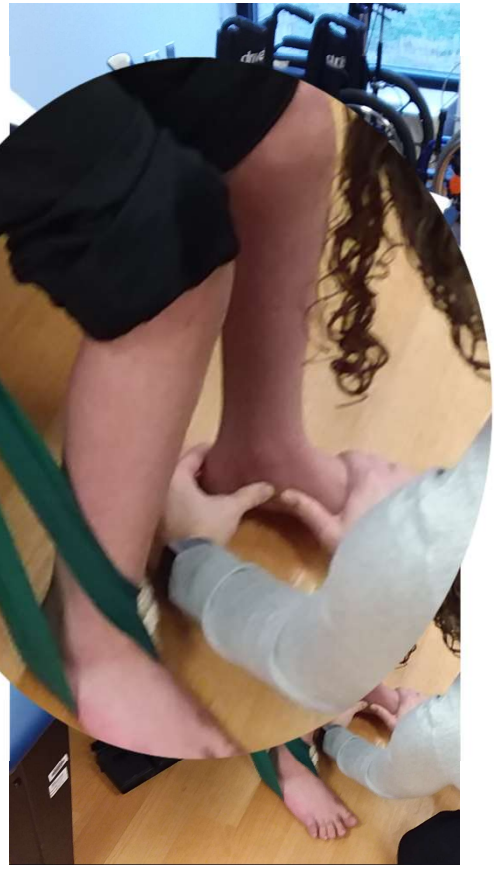
Improving Foot and Ankle Motor Control

Progressive Exercise

Resisted diagonal

step-down

- Sitting, semi-standing
  - Direct assist/cues for alignment of stance foot



Improving Foot and Ankle Motor Control

Progressive Exercise

Resisted diagonal

step-down

- Sitting, semi-standing
  - Indirect assist to align stance limb

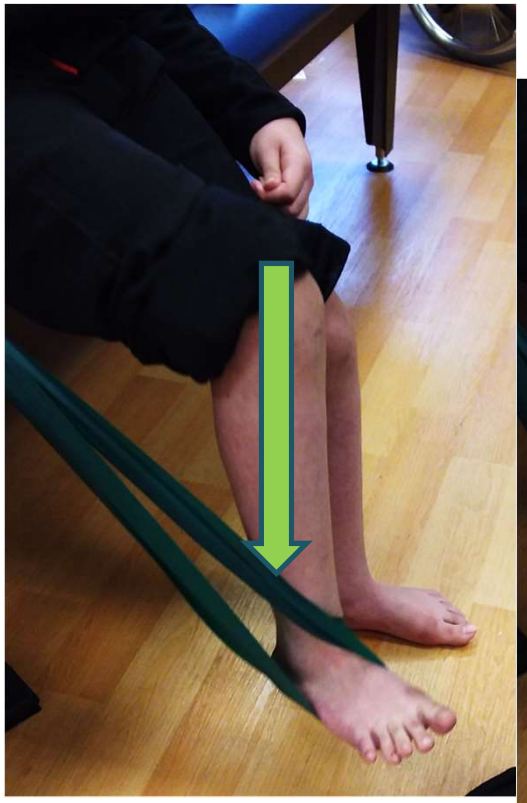
Improving Foot and Ankle Motor Control

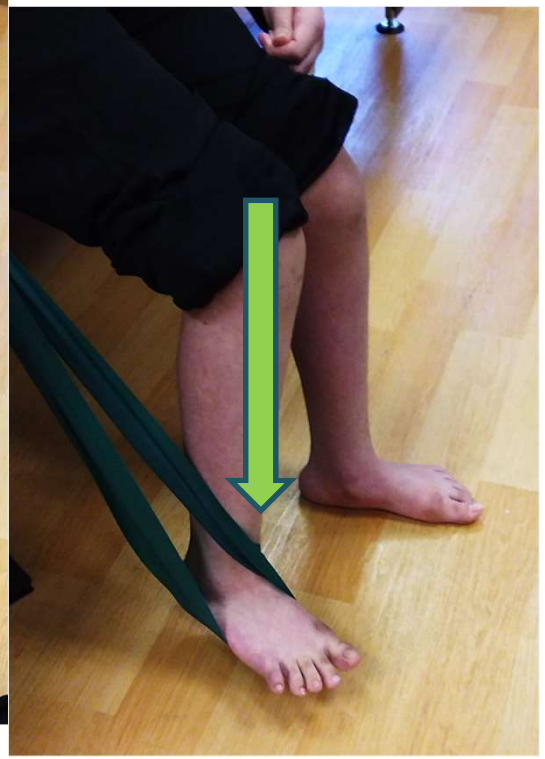
Progressive Exercise

Resisted diagonal

step-down

- Sitting, semi-standing
  - No assist



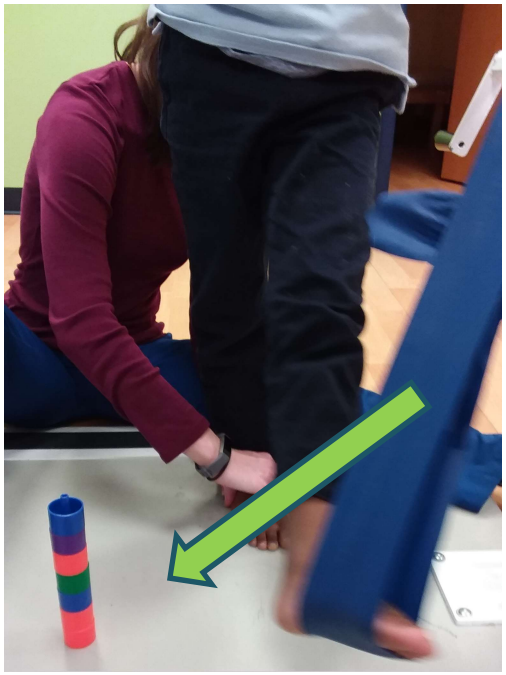


Improving Foot and Ankle Motor Control

Progressive Exercise

Resisted diagonal step-down

- Standing
  - Assist to align stance foot



Improving Foot and Ankle Motor Control

Progressive Exercise

Resisted diagonal step-down

- Standing
  - Standing with UE support

Improving Foot and Ankle Motor Control

Progressive Exercise

Resisted diagonal step-down

- Standing
  - SLS

Improving Foot and Ankle Motor Control

Progressive Exercise

Resisted diagonal step-down

- Standing
  - SLS

Improving Foot and Ankle Motor Control

Progressive Exercise

Resisted hip adduction/abduction

- Progression toward SLS

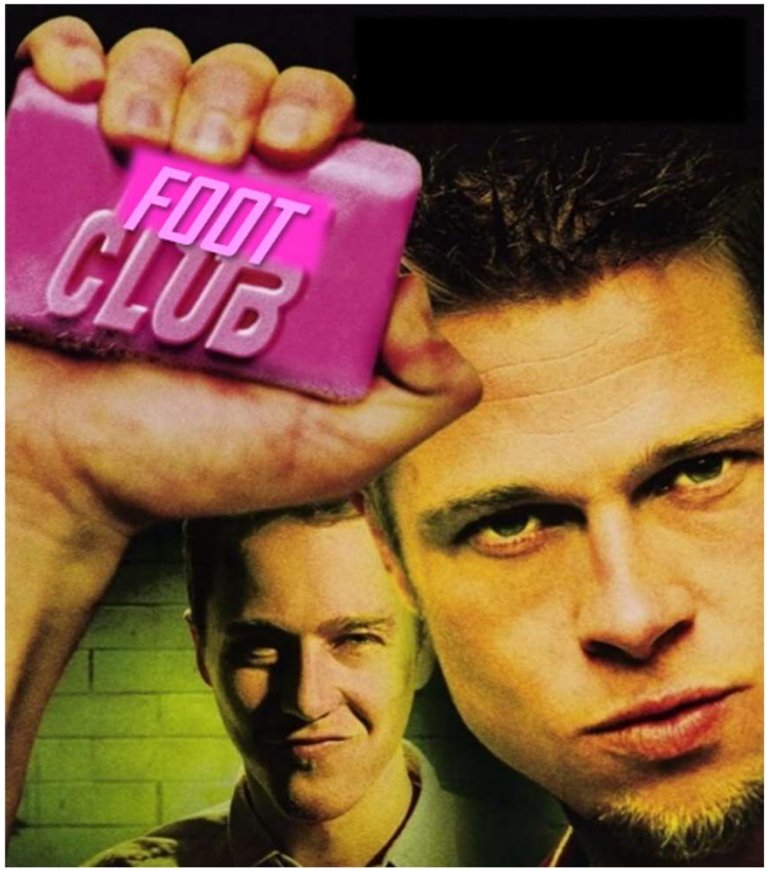
Improving Foot and Ankle Motor Control

Progressive Exercise

Resisted hip flexion/extension
(1^{st} ray stabilization)

- Progression toward SLS

I. Introduction
II. Pediatric Ankle Impairments
III. Do We Need To Intervene?
IV. How Should We Intervene?
    A. #Goals
    B. Motion
    C. Functional Strength
    D. Neuroplasticity
    E. Education
    F. External Supports



How does the developing movement system create a useful cortical matrix of the foot and ankle?

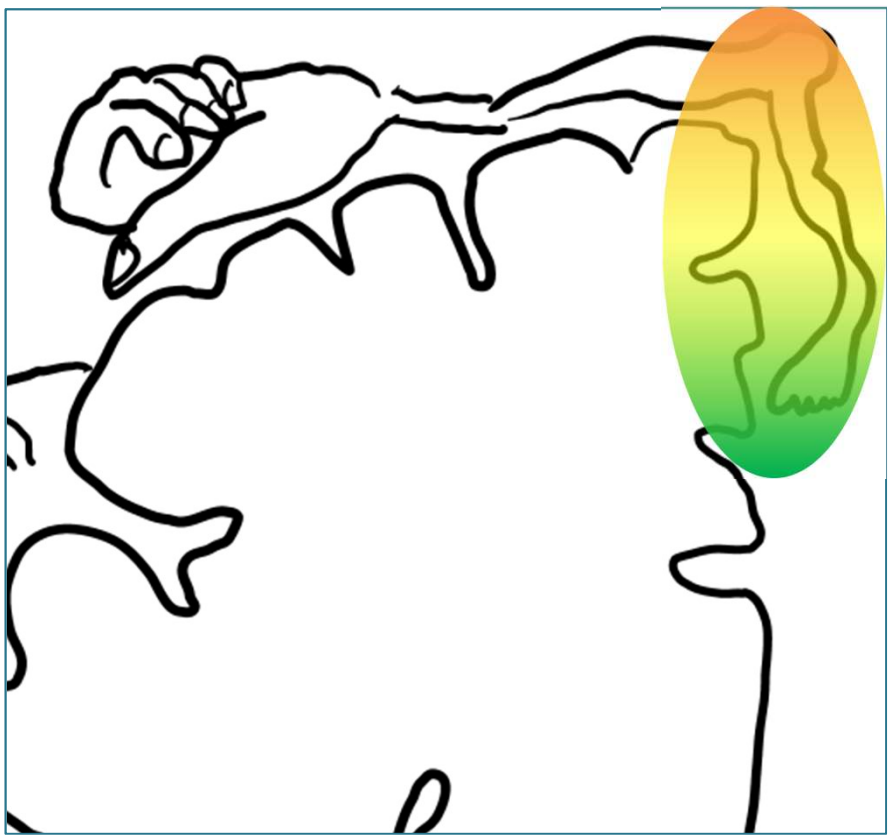
Visual Exploration

Sensory exploration with upper extremities (and mouth)

Bilateral LE sensory exploration

Motor exploration with sensory experiences with the environment

- How can we provide age-appropriate map-building information to developing systems in the context of a health condition?



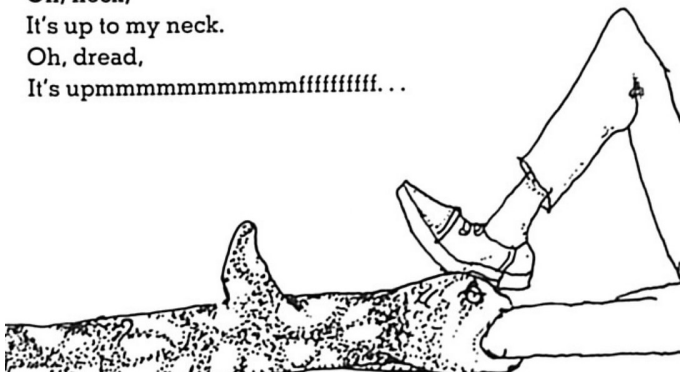
Improving Cortical Mapping

Auditory Activities

- Boa Constrictor

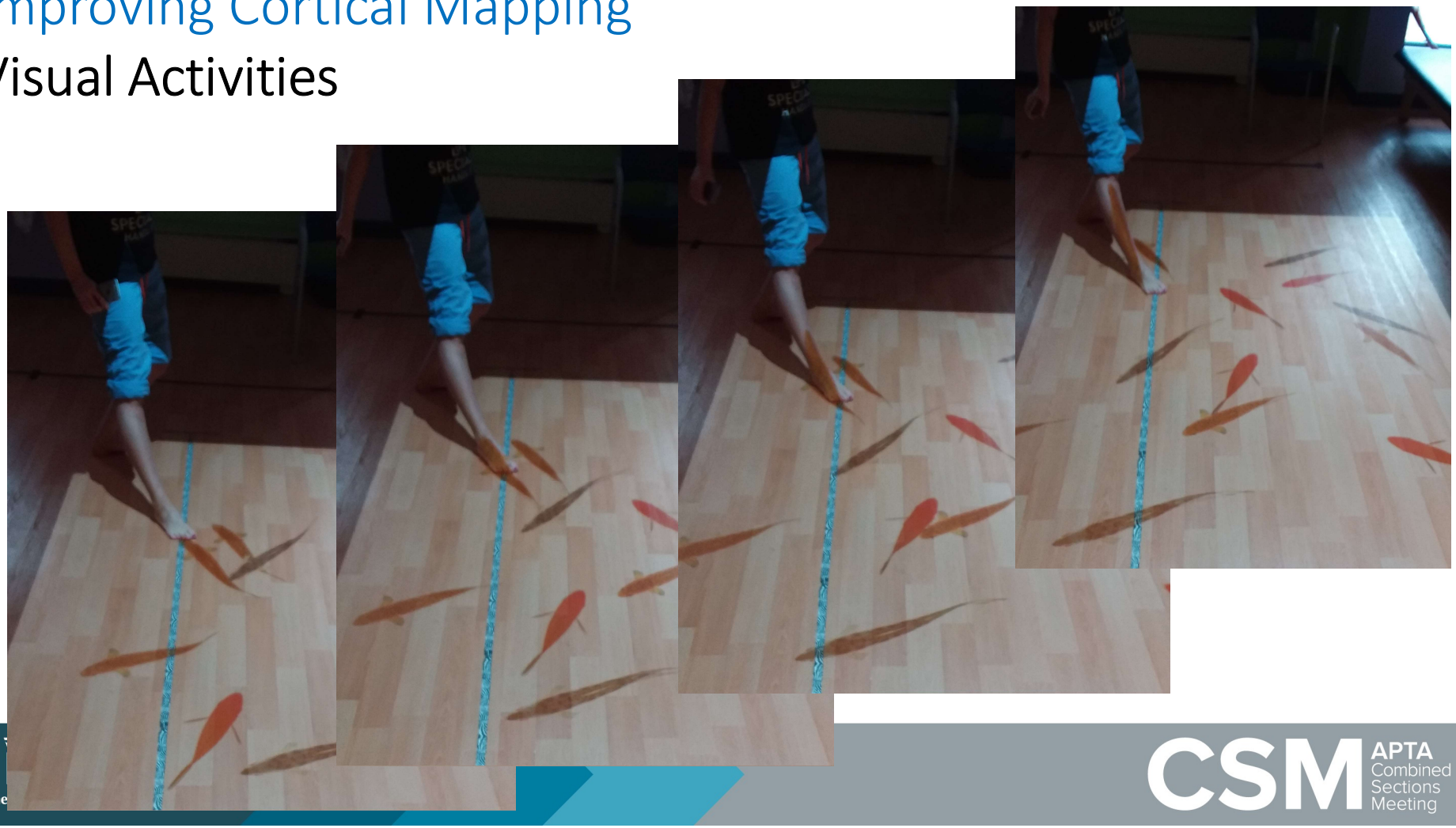
BOA CONSTRICTOR

Oh, I'm being eaten
By a boa constrictor,
A boa constrictor,
A boa constrictor,
I'm being eaten by a boa constrictor,
And I don't like it—one bit.
Well, what do you know?
It's nibblin' my toe.
Oh, gee,
It's up to my knee.
Oh my,
It's up to my thigh.
Oh, fiddle,
It's up to my middle.
Oh, heck,
It's up to my neck.
Oh, dread,
It's upmmmmmmmmmmfffffffff. . .



Improving Cortical Mapping

Visual Activities



Improving Cortical Mapping

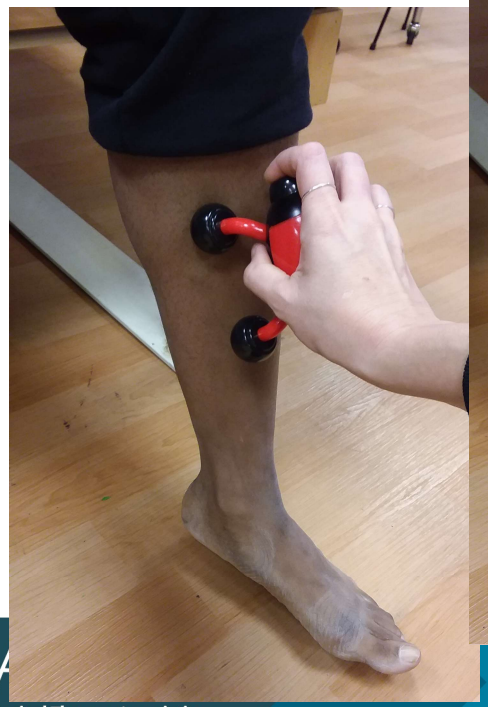
Direct Stimulation

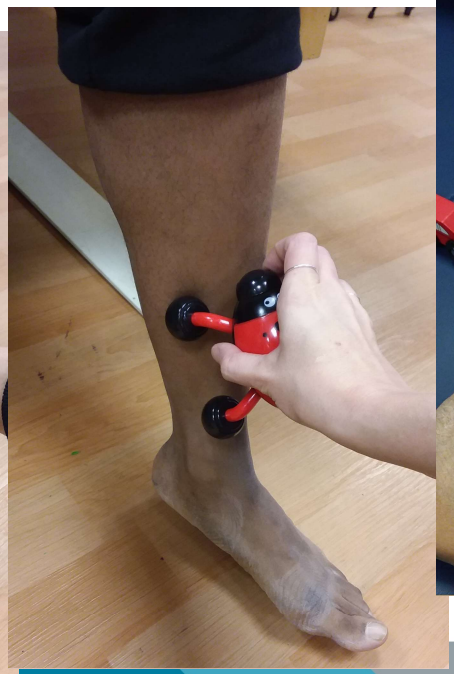
- External
- Assisted
- Self-exploration
- Comparison– helping the patient “calibrate” by comparing the sensation to a more familiar area of the body

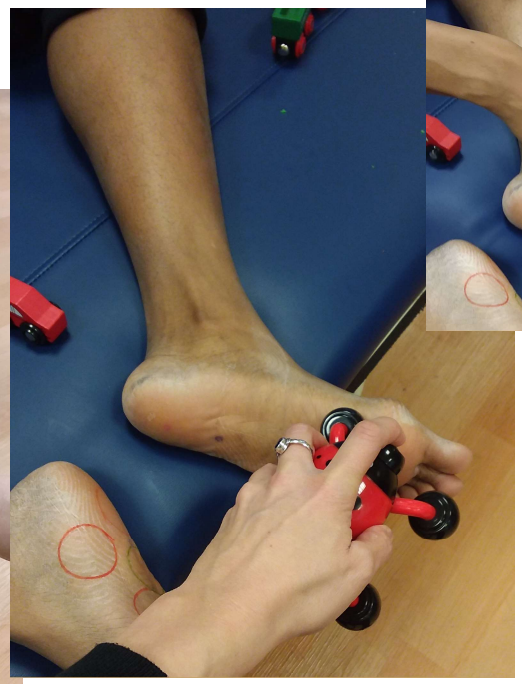
Improving Cortical Mapping

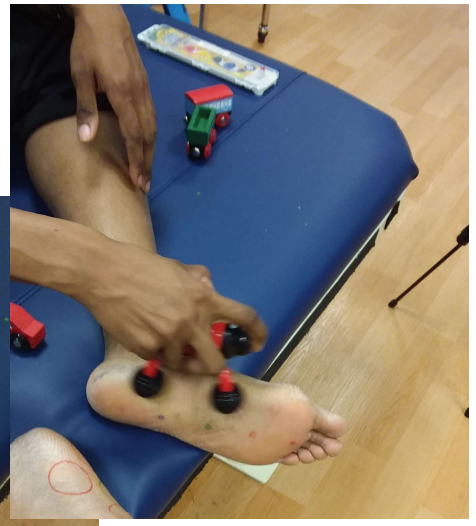
Direct Stimulation

Example: vibration





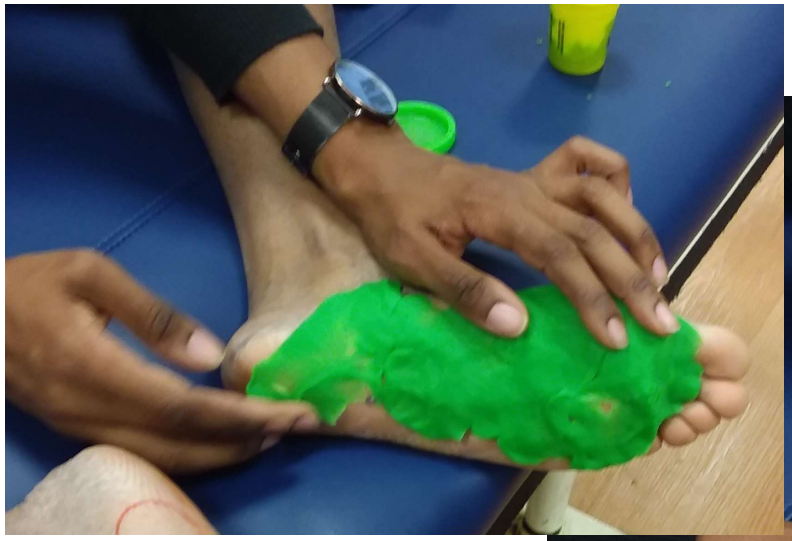


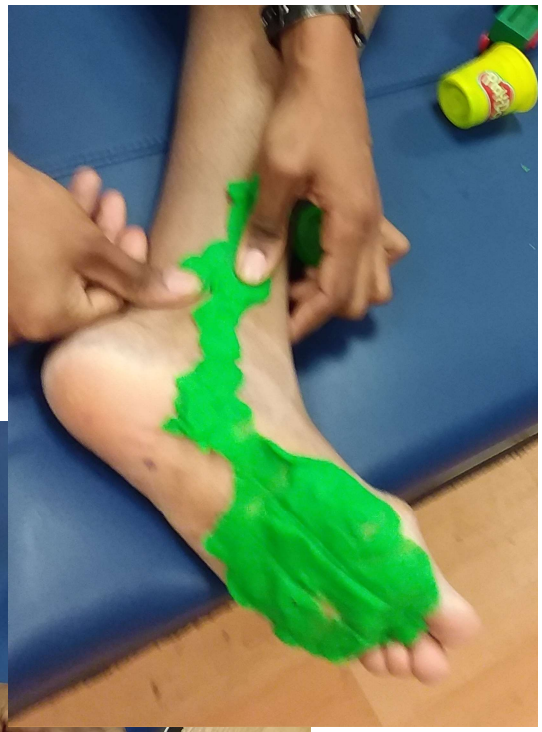


Improving Cortical Mapping

Sensory Exploration

FEETCRAFT



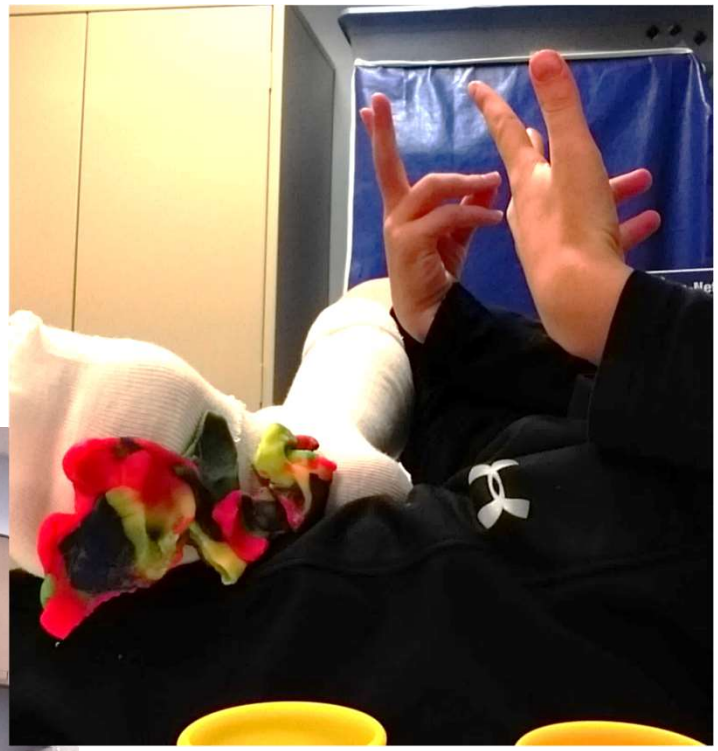


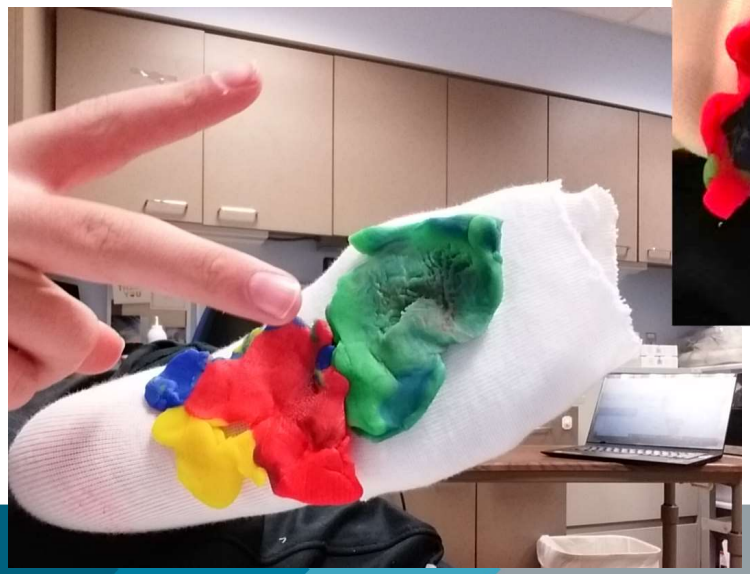
Improving Cortical Mapping

Sensory Exploration

ABSTRACT ART

FEET GRAFFITI





Improving Cortical Mapping

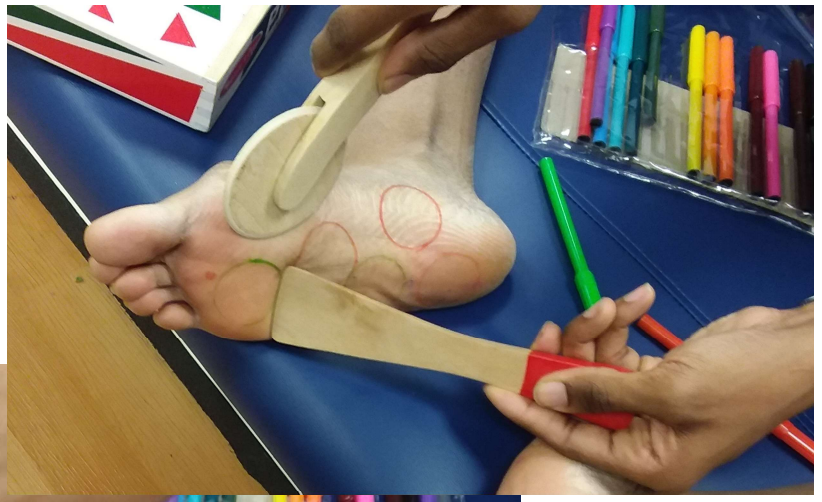
Sensory Exploration

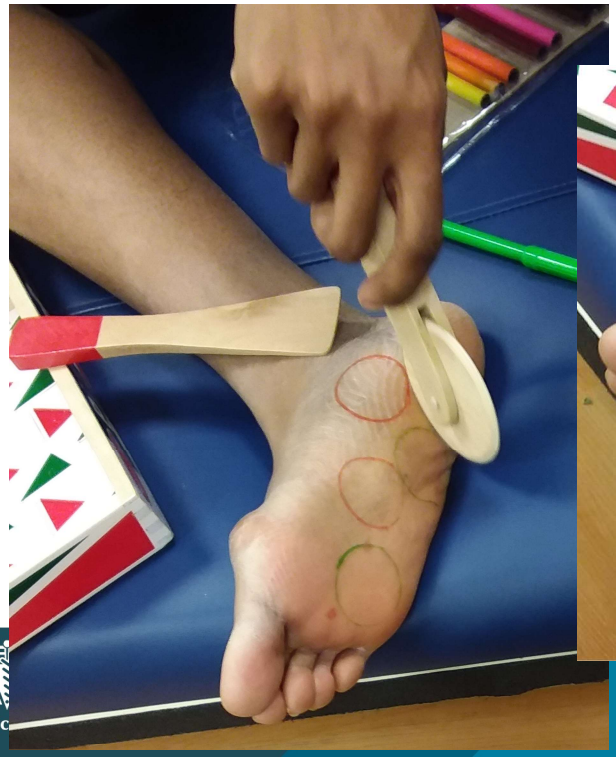
Feet pizza

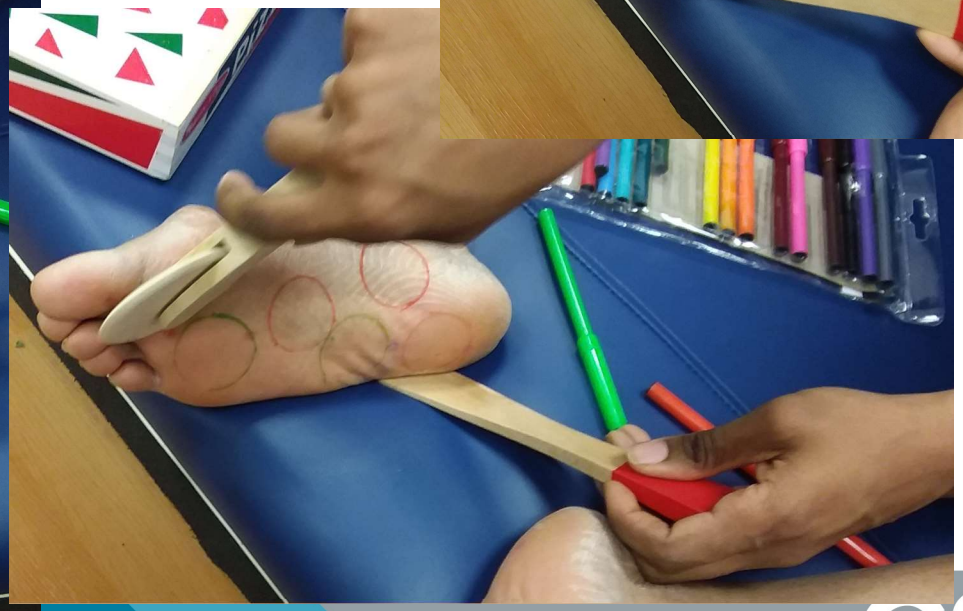
Improving Cortical Mapping

Sensory Exploration

"It's not delivery, it's de feet!"

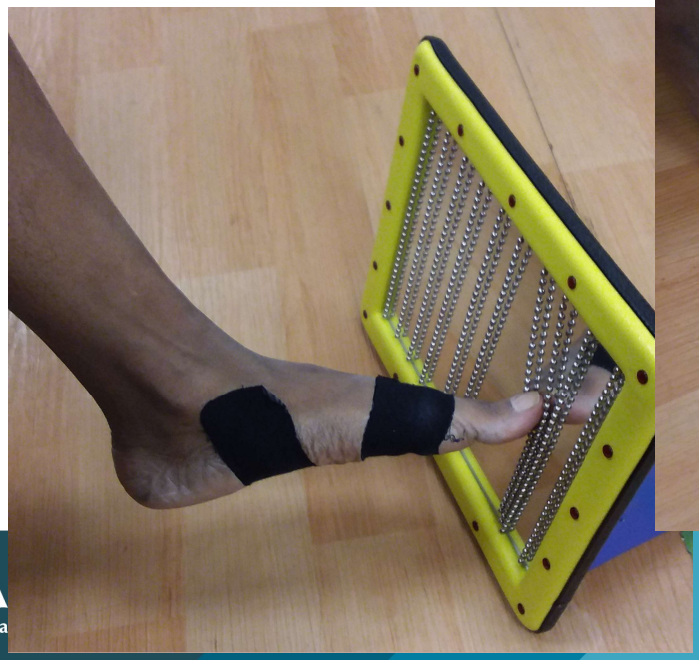


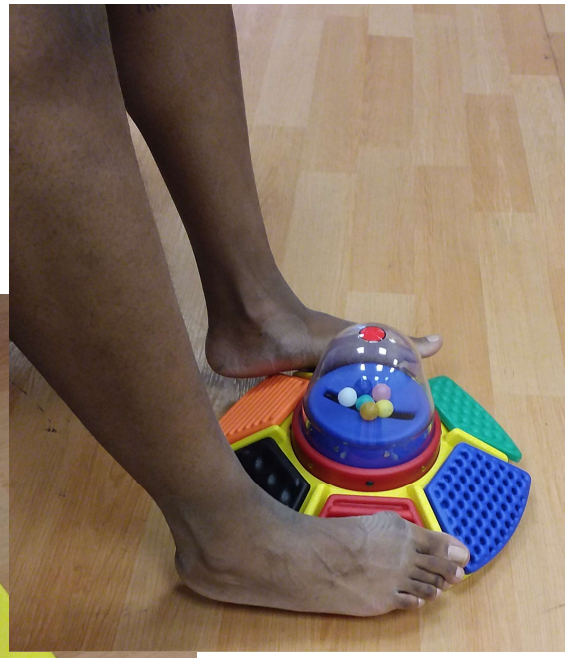




Improving Cortical Mapping

Enhanced Sensory-Motor Activities

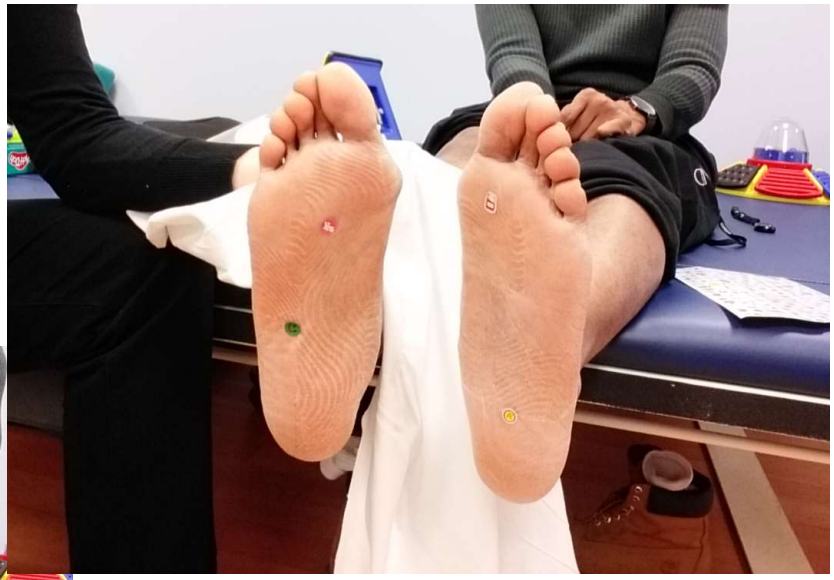


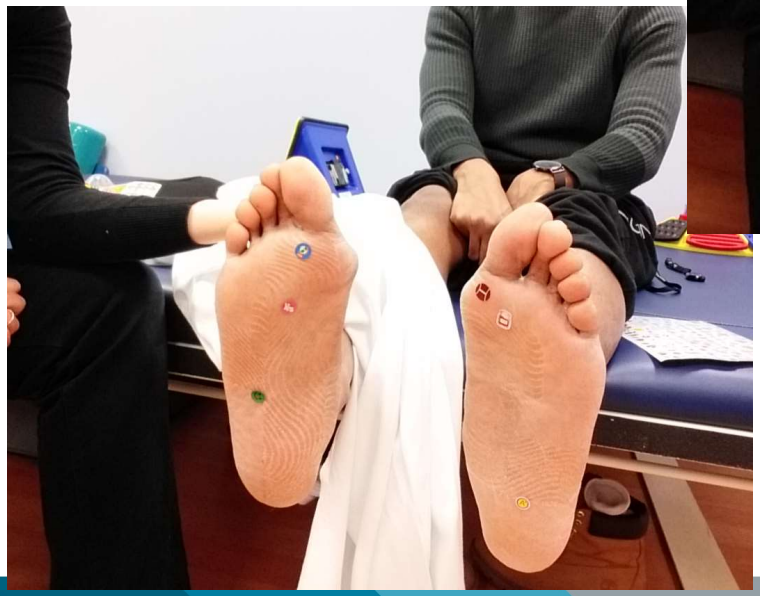


Improving Cortical Mapping

Mapping Activities

Sticker matching: contralateral

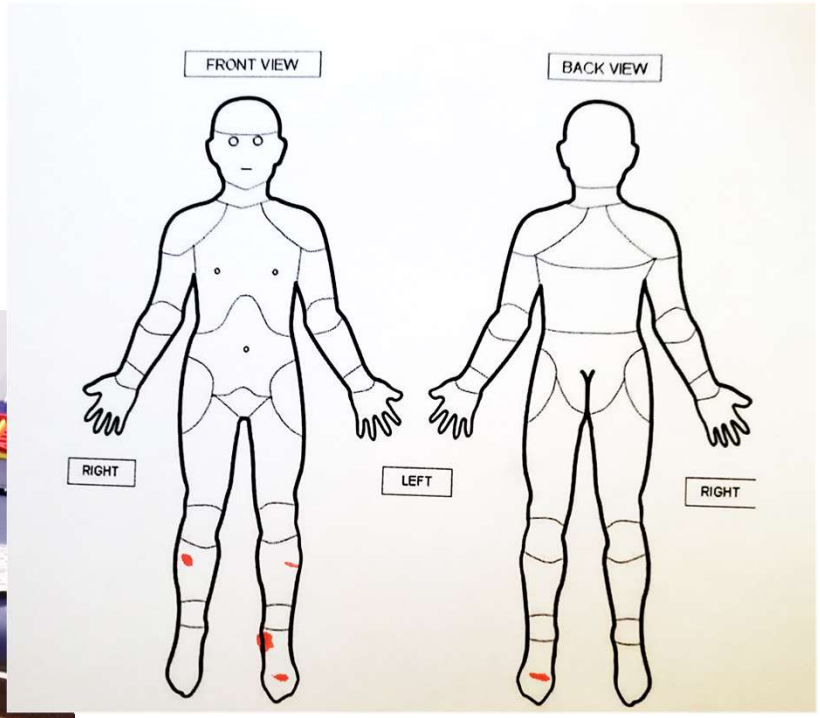




Improving Cortical Mapping

Mapping Activities

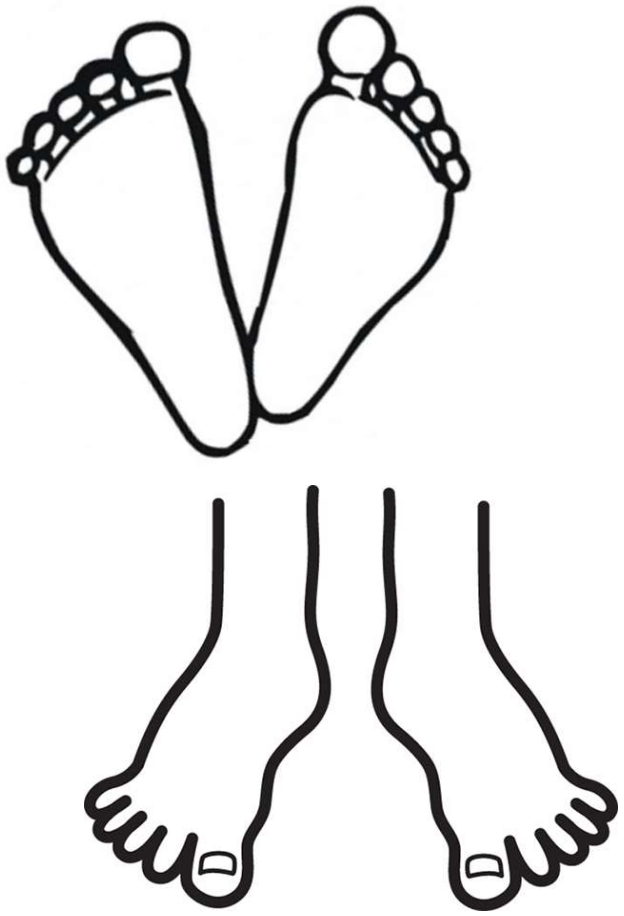
Sticker matching: paper map



Improving Cortical Mapping

Mapping Activities

Sticker matching: paper map



Improving Cortical Mapping

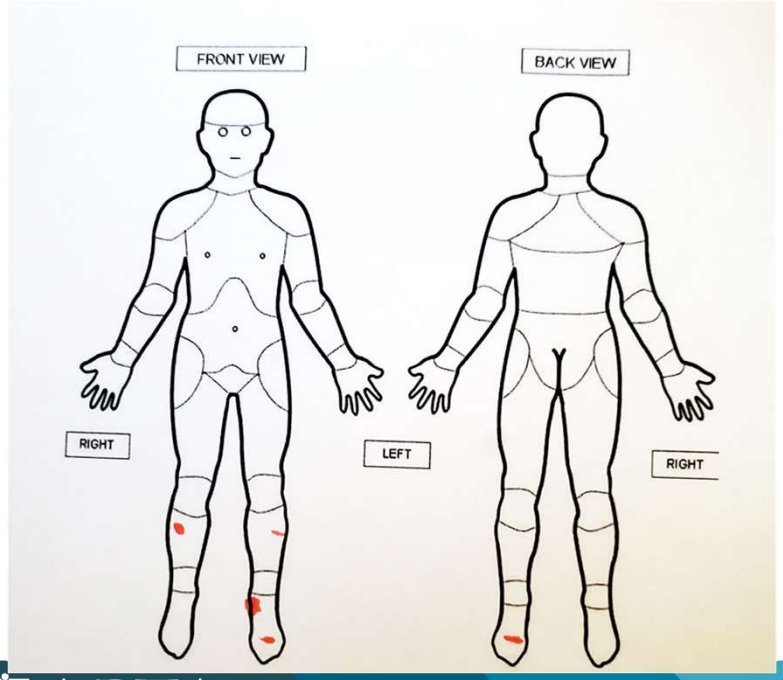
Mapping Activities

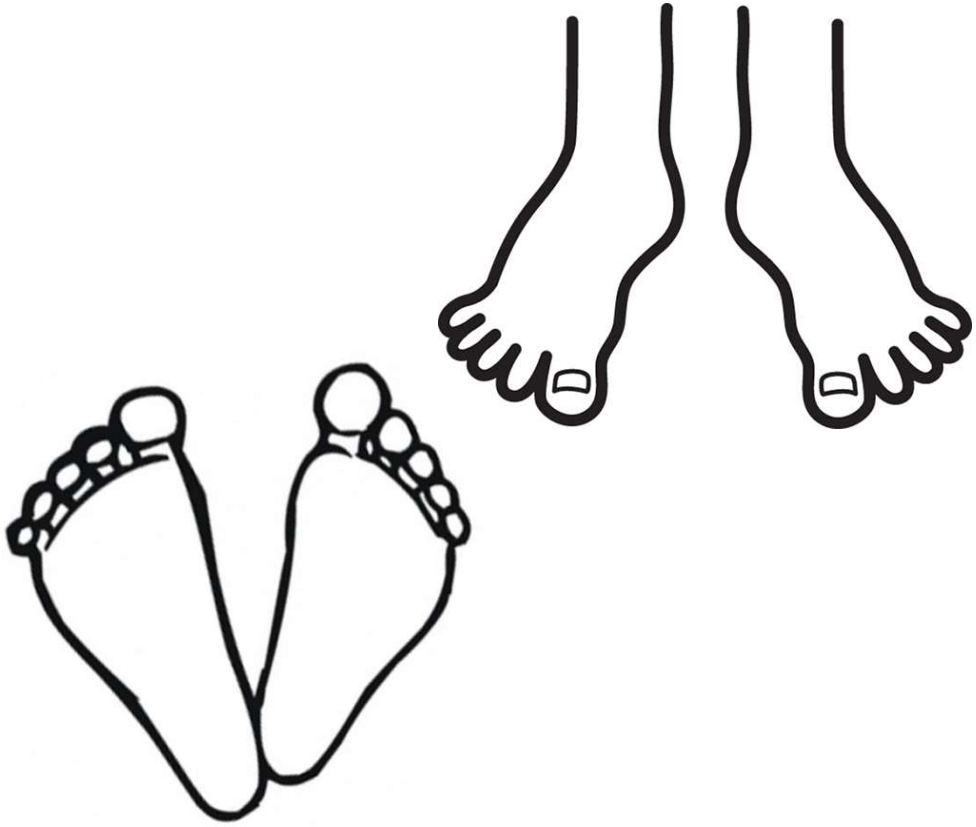
- Assisted map building
- Color zones

Improving Cortical Mapping

Mapping Activities

Left/right, medial/lateral

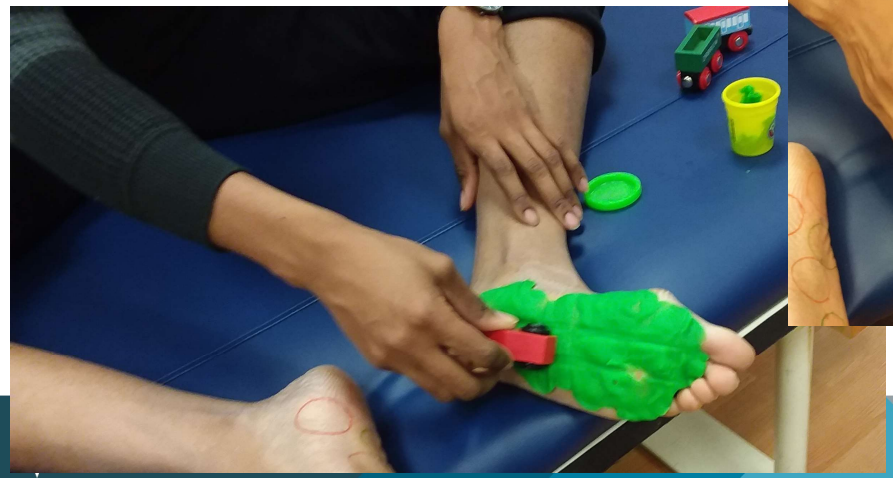




Improving Cortical Mapping

Mapping Activities

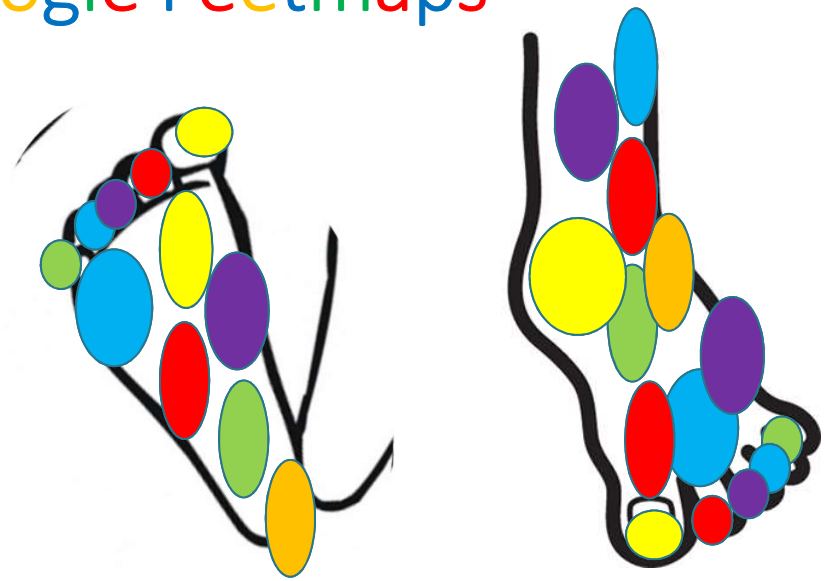
Google Feetmaps



Improving Cortical Mapping

Mapping Activities

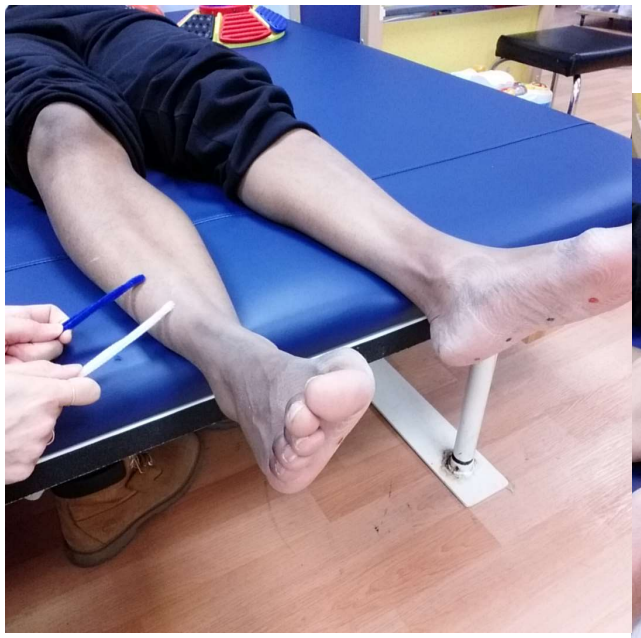
Google Feetmaps

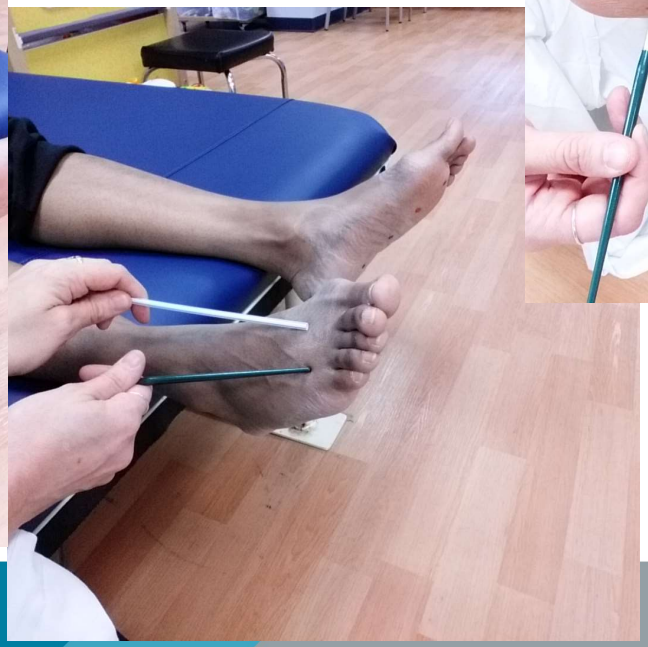


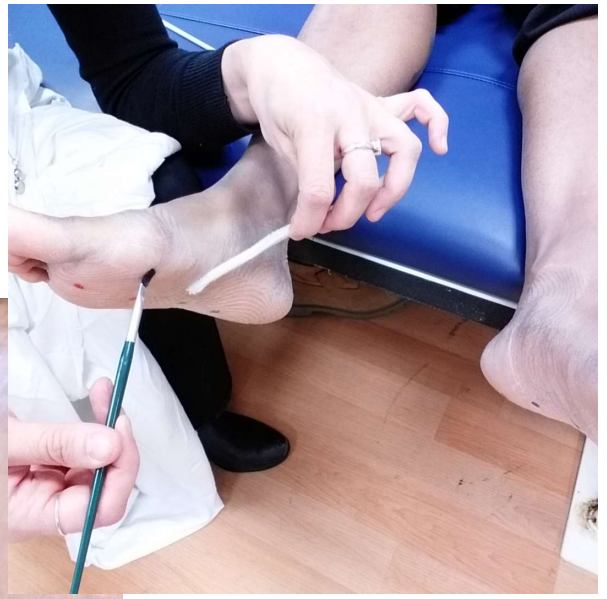
Improving Cortical Mapping

Mapping Activities

2 point discrimination







Improving Cortical Mapping

Mapping Activities

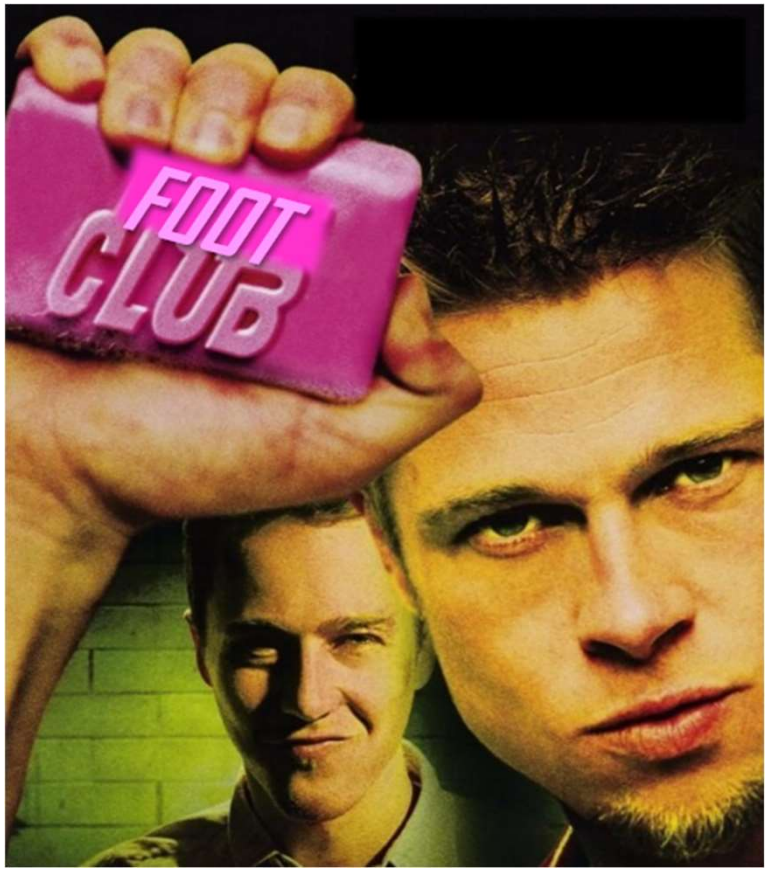
Stereognosis

Improving Cortical Mapping

Use of Resistance

Use of resistance to kinesthesia and motor response

I. Introduction
II. Pediatric Ankle Impairments
III. Do We Need To Intervene?
IV. How Should We Intervene?
    A. #Goals
    B. Motion
    C. Functional Strength
    D. Neuroplasticity
    E. Education
    F. External Supports



Pain Neuroscience Education (PNE)

- Pain Neuroscience Education: State of the Art and Application in Pediatrics. (Hannah 2016)
- The efficacy of pain neuroscience education on musculoskeletal pain: A systematic review of the literature. (Louw 2016)
- The clinical application of teaching people about pain. (Louw 2016)
- Use of Pain Neuroscience Education, Tactile Discrimination, and Graded Motor Imagery in an Individual With Frozen Shoulder. (Sawyer 2018)
- Know Pain, Know Gain? A Perspective on Pain Neuroscience Education in Physical Therapy. (Louw 2016)

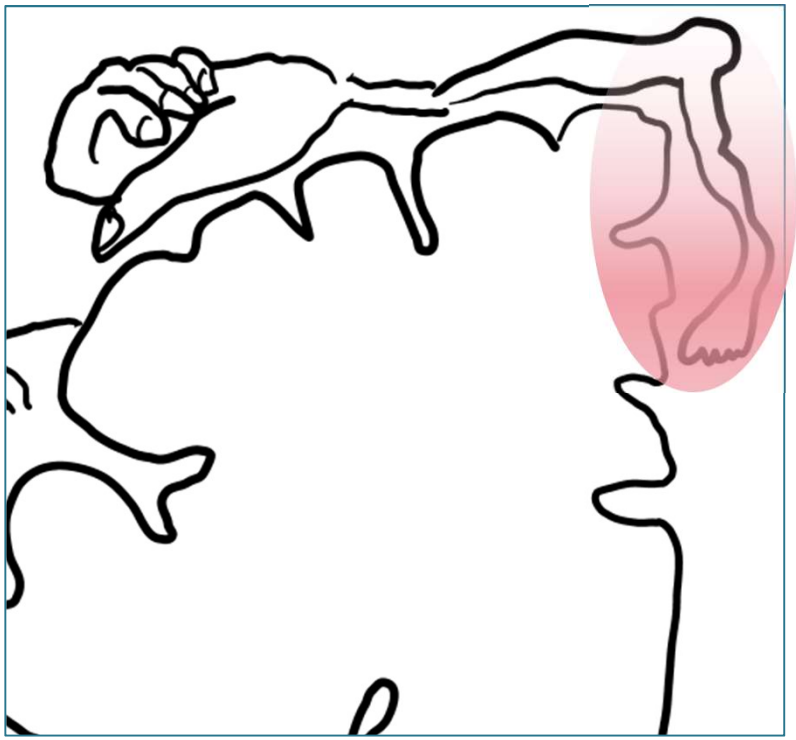
Pain Neuroscience Education (PNE)

What individuals need:

- To be heard
- Validation of their experience
- Reassurance
- Realistic *but optimistic* expectations
- Education regarding pain mechanisms

Developmental Pain Neuroscience Education (D-PNE)

Supporting the individual to develop a developmentally-appropriate, personal system for describing discomfort and pain



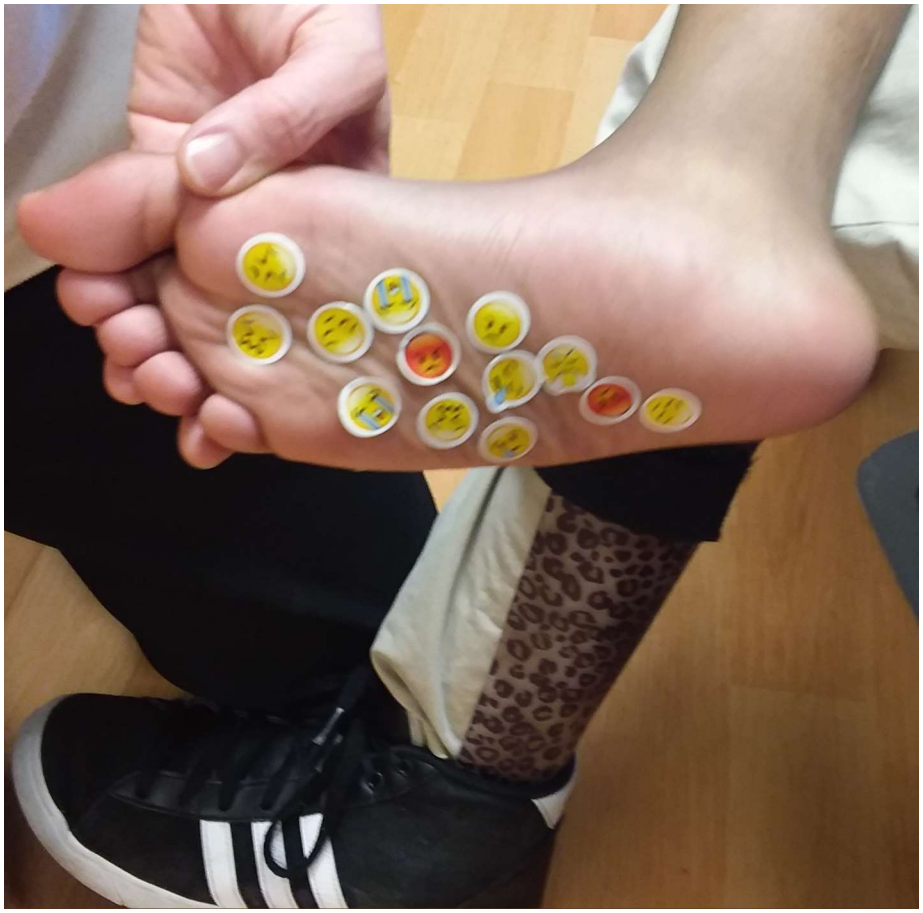
Developmental Pain Neuroscience Education (D-PNE)

- Compare expectations of pain tolerance and expression to those of neurotypical children
- Education on various kinds of pain
    - Stretch/"good hurt"
    - Damage/"bad hurt"
    - Muscle soreness
- Listen, **believe**, explore, educate, and **learn**

D-PNE

Emoji therapy: direct

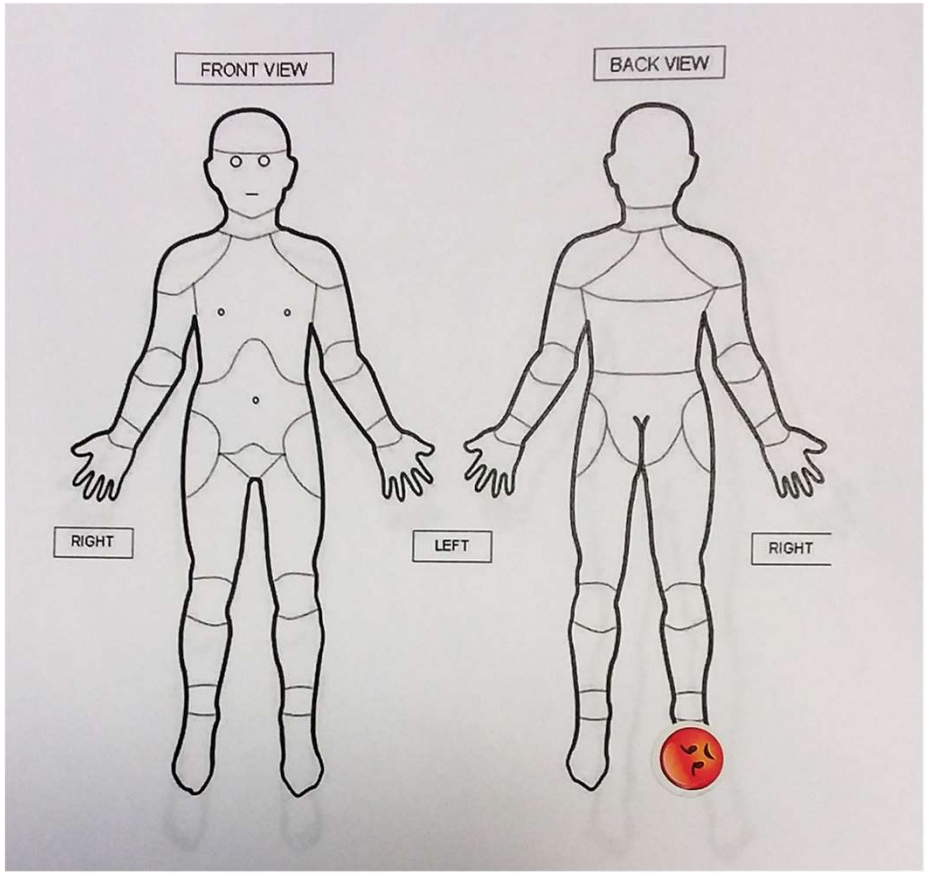
- Acknowledging pain



D-PNE

Emoji therapy: indirect

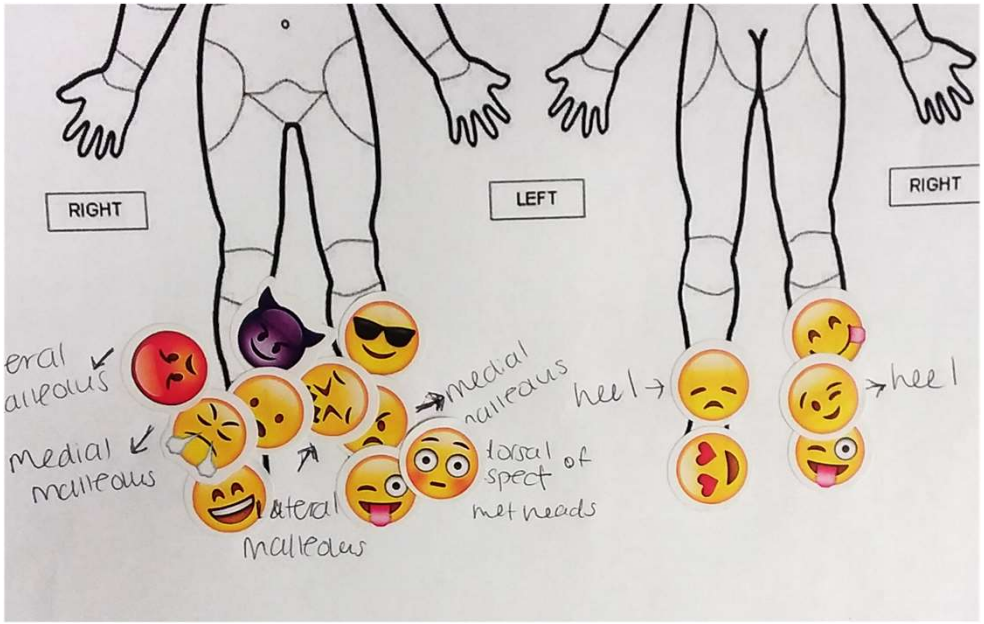
- Acknowledging pain
- Directing attention



D-PNE

Emoji therapy: indirect

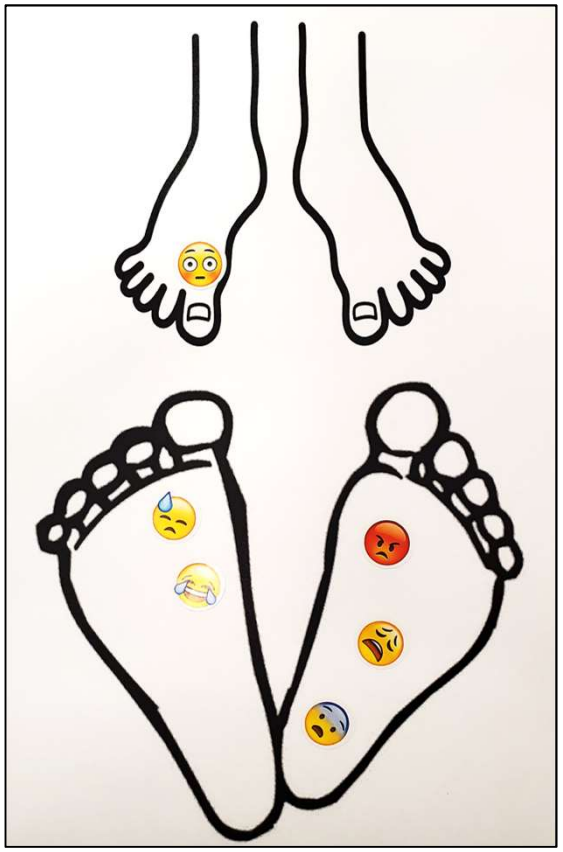
- Acknowledging pain
- Directing attention



D-PNE

Emoji therapy: indirect

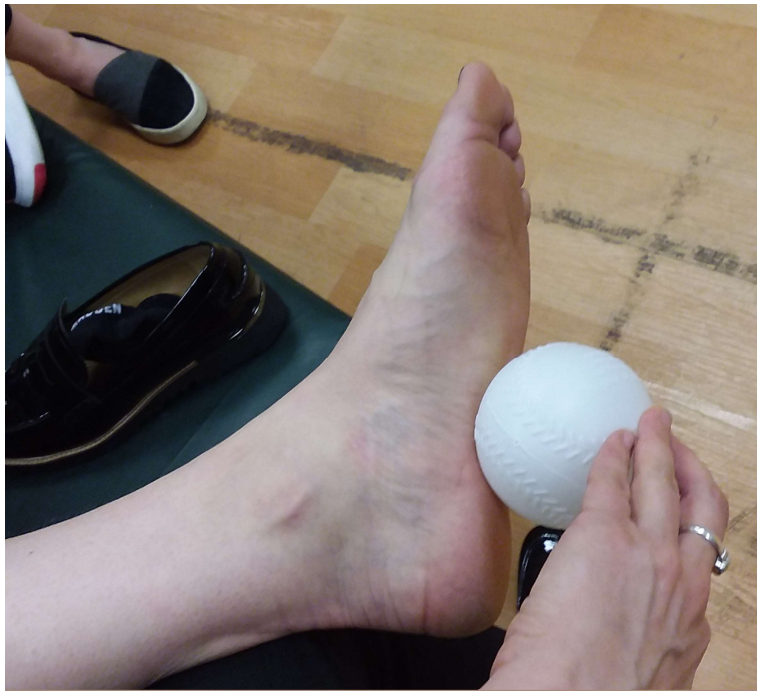
- Acknowledging pain
- Directing attention



D-PNE

Progressing input

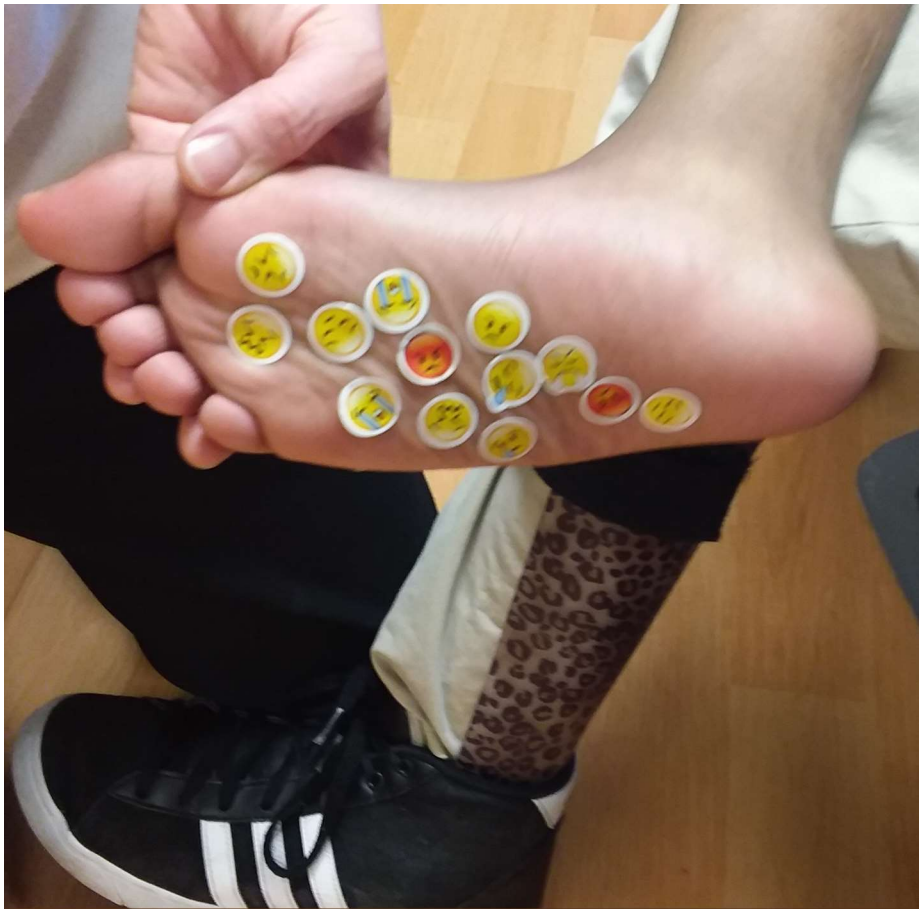
- Finding the borders of pain
- *Anxiety with loss of pain



D-PNE

Emoji therapy: direct

- Acknowledging pain



D-PNE

Emoji therapy: direct

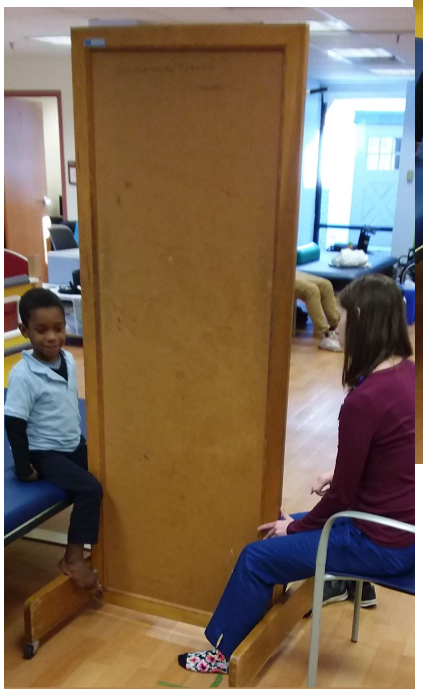
- Acknowledging pain

Health Condition Education

- Meet patient where they are
- Use the ICF Model as a guide
- Ask *if* and *what* they want to know about their health condition
- Use positive, developmentally appropriate stories
  - "Sticky" stories

Health Condition Education

Sticky stories



Therapeutic Alliance

In neurotypical adults, athletes, older adults:

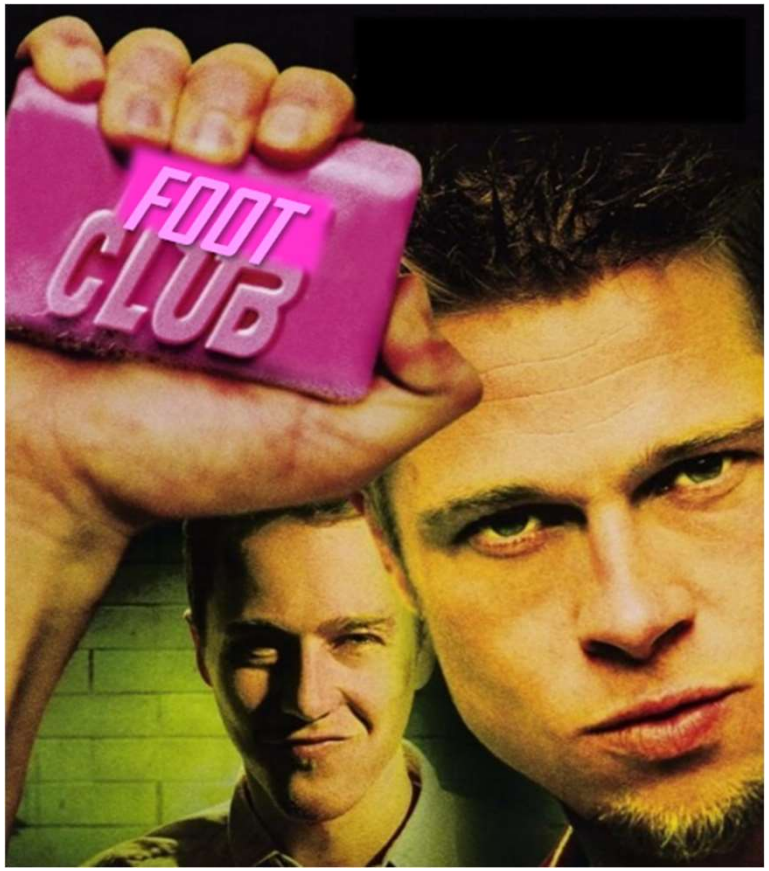
- Kinesiophobia and low self-efficacy are associated with decreased:
  - Postural control, range of motion, gait parameters

- High self-efficacy is associated with increased performance

Therapeutic Alliance

Self-efficacy, flow, affect, worry and performance in elite world cup ski jumping. (Sklett 2018)

I. Introduction
II. Pediatric Ankle Impairments
III. Do We Need To Intervene?
IV. How Should We Intervene?
    A. #Goals
    B. Motion
    C. Functional Strength
    D. Neuroplasticity
    E. Education
    F. External Supports



External Supports

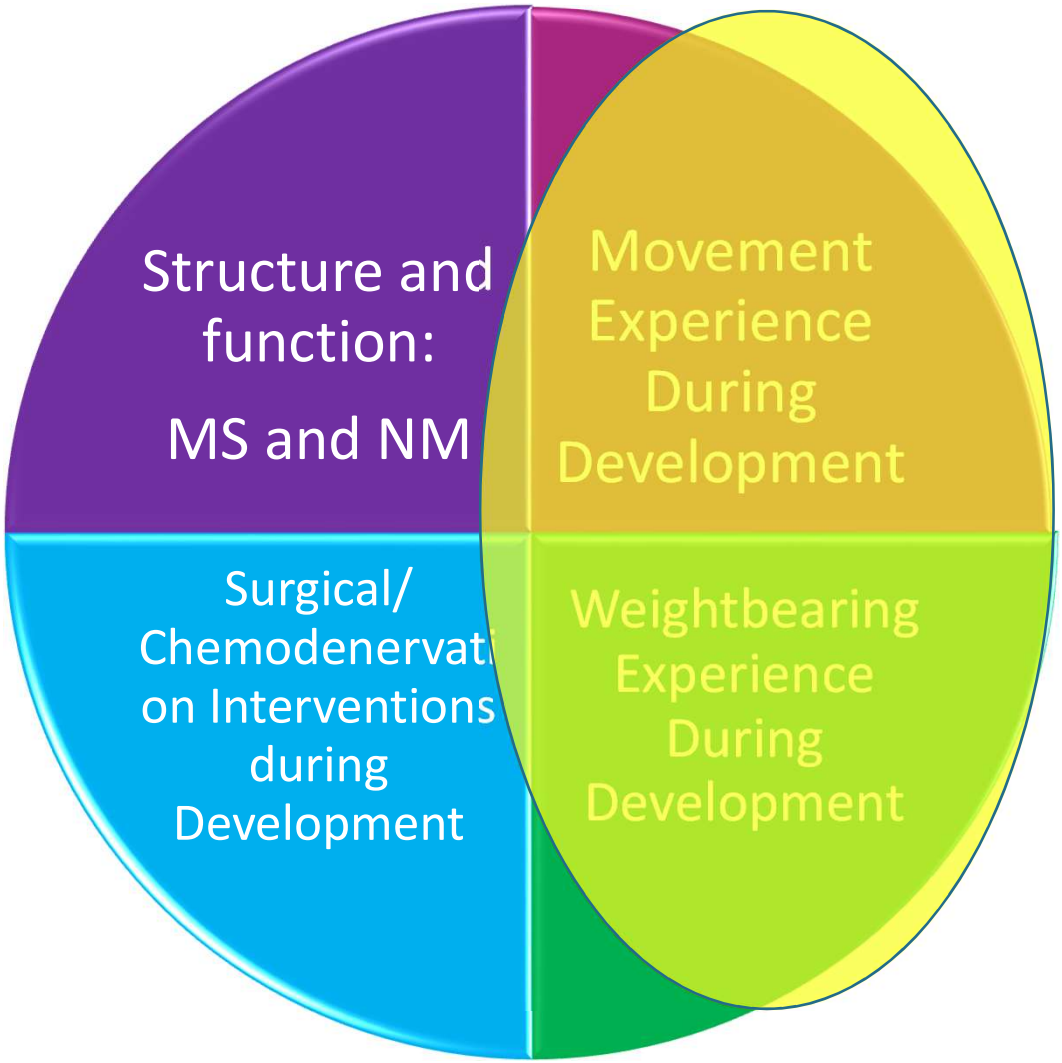
Taping, Orthotics, and Casting

External Supports

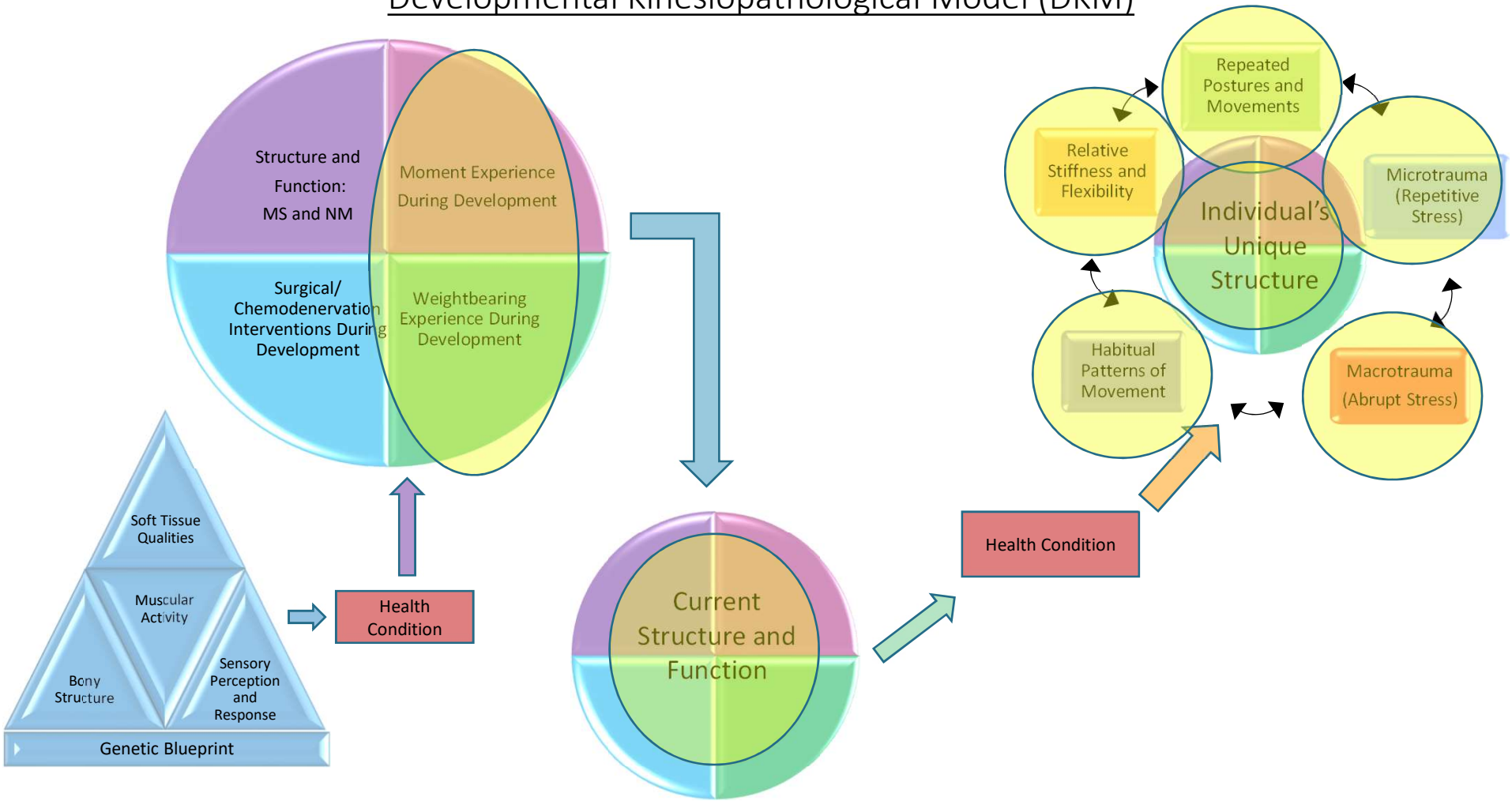
- Targeted use of external support to guide adaptive tissue-specific stresses
- Adjuncts to joint mobilization/soft tissue interventions

External Supports

- Support for emerging neuromotor control
- Support for mass practice of motor skill
- Supporting repeated movements and sustained alignments that promote best possible structural development


Structure and function:
MS and NM
Movement Experience During Development
Surgical/ Chemodenervation Interventions during Development
Weightbearing Experience During Development

Developmental Kinesiopathological Model (DKM)



Orthotic Intervention

Developmental Kinesiopathology

An orthoses can guide forces during repetitive movement and sustained alignments in order to:

- provide stress and strain that encourage tissues to form in a manner compatible with healthy movement patterns.
- reduce the system's tendency to experience microtrauma and macrotrauma in the future.
- provide mass practice of target motor patterns.

Brace “Prescription” versus “Design”

Prescription: Capturing the individual characteristics of the movement system, including structural variants and support of compromised or at-risk structures

Design: Selection of brace features

Brace “Prescription” versus “Design”

- Prescription: helping the body interface with the world

Orthotic Prescription

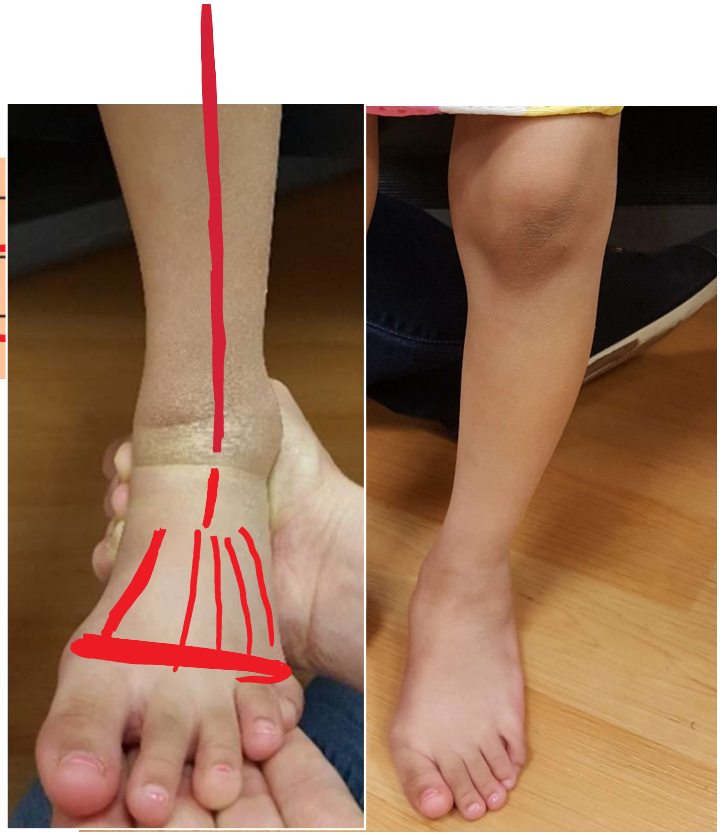
- Structural Findings

  What structural findings need to be captured in the device to allow the movement system to interface with the world?

Orthotic Prescription: TC Axis Test

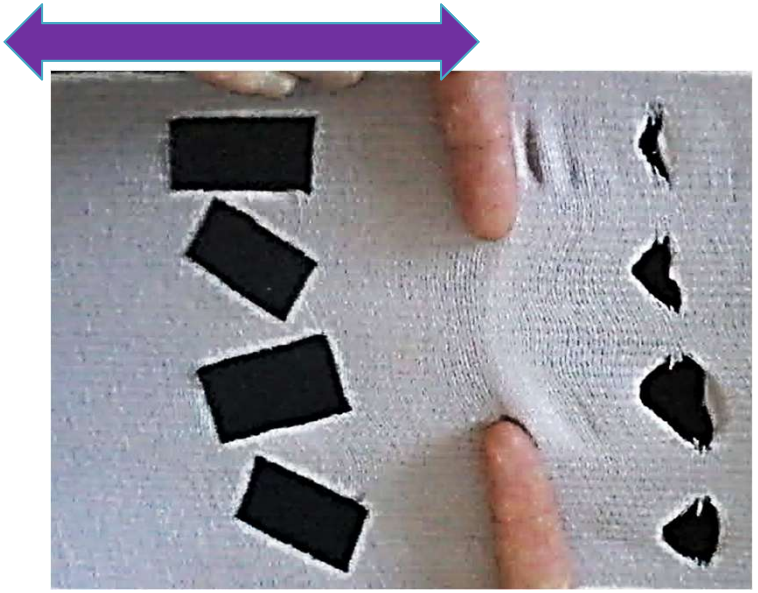
- ❒ Structural variants_____
  - ❒ Atypical structure
  - ❒ TC Axis test: TC joint alignment_____
  - ❒ Structural findings:

- Identifying the axis of the talo-crural joint
- Identifying structural variants



Orthotic Prescription

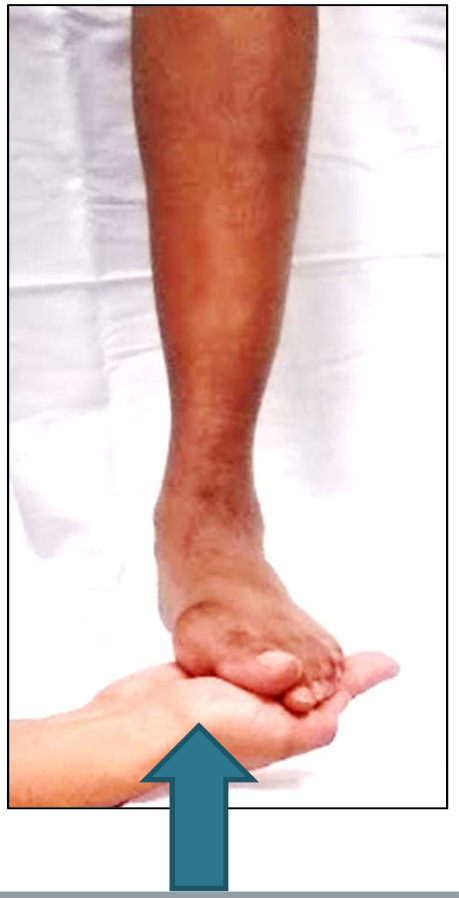
- ❑ Functional Findings
  - In what way does the system tend to move?
  - What structures need protection?
  - What structures need forces directed to them?



Orthotic Prescription: DF Stress Test

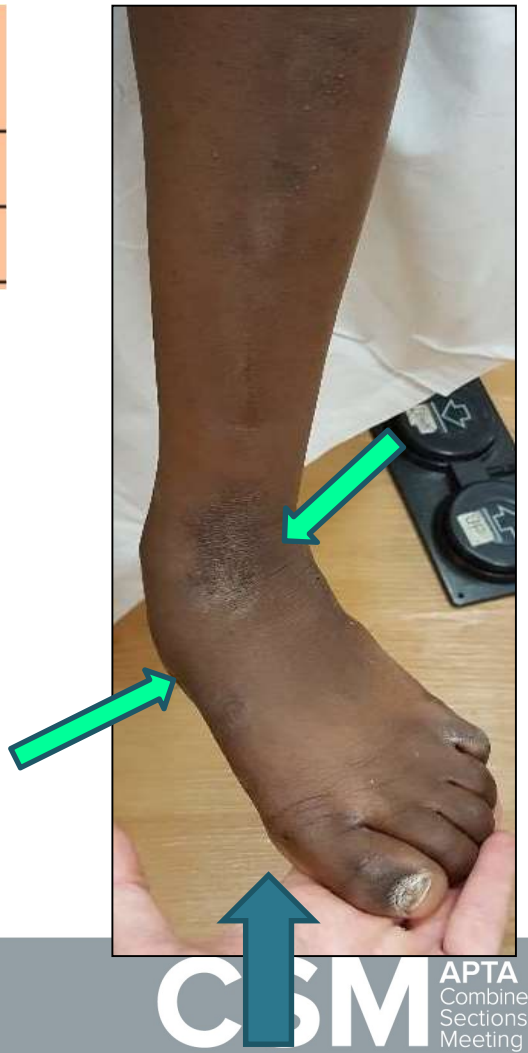
- ❒ Functional Variants
  - ❒ DF Stress test, End feel
    - ❒ 1-Neutral hindfoot_____
    - ❒ 2-Pronated hindfoot_____
    - ❒ 3-Supinated hindfoot_____

- Where does DF (foot towards tibia) occur when a general stress is applied?
- What structures limit further motion in the direction of foot toward tibia?



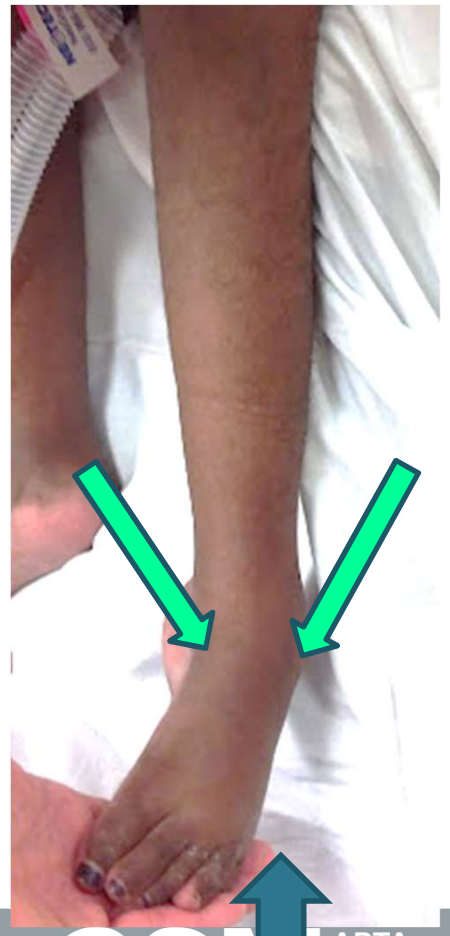
- ❒ Functional Variants
  - ❒ DF Stress test, End feel
    - ❒ 1-Neutral hindfoot_____
    - ❒ 2-Pronated hindfoot____
    - ❒ 3-Supinated hindfoot____

2. Pronated hindfoot



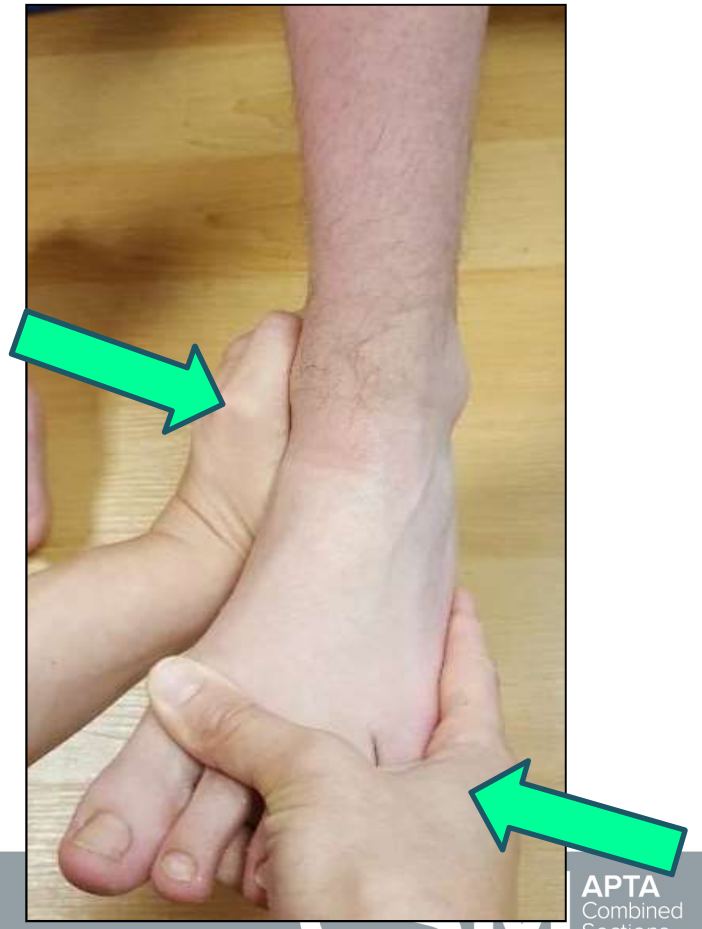
- ❒ Functional Variants
  - ❒ DF Stress test, End feel
    - ❒ 1-Neutral hindfoot_____
    - ❒ 2-Pronated hindfoot____
    - ❒ 3-Supinated hindfoot____

3. Supinated hindfoot



Orthotic Design

- NWB Corrective Force
  - What support is required to:
  - Bring the foot and ankle in into position with the joints congruent?

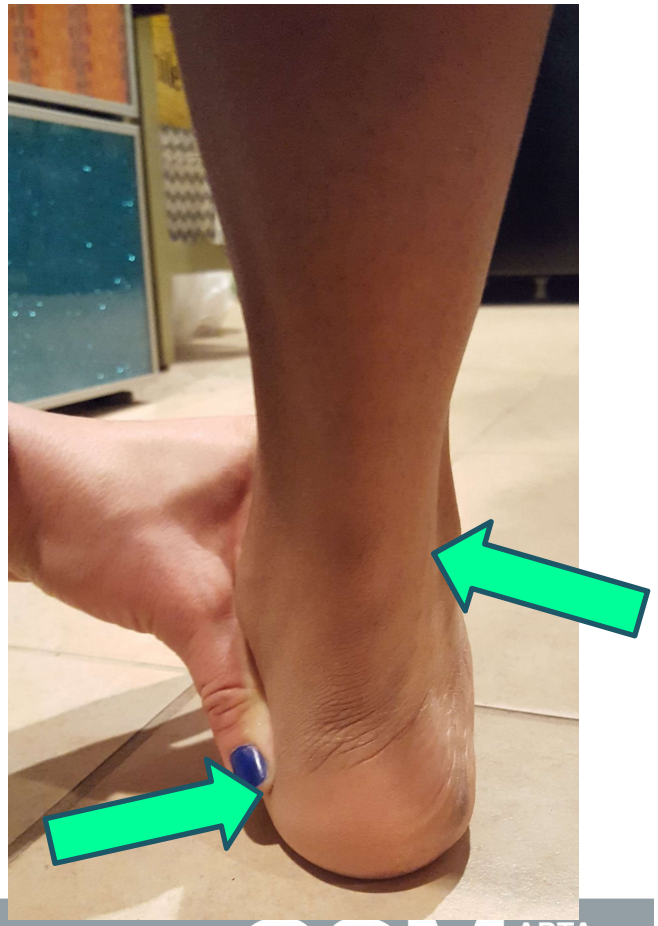


Orthotic Design

- WB Corrective Force Test

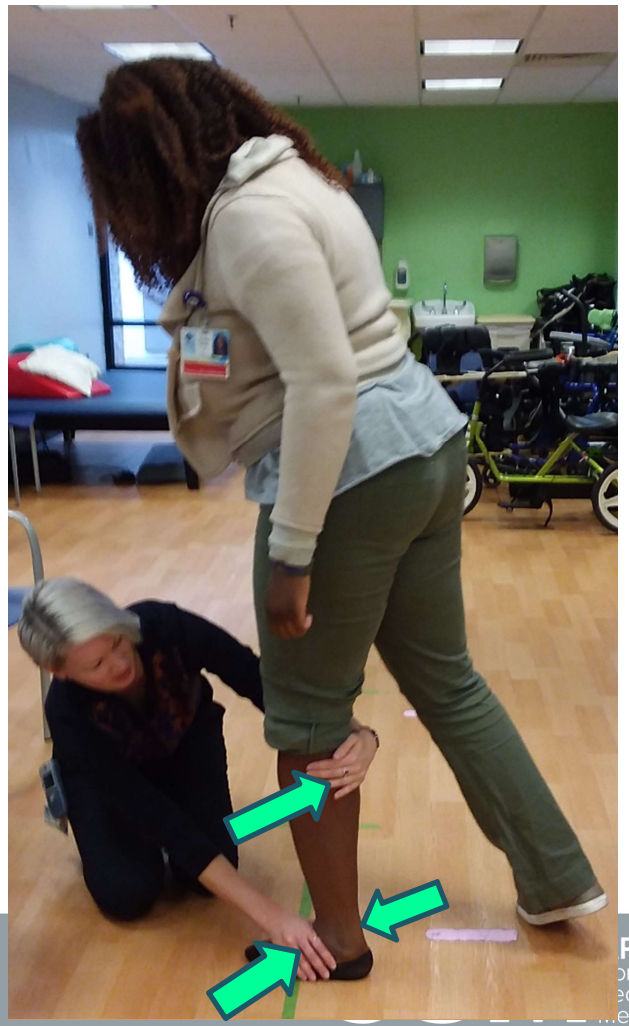
  What support is required to:

  correct alignment of hindfoot and midfoot in the frontal and transverse planes to *allow dorsiflexion to occur primarily* at the talocrural joint as the shank advances over the foot?



Orthotic Design

- WB Corrective Force Test

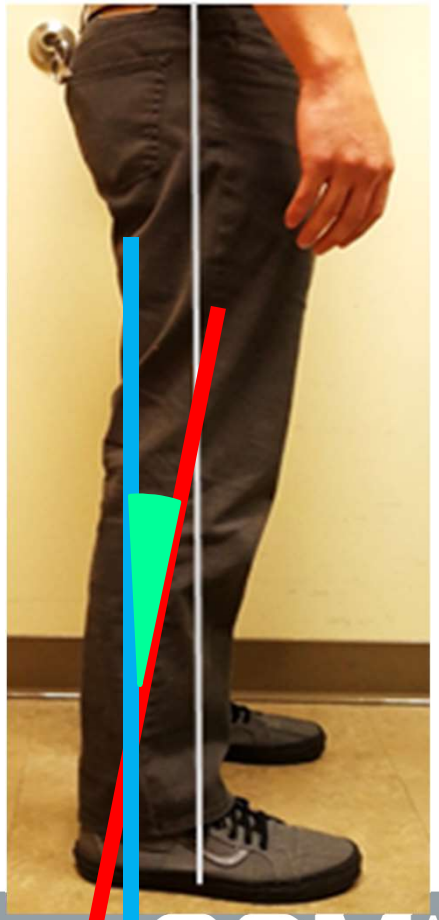


Orthotic Design: Sagittal Plane

- ❑ Midstance

What support is required to:

- Obtain 5-15 degree shank angle in midstance/quiet standing?



Orthotic Design

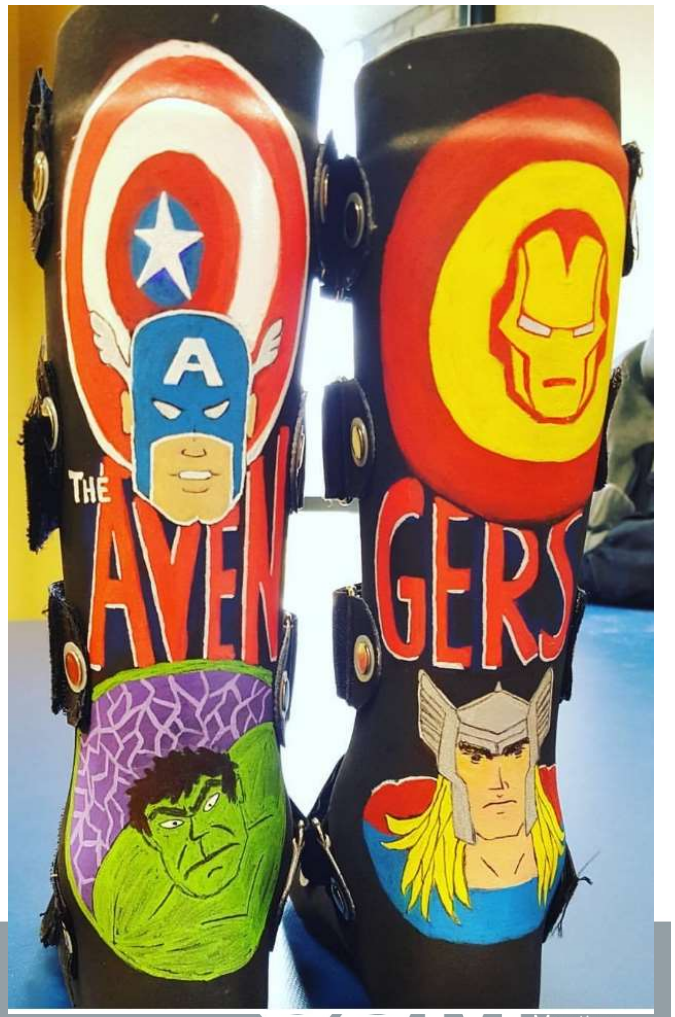
Individual Characteristics: Aesthetics

What are our beliefs around the rights of children with special healthcare needs and:

- Fault
- Choice
- Self expression
- Autonomy
- Body boundaries

Individual Characteristics: Aesthetics

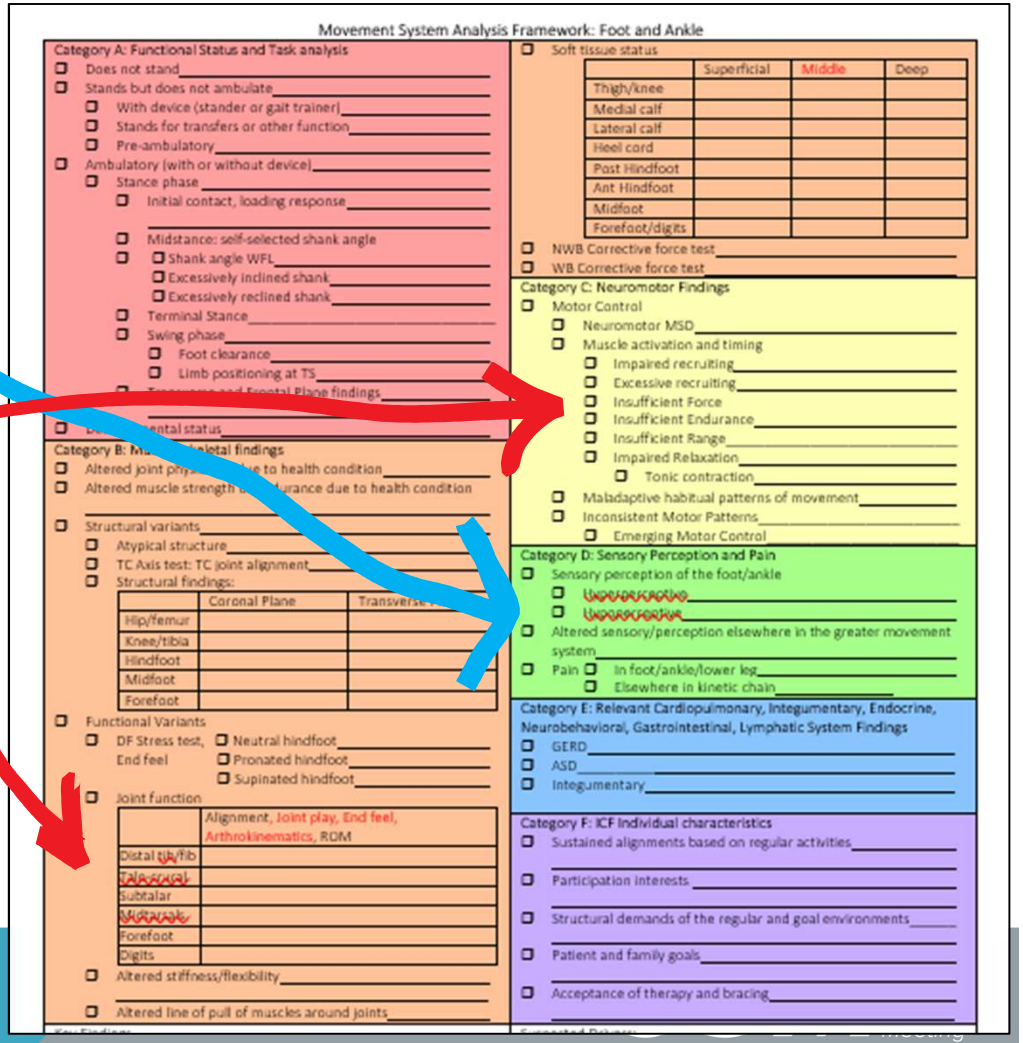
- Physical therapists have an ethical responsibility to support the autonomy of patients, especially those who may have decreased abilities to make choices in their lives and particularly to set boundaries around their bodies.
- We should avoid adding “insult to injury” with ugly orthoses.



Comprehensive Orthotic Plan

Suspected drivers:

Limiting factors:



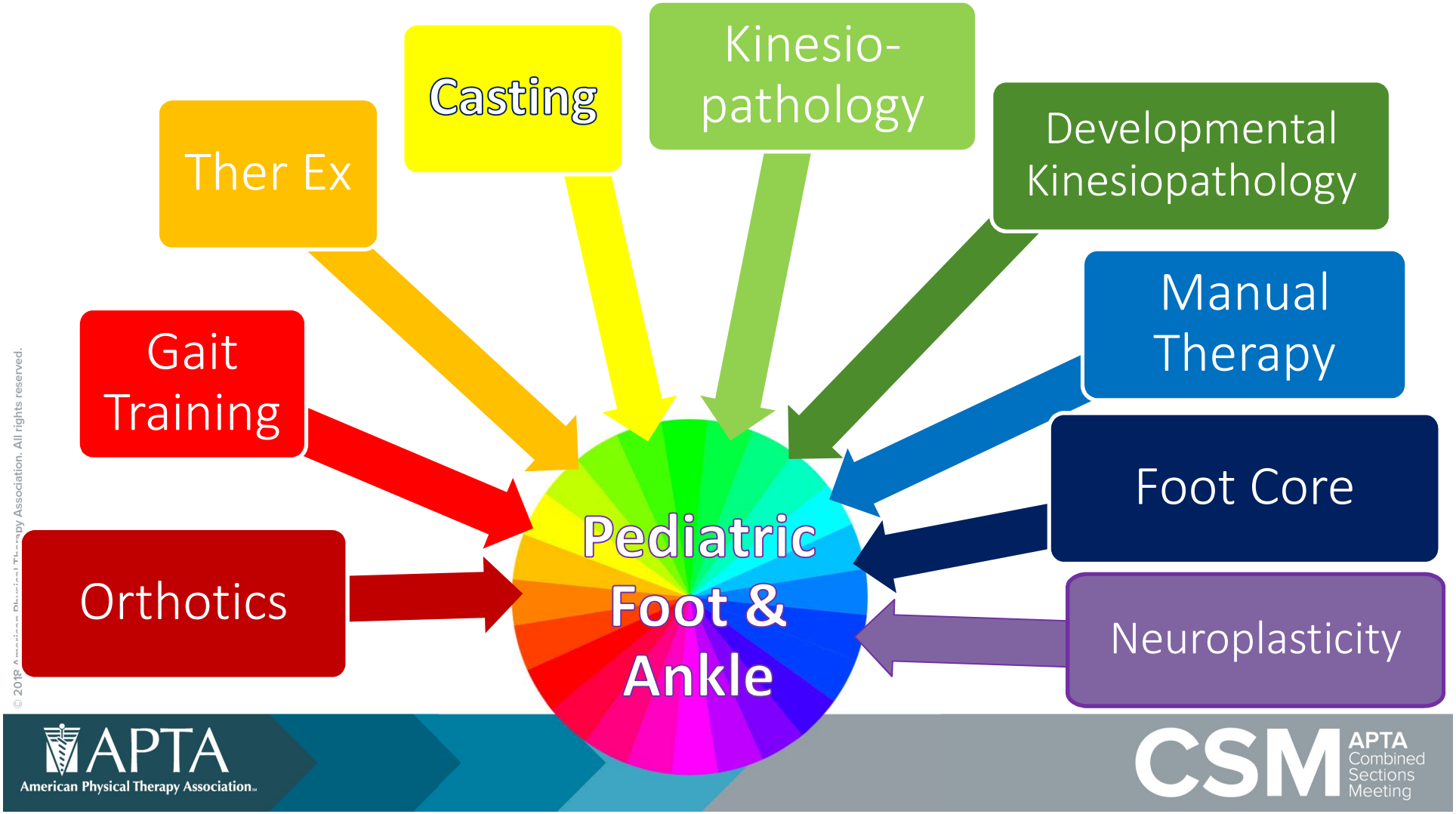
Comprehensive Orthotic Plan

- Consider the cost of removing a degree of freedom
- Bracing, even solid-ankle does not mean no other intervention to the foot and ankle
- We should always look for opportunities to mobilize, strengthen, and support motor learning
- Dosage can be key for multiple movement experiences

Comprehensive Treatment Plan

Orthotic Plan		
	Setting	Schedule
No Device		
Device 1		
Device 2		
Device 3		

Physical Therapy:
Home Program:
Community Exercise Activity:



Thank you!

Questions?

email: amanda@allstaralignment.com

Slides: amandahallpt.com/CSM2020

References

Sahrmann S, Azevedo DC, Dillen LV. Diagnosis and treatment of movement system impairment syndromes. Braz J Phys Ther. 2017;21(6):391-399.

Buldt, Andrew K., Murley, George S., Butterworth, Paul, Levinger, Pazit, Menz, Hylton B., Landorf, Karl B. The relationship between foot posture and lower limb kinematics during walking: A systematic review. Gait Posture. 2013;38(3):363-372.

Yoon JY, Hwang YI, An DH, Oh JS. Changes in kinetic, kinematic, and temporal parameters of walking in people with limited ankle dorsiflexion: pre-post application of modified mobilization with movement using talus glide taping. J Manipulative Physiol Ther. 2014 Jun;37(5):320-5.

Kim SL, Lee BH. The Effects of Posterior Talar Glide and Dorsiflexion of the Ankle Plus Mobilization with Movement on Balance and Gait Function in Patient with Chronic Stroke: A Randomized Controlled Trial. J Neurosci Rural Pract. 2018;9(1):61-67.

Okamura, K, Kanai, S, Hasegawa, Mi, Otsuka, A, Oki, S. The effect of additional activation of the plantar intrinsic foot muscles on foot dynamics during gait. Foot. 2018;34:1-5.

Piccoli A, Rossettini G , Cecchetto S, et al. Effect of Attentional Focus Instructions on Motor Learning and Performance of Patients with Central Nervous System and Musculoskeletal Disorders: a Systematic Review. J Funct Morphol Kinesiol. 2018;3(3):40-0.

Capobianco RA, Almuklass AM, Enoka RM. Manipulation of sensory input can improve stretching outcomes. Eur J Sport Sci. 2018 Feb;18(1):83-91.

Liu XC, Embrey D, Tassone C, et al. Long-Term Effects of Orthoses Use on the Changes of Foot and Ankle Joint Motions of Children With Spastic Cerebral Palsy. PM R. 2017 Sep 1. pii: S1934-1482(17)30004-7.

Louw A, Zimney K, Puentedura EJ, Diener I. The efficacy of pain neuroscience education on musculoskeletal pain: A systematic review of the literature. *Phsyiother Theory Pract*. 2016; 32: 332-55.

Hall AM, Ferreira PH, Maher CG, Latimer J and Ferreira ML. The influence of the therapist-patient relationship on treatment outcome in physical rehabilitation: a systematic review. *Phys Ther*. 2010; 90: 1099-110.

Lakke SE, Meerman S. Does working alliance have an influence on pain and physical functioning in patients with chronic musculoskeletal pain: a systematic review. *J Compassionate Health Care*. 2016; 3:1-10.

Ferreira PH, Ferreira ML, Maher CG, et al. The therapeutic alliance between clinicians and patients predicts outcome in chronic low back pain. Phys Ther 2013;93:470-478.

Pinto RZ, Ferreira ML, Oliveira VC, et al. Patient-centred communication is associated with positive therapeutic alliance: a systematic review. Journal of Physiotherapy 2012;58:77-87.

Brun-Cottan ND, McMillian D Pt DOCS, Hastings J Pt PNCS. Defending the art of physical therapy: Expanding inquiry and crafting culture in support of therapeutic alliance. Physiother Theory Pract 2018:1-10.

Miciak M, Mayan M, Brown C, et al. A framework for establishing connections in physiotherapy practice. Physiother Theory Pract 2019;35:40-56.

Beales D, Lutz A, Thompson J, Wand BM, O'Sullivan P. Disturbed body perception, reduced sleep, and kinesiophobia in subjects with pregnancy-related persistent lumbopelvic pain and moderate levels of disability: An exploratory study. *Manual therapy.* Feb 2016;21:69-75.

Falling C, Mani R. Ageing and obesity indices influences the tactile acuity of the low back regions: A cross-sectional study. *Manual therapy.* Jun 2016;23:25-31.

Moseley GL. I can't find it! Distorted body image and tactile dysfunction in patients with chronic back pain. *Pain.* Nov 15 2008;140(1):239-243.

Louw A. Treating the brain in chronic pain. In: C FdlP, J C, Dommerholt J, eds. Manual Therapy for Musculoskeletal Pain Syndromes. Vol 1. London: Churchill Livingston; 2015

Maihöfner C, Handwerker HO, Neundörfer B, Birklein F. Patterns of cortical reorganization in complex regional pain syndrome. *Neurology.* December 23, 2003 2003;61(12):1707-1715.

Flor H. The functional organization of the brain in chronic pain. Prog Brain Res. 2000;129:313-322.

Stenekes, M. W., et al. (2009). "Effects of motor imagery on hand function during immobilization after flexor tendon repair." Arch Phys Med Rehabil 90(4): 553-559.

Meugnot, A., et al. (2014). "The embodied nature of motor imagery processes highlighted by short-term limb immobilization." Exp Psychol 61(3): 180-186.

Bassolino, M., et al. (2014). "Training the motor cortex by observing the actions of others during immobilization." Cereb Cortex 24(12): 3268-3276. von Piekartz H, Mohr G. Reduction of head and face pain by challenging lateralization and basic emotions: a proposal for future assessment and rehabilitation strategies. *J Man Manip Ther.* Feb 2014;22(1):24-35.

Wand, Benedict Martin, Parkitny, Luke, O'connell, Neil Edward, et al. Cortical changes in chronic low back pain: Current state of the art and implications for clinical practice. *Manual Therapy*. 2011;16(1):15-20.

Moseley GL, Gallagher L, GallaceA. Neglect-like tactile dysfunction in chronic back pain. Neurology. 2012 Jul 24;79(4):327-32.

Melzack R. Evolution of the neuromatrix theory of pain. The Prithvi Raj Lecture: presented at the third World Congress of World Institute of Pain, Barcelona 2004. Pain Pract. 2005 Jun;5(2):85-94.

Fuentes J, Armijo-Olivo S, Funabashi M, et al. Enhanced therapeutic alliance modulates pain intensity and muscle pain sensitivity in patients with chronic low back pain: an experimental controlled study. *Phys Ther* 2014;94:477-489.

Lorenzo-Sánchez-Aguilera C, Rodríguez-Sanz D, Gallego-Izquierdo T, et al. Neuromuscular Mechanosensitivity in Subjects with Chronic Ankle Sprain: A Cross-Sectional Study. Pain Med. 2019 Jan 14.

Bassolino, M, Campanella, M, Bove, M, et al. Training the Motor Cortex by Observing the Actions of Others During Immobilization. Cereb Cortex. 2014;24(12):3268-3276.

The foot is more than a spring: human foot muscles perform work to adapt to the energetic requirements of locomotion. Riddick R, Farris DJ, Kelly LA. J R Soc Interface. 2019 Jan 31;16(150):20180680.

Babatunde F, MacDermid J, MacIntyre N. Characteristics of therapeutic alliance in musculoskeletal physiotherapy and occupational therapy practice: a scoping review of the literature. BMC Health Serv Res 2017;17:375.

Toussaint, L. and A. Meugnot (2013). "Short-term limb immobilization affects cognitive motor processes." J Exp Psychol Learn Mem Cogn 39(2): 623-632.