ACADEMY OF PEDIATRIC PHYSICAL THERAPY

Orthotic Device Design

Using Movement System Analysis as a guide

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Disclosures & Housekeeping

- Disclosures: None
- Photographs
- Handouts
  - Diagram & Form: end of handout

Disney's One Hundred and One Dalmatians (1961)

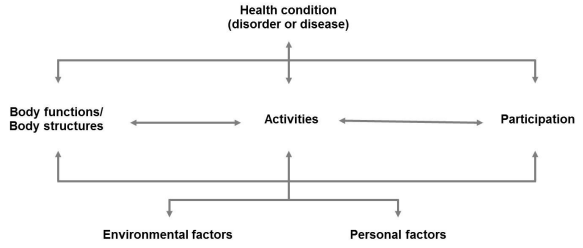
Objectives

- Describe elements of the ICF model that may impact individual goals in regards to lower extremity orthosis recommendations.
- Describe crucial elements of examination including gait kinematics, neuromotor function, and musculoskeletal structures which inform orthotic recommendations.
- Discuss movement system analysis for gait and foot/ankle findings in pediatric practice.
- Apply movement system analysis concepts and the ICF model to make orthotic recommendations.

Why the difference in recommendations?

What is your idea of the perfect brace?

Perfect Brace: ICF Model



World Health Organization. (2001). International classification of functioning, disability and health : ICF. World Health Organization.

Varied Recommendations: ICF Model

- Prioritizing Body Functions and Structures versus Activity and Participation may lead to different recommendations
- Each clinician filters the impact of Environmental and Personal Factors through the lens of their own values and experiences
- Use of a movement system approach can help to facilitate these complex conversations

Varied Recommendations

- Evidence-Based Practice?

Research Challenges: Ethics

Smith, GS. ***Parachute use to prevent death and major trauma*** related to gravitational challenge: ***systematic review*** of randomised controlled trials. BMJ 2003;327:1459.

- 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.
- *"We think that everyone might benefit if the most* ***radical protagonists of evidence based medicine organised and participated in a double blind, randomised, placebo controlled, crossover trial of the parachute."***

Research Challenges: Heterogeneity

Krzak JJ, Corcos DM, Damiano DL, Graf A, Hedeker D, Smith PA, Harris GF. ***Kinematic foot types in youth with equinovarus secondary to hemiplegia.*** Gait Posture. 2015 Feb;41(2):402-8.

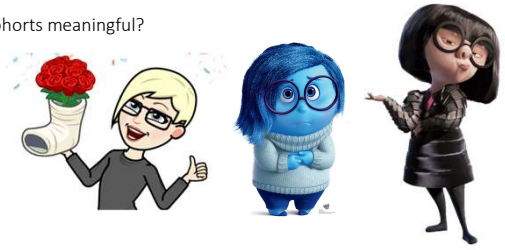
- Participants ***with hemiplegia and equinovarus*** fell between
  - **Five distinct subgroups -**
- Neurotypical controls were distributed among **4** of the subgroups
- Noted: **inherent variability even in neurotypical, asymptomatic movement systems**

Research Challenges: Heterogeneity

Do glasses work for individuals with visual impairment?

Research Challenges: Heterogeneity

- Are cohorts meaningful?



Research Challenges: "Efficacy"

What outcome does each study value?
What level of the ICF are they focusing on?

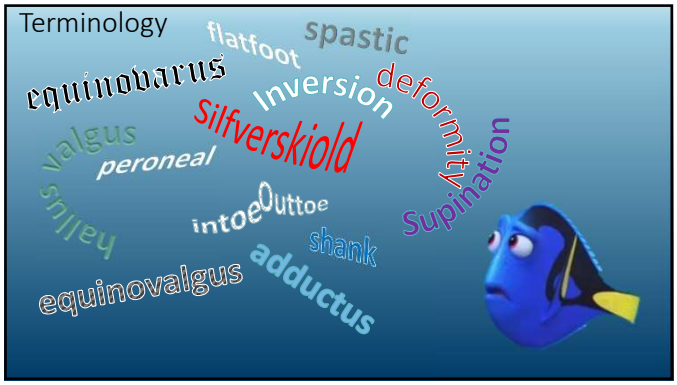
Varied Recommendations

The Parable of the Roast

Varied Recommendations

The Parable of the Roast

- *Gurus*
- *Institutional Practices*
- *Health-condition based decision making*
- *Lack of flexibility*
- *Lack of consistency*



Research Challenges: Terminology
Speaking the Same (Sane) Language

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 - Neuromotor

There is a growing body of evidence that for patients with CP, stroke, and TBI, **passive muscle properties** are:

- Altered
- highly variable between patients
- **difficult to distinguish clinically** from hyper-responsive stretch reflexes

Terminology: Inconsistency - Neuromotor

De Gooijer-van de Groep, K.L., De Vlugt, E., De Groot, J.H., et al. **Differentiation between non-neural and neural contributors to ankle joint stiffness in cerebral palsy.** Journal of NeuroEngineering and Rehabilitation, 10, 2013. July 2013:urn:issn:1743-0003.

- "Ratios between the contribution ***of neural and non-neural components*** to ankle joint stiffness *varied substantially* within the group with CP".
- Even in a group the researchers cohorted for their similarities and were relatively mildly affected.

Terminology: Inconsistency - Neuromotor

Willerslev-Olsen, M, Lorentzen, J, Sinkjær, T, Nielsen, JB. **Passive muscle properties are altered in children with cerebral palsy before the age of 3 years and are difficult to distinguish clinically from spasticity**. Developmental Medicine & Child Neurology. 2013;55(7):617-623.

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

Bar - On, L, Kalkman, BM, Cenni, F, et al. The relationship between medial gastrocnemius lengthening properties and stretch reflexes in cerebral palsy. October 2018:1-11.

- "In general, given the large variability in the amount of muscle lengthening and hyperactive stretch reflex in the subject sample included in this study, **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

Passive muscle properties are also being found to be a major contributor to changes in muscle stiffness in:

- Acquired brain injury
- Hemiplegia
- Stroke

Terminology: Inconsistency - Neuromotor

Assumptions → Observations

Terminology: Specificity

Tight		Short
Spastic/spasticity		Decreased muscle length
Hypertonicity		Tonic muscle contraction
Hyperreflexia	→	Spasm
Tone		Decreased elasticity
Guarding		Stiff
Fixing		Increased density
		Soft tissue restriction

Terminology: Inconsistency

☑ Vote:

Which clinical presentations are described by the term:

Contracture

Terminology: Inconsistency - Musculoskeletal

"Contracture"

Terminology: Inconsistency

☑ Vote:

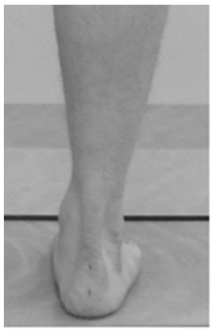
Which clinical presentations are described by the term:

Flatfoot
(Pes Planus)

Terminology: Inconsistency
"Flatfoot"

Terminology: Inconsistency
"Flatfoot"

Terminology: Inconsistency
"Flatfoot"



Terminology: Inconsistency
"Flatfoot"

Terminology: Inconsistency

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

-Inigo Montoya

Terminology

Incompatible definitions → Differentiation

Unclear → Systematic

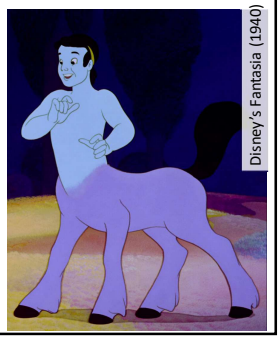
Logical

Terminology: Historical

☑ Vote:

Which clinical presentation is best described by the term:

Equinus Deformity



Disney's Fantasia (1940)

Terminology: Words Have Power

"Contracture"
"Deformity"

- Implied permanence
- Nocebo effect

Terminology: Words Have Power

WIKIPEDIA
The Free Encyclopedia

Contracture

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

www.wikipedia.com

Terminology: Words Have Power

- How do the words we select impact our patients?

Terminology: Words Have Power

deformity

noun **disfigurement, distortion**

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.
4. hatefulness; ugliness.

Synonyms for *deformity*

abnormality, defect, impairment, malformation, aberration, asymmetry, unsightliness, warp, malconformation, misproportion, misshape

Terminology: Words Have Power

Pejorative		Neutral "lay" meaning
Pessimistic	→	Optimistic
Ableist		Positively Googleable
Rude		Respectful

Terminology

restriction

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

Dictionary.com/Thesaurus.com

Terminology: Words Have Power

Terminology: Words Have Power

Terminology

Equinus	→	Plantarflexion
Deformity Contracture	→	Structural variance Restriction Limiting Structure Quality of end feel
Flatfoot	→	Pronated Everted Dropped navicular
Subtalar neutral*	→	Talus on axis Talocrural Dorsiflexion *TC DF*

Subtalar neutral → Talus on axis
Talocrural Dorsiflexion *TC DF*

- Jarvis, Hannah L., et al. "Challenging the Foundations of the Clinical Model of Foot Function: Further Evidence That the Root Model Assessments Fail to Appropriately Classify Foot Function." *Journal of Footand Ankle Research*, vol. 10, no. 1, Mar. 2017.
- Harradine, Paul, et al. "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." *Journal of Orthopaedic & Sports Physical Therapy*, vol. 48, no. 3, 2018, pp. 130–132.

Terminology: Specificity


Plantarflexion Restriction


Structural Variance


Magical Creature

☑ Vote:

Equinovalgus
or
Equinovarus
?

Terminology: Function vs. Structure

Terminology: Structural Vs. Functional


"Pes Valgus"


"Metatarsus Adductus, Varus"

Terminology: Structure vs. Function

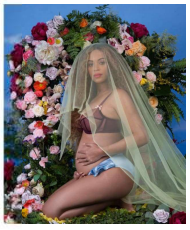
Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Med Torsion – Lat Torsion Adduct**us** – Abduct**us**	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus – Valgus	Invert – Evert
Sagittal		Flex – Extend
Triplanar		Supinate(d) – Pronate(d)

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

Structure:
Hindfoot varus
Metatarsus adductus and varus

Disney's "Up" (2009)

Disney's The Lion King (2019)



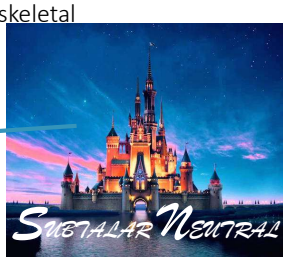
The Developmental Kinesiopathological Model of the Movement System

Movement System Analysis Framework: Foot and Ankle

Orthotic Design

Traditional
Pediatric Ankle Model

Pediatric Ankle Model: Musculoskeletal



Syndesmoses/Sutures/?.....

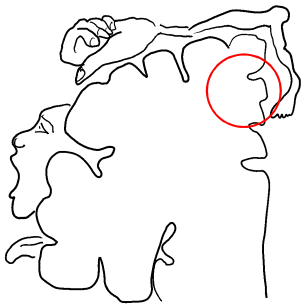
Pediatric Ankle Model

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

Tibialis anterior
- Weak
- No spasticity
- Powerless Victim
- Good
- Underdog
- Send Estim, kinesiotape

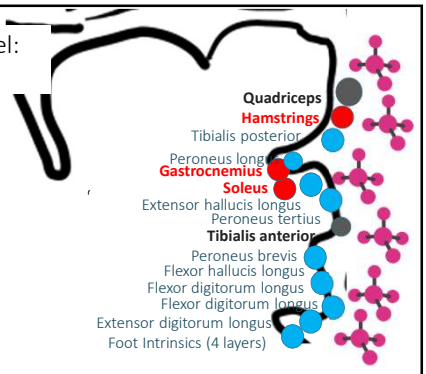
Disney's One Hundred and One Dalmations (1961)

Pediatric Ankle Model: Neuropathology



Pediatric Ankle Model: Neuropathology

Key
- Weak
- Spastic
- Irrelevant

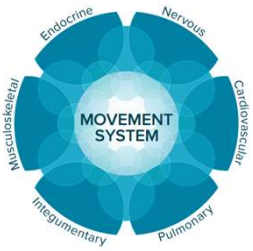


Pediatric Ankle Model

Benefit our patients, a more complex model would.

APTA: Movement System

"The movement system is the integration of body systems that generate and maintain movement at all levels of bodily function. Human movement is a complex behavior within a specific context, and is influenced by social, environmental, and personal factors."



American Physical Therapy Association. Movement System. https://www.apta.org/MovementSystem. Accessed October 15, 2019.

Kinesiopathological Model
Shirley Sahrmann, PT, PhD, FAPTA

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

Kinesiopathological Model

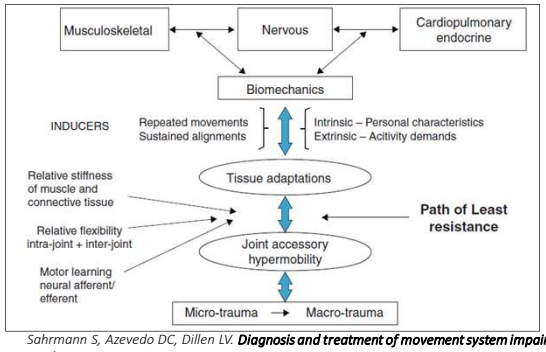
- Repetitive movement and sustained alignments can induce pathoanatomical changes in tissues and joint structures
- The body, at the joint level, follows the laws of physics and takes the path of least resistance for movement
- Determinants of the path of motion are
  - intra- and inter-joint relative flexibility
  - relative stiffness of muscle and connective tissue
  - motor control

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

Kinesiopathological Model

- Sustained alignments and repeated movements associated with daily activities are the inducers of tissue adaptations, impaired alignments and movements.
- Micro-instability → tissue microtrauma → macro-trauma

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



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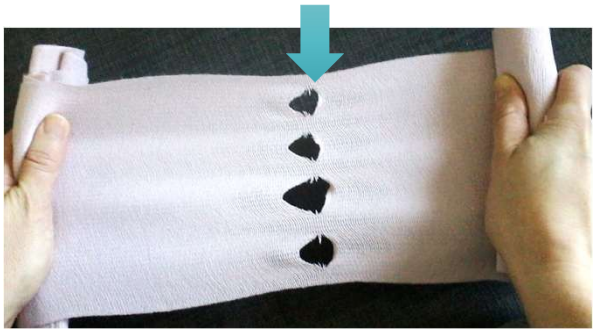
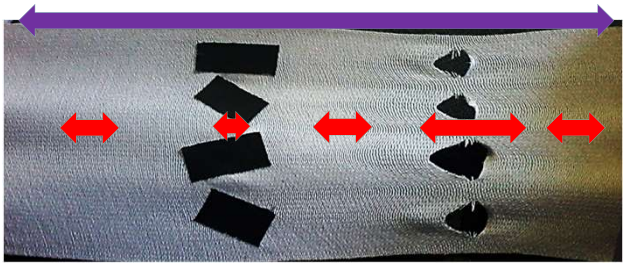


Relative Flexibility



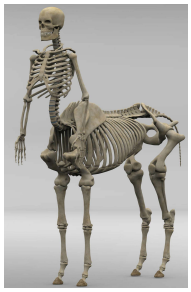
Kinesiopathology

- Lumbar spine model

Pediatric Ankle Model

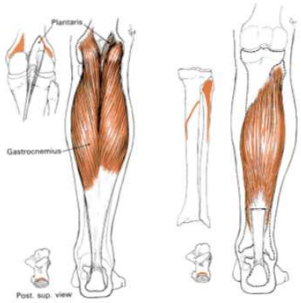
Building a more complex foot/ankle model

Peds/Neuro Ankle Model



Muscles - Plantarflexors

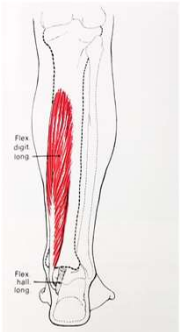
- **Gastrocnemius, Soleus** (complex)
  - plantarflexes ankle
  - flexes knee (gastrocnemius)
  - *slows advancement of the tibia during loading response into midstance*
  - *main driver of the limb from stance into swing*



Kendall, FP. Muscles: Testing and Function; 1993.

Muscles - Plantarflexors

- **Flexor digitorum longus (FDL)**:
  - flexes distal phalanges of lateral four digits
  - **plantarflexes ankle**
  - supports medial and lateral longitudinal arches.



Kendall, FP. Muscles: Testing and Function; 1993.

Muscles – Plantarflexors

- **Tibialis posterior**:
  - attachment on the navicular
  - **plantarflexes ankle**
  - inverts subtalar and transverse tarsal joints
  - supports medial longitudinal arch, controls pronation forces during loading response into midstance

Kendall, FP. Muscles: Testing and Function; 1993.

Muscles – Dorsiflexors

- **Tibialis anterior (TA)**: dorsiflexes ankle, inverts subtalar and transverse tarsal joints, supports medial longitudinal arch, *eccentrically lowers from initial contact into loading response.*
- *Looses moment arm or ability to act when TC DF is restricted… who else can help with DF for function?*

Kendall, FP. Muscles: Testing and Function; 1993.

Muscles – Dorsiflexors

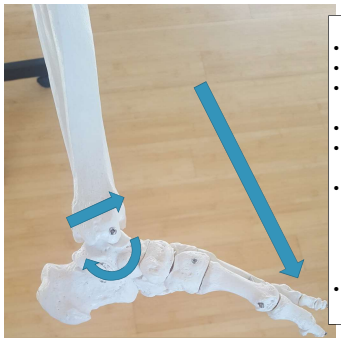
- **Extensor digitorum longus (EDL)**: extends toes, dorsiflexes ankle
- **Peroneus tertius**: (attachment on the base of 5th met) dorsiflexes ankle, *everts at subtalar and transverse tarsal joints.*
- *Longer lever arm for DF if the TA cannot*

Kendall, FP. Muscles: Testing and Function; 1993.

Muscles - Dorsiflexors

- **Extensor hallucis** longus (EHL): extends big toe, dorsiflexes ankle, inverts subtalar and transverse tarsal joints.
- *Longer lever arm for DF if the TA cannot*

Kendall, FP. Muscles: Testing and Function; 1993.



Plantarflexion

- Anterior slide of talus
- Roll of talus
- Lengthening of anterior tendon, ligaments, anterior capsule
- Superior movement of calcaneous
- Shortening of Achilles tendon, calcalneofibular ligament
- Lengthening of
  - Tibialis anterior
  - Extensor digitorum longus
  - Extensor hallucis longus
  - Peroneus tertius
- Movement and glide of fascia and skin

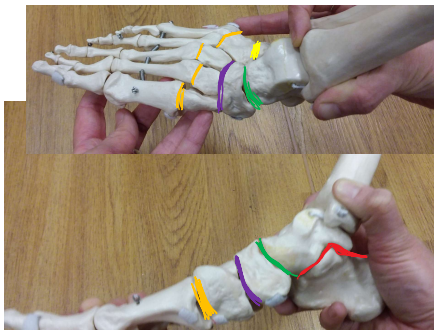
Ankle Structure

Joints

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

Joints

- Subtalar (talus-calcaneous)
- Talus-Navicular
- Calcaneous-cuboid
- Navicular-cuneiforms
- Cunieforms/cuboid-metatarsals

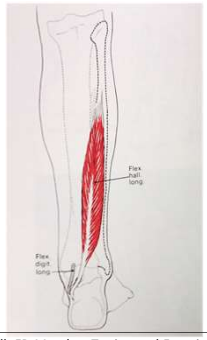


Muscles - Plantarflexors

- **Gastrocnemius, Soleus** (complex)
  - plantarflexes ankle
  - flexes knee (gastrocnemius)
  - *slows advancement of the tibia during loading response into midstance*
  - *main driver of the limb from stance into swing*
  - *eccentrically controls dorsiflexion for descending stairs*

Muscles – Plantarflexors

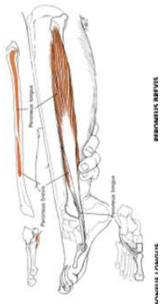
- **Flexor hallucis longus (FHL)**:
  - flexes distal phalanx of big toe
  - **plantarflexes ankle**
  - supports medial longitudinal arch



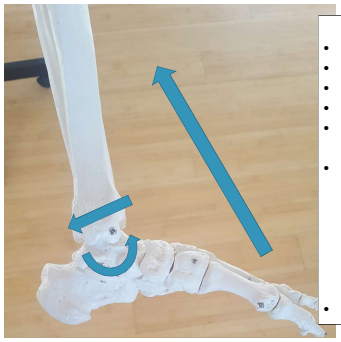
Kendall, FP. Muscles: Testing and Function; 1993.

Muscles - Plantarflexors

- **Peroneus longus**: (attachment on the base of 1st met & medial cuneiform) plantarflexes ankle, everts subtalar & transverse tarsal joints, *supports lateral longitudinal and transverse arches.*
- **Peroneus brevis** (attachment on the base of 5th metatarsal) plantarflexes ankle, everts at subtalar & transverse tarsal joints, *supports lateral longitudinal arch.*



Kendall, FP. Muscles: Testing and Function; 1993.

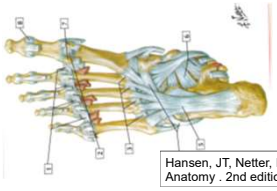


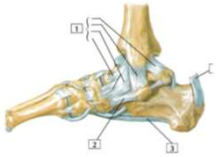
Talocural Dorsiflexion

- Posterior slide of talus
- Roll of talus
- Lengthening of posterior capsule
- Inferior movement of calcaneous
- Shortening of anterior capsule, anterior talofibular ligament
- Lengthening of
  - gastrocnemius
  - Soleus
  - Tibialis posterior
  - Fibularis brevis and longus
  - Flexor hallucis longus
  - Flexor digitorum longus plantaris
- Movement and glide of fascia and skin

Foot Stability

- Mckeon, PO, Hertel, J, Bramble, D, Davis, I. **The foot core system: a new paradigm for understanding intrinsic foot muscle function.** British Journal of Sports Medicine. 2015;49(5):290.
  - Passive Subsystem



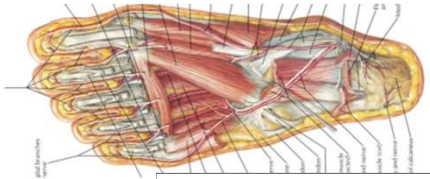


Hansen, JT, Netter, FH, Machado, CA. Netter's Clinical Anatomy . 2nd edition. East Hanover; NJ: Elsevier; 1997.

Foot Stability

Mckeon, PO, Hertel, J, Bramble, D, Davis, I. **The foot core system: a new paradigm for understanding intrinsic foot muscle function.** British Journal of Sports Medicine. 2015;49(5):290.

- Active Subsystem



Hansen, JT, Netter, FH, Machado, CA. Netter's Clinical Anatomy . 2nd edition. East Hanover; NJ: Elsevier; 1997.

Foot Stability

Mckeon, PO, Hertel, J, Bramble, D, Davis, I. **The foot core system: a new paradigm for understanding intrinsic foot muscle function.** British Journal of Sports Medicine. 2015;49(5):290.

- 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 to primarily to stabilize the multiple joints of the foot.
    - act to control the degree and velocity of arch deformation with each foot step
  - Muscular fatigue of foot intrinsics leads to navicular drop

Foot Stability

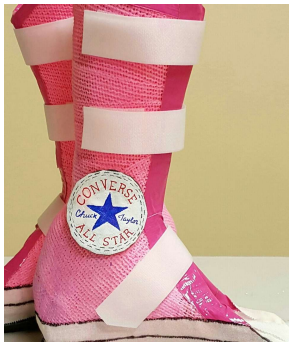
Mckeon, PO, Hertel, J, Bramble, D, Davis, I. **The foot core system: a new paradigm for understanding intrinsic foot muscle function.** British Journal of Sports Medicine. 2015;49(5):290.

- 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

Foot Stability

Mckeon, PO, Hertel, J, Bramble, D, Davis, I. **The foot core system: a new paradigm for understanding intrinsic foot muscle function.** British Journal of Sports Medicine. 2015;49(5):290.

- Interaction of global movers with foot core
  - The Achilles tendon modulates tension in the plantar aponeurosis based on the common connection to the calcaneous
  - As tension in the gastroc-soleus increases, so does the tension in the planar fascia



Kinesiopathology: The Ankle as a Movement System

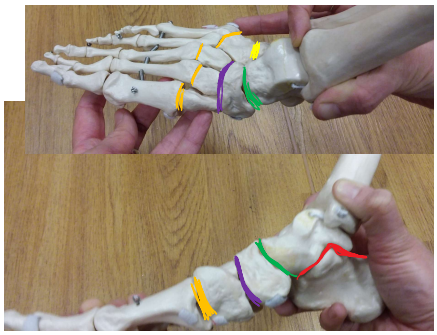
Due to the complexity of the foot and ankle, there are many ways which the system may compensate for MS or NM dysfunction.

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

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

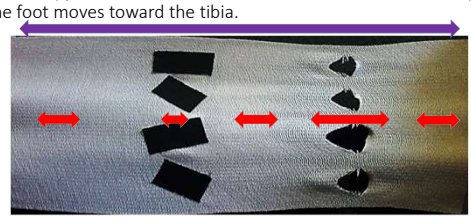
Joints

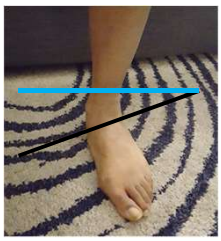
- Subtalar (talus-calcaneous)
- Talus-Navicular
- Calcaneous-cuboid
- Navicular-cuneiforms
- Cunieforms/cuboid-metatarsals



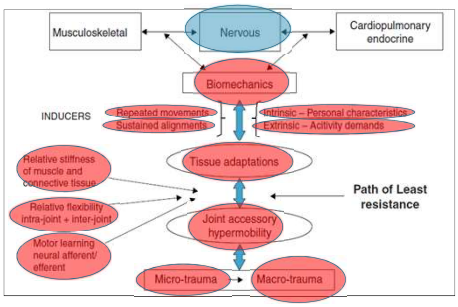
Kinesiopathology: The Ankle as a Movement System

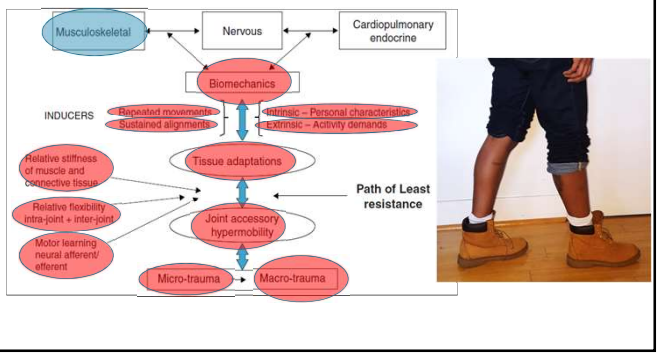
- Df is a component movement of many of the accessory joints of the system, so when the hindfoot is stiff, the dorsiflexion component of accessory joint motion sometimes becomes the dominant way that the foot moves toward the tibia.

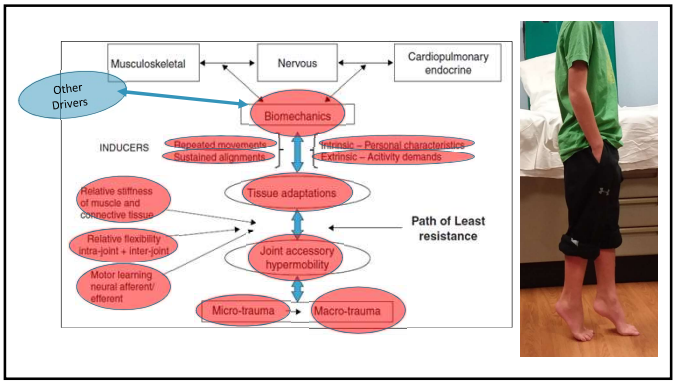




Forces are mechanically directed to relatively more flexible structures and away from TC dorsiflexion.



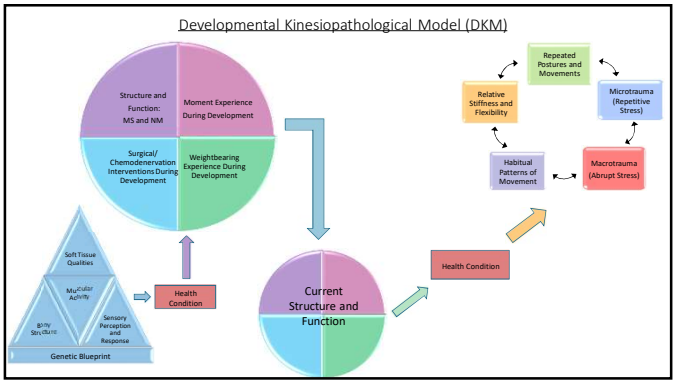


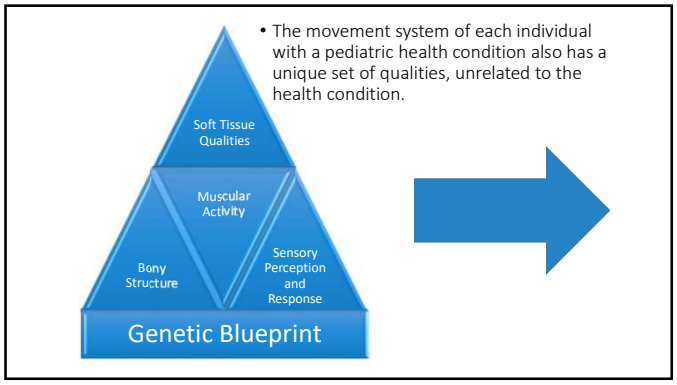


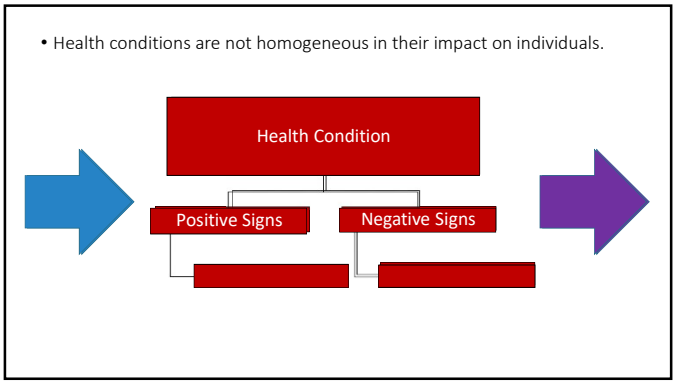
- Limiting Factors vs. Drivers

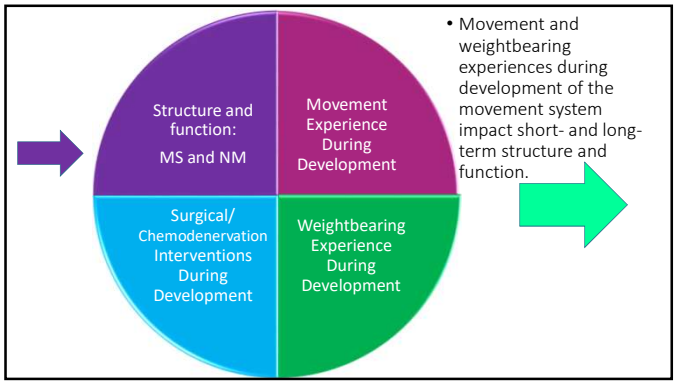
New Paradigm: Developmental Kinesiopathology

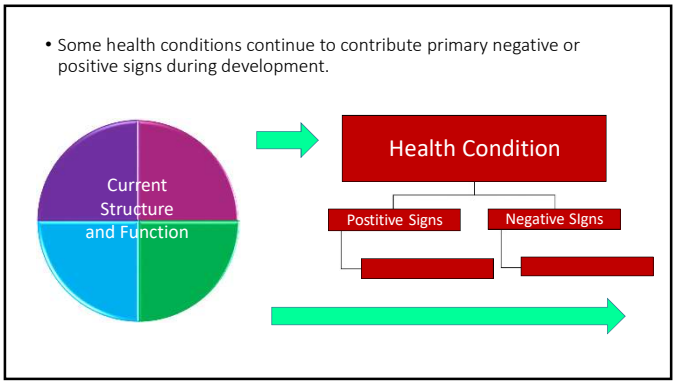
- Function of the movement system is multifactorial and depends not just the health condition, but influence of multiple internal and external factors.
- The structure and function of the mature movement system will be impacted by the movement experiences as it develops.

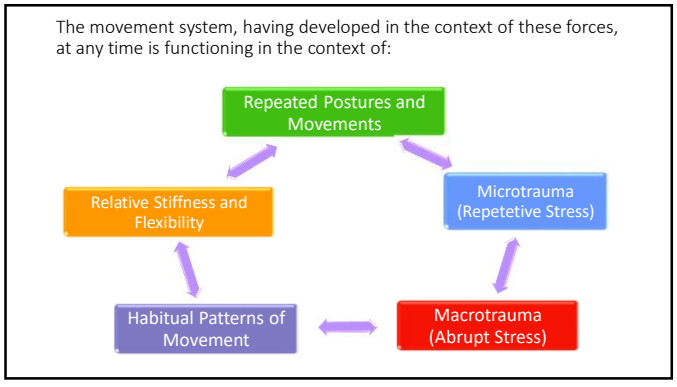












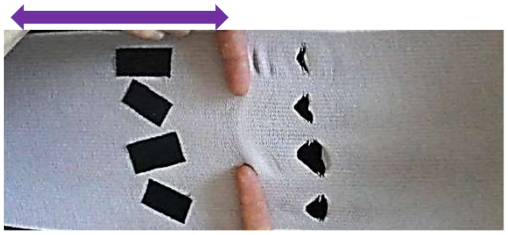
Developmental Kinesiopathology

- The movement and weightbearing experiences during development of the movement system impact short- and long-term structure and function.
  - We will influence long term kinesiopathology with our interventions during development of the system.

Developmental Kinesiopathology: *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.

- 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 Kinesiopathology: *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 Kinesiopathology: *Sensory-Perceptual Development*

- The more the movement system functions in an altered alignment, it is an expert at functioning in that alignment, and the system perceives changes and will attempt to return to the known alignment.

Sensory-Perceptual Development

Mckeon, PO, Hertel, J, Bramble, D, Davis, I. **The foot core system: a new paradigm for understanding intrinsic foot muscle function.** British Journal of Sports Medicine. 2015;49(5):290.

- 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 also leads to loss of this information

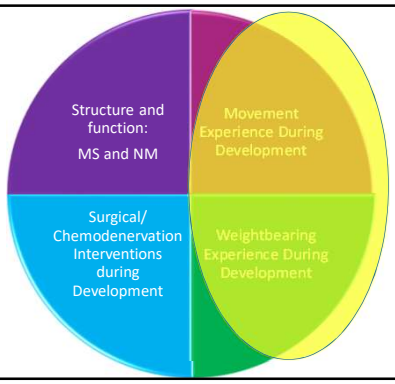
→Loss of alignment of the foot during development impacts the development of the perception of this information

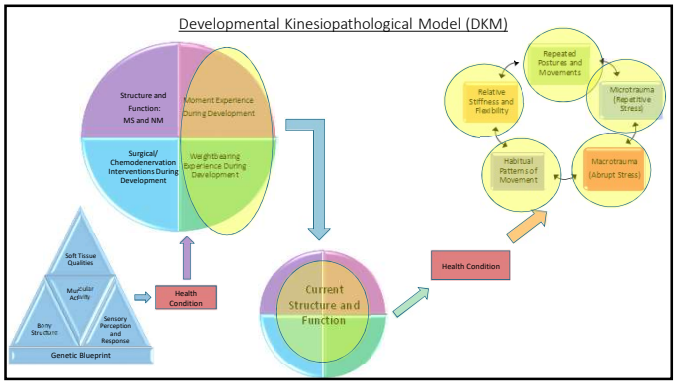
→Biasing the foot intrinsics to develop with typical alignment allows for this information to be available

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

Developmental Kinesiopathology

- How can we ask the movement system to move in a certain manner when it was built for something else?



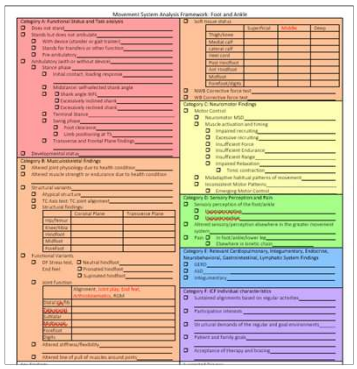


Developmental Kinesiopathological Model of the Movement System

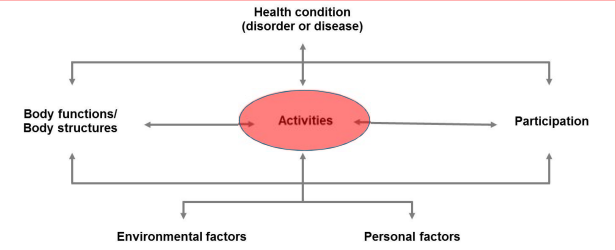
Movement System Analysis Framework: Foot and Ankle

Orthotic Design

Movement System Analysis Framework: Foot and Ankle



Functional Status and Task analysis



Functional Status and Task analysis

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

Functional Status and Task Analysis

- ❑Ambulatory (with or without device)
- ❑Stance phase
  - ❑Loading response
    - --Eccentric Control of tibial advancement

- ❒Stance phase
  - ❒Loading response

Lack of deceleration of tibial (shank) advancement

Reversal of the forces during loading response; knee extension versus flexion moment (shank reversal)

Functional Status and Task analysis

- ❑Ambulatory (with or without device)
  - ❑Stance phase
    - ❑Midstance: self-selected shank angle
      - ❑1- Shank ankle WFL
      - ❑2- Excessively inclined shank
      - ❑3- Excessively reclined shank

❒1-Shank Angle WFL

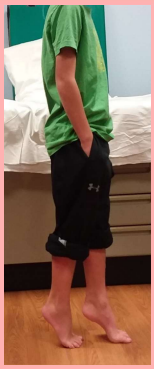
Weight line: Anterior to the knee
Posterior to hip

Mild incline of the shank

❒1-Shank Angle WFL

Movement system not impacted proximal to foot/ankle

e.g. Toe Walking



❒1-Shank Angle WFL

Movement system is able to compensate for any changes at the foot/ankle

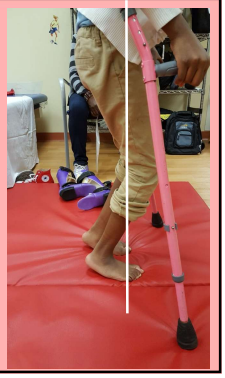
-or-

The greater movement system is ***driving*** the change in the foot/ankle

❑ 2-Excessively inclined shank (crouch)

Weight line

- anterior to hip
- posterior to the knee



❑ 3-Excessively reclined shank (knee hyperextension)

Weight line

- anterior to hip
- anterior to the knee

❒Terminal Stance

Dorsiflexion with hip and knee extension?

*Requisite of Therapeutic Gait. (Owen)

MTP extension with pre-swing?

Functional Status and Task analysis

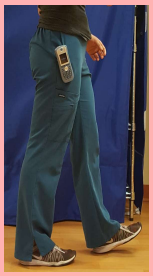
- ❑Swing phase
  - ❑Foot clearance

Functional Status and Task analysis

- ❑Swing phase
  - ❑Limb positioning at Terminal Swing

Initial contact at heel with hip flexion and knee extension?

*Requisite of Therapeutic Gait.



Functional Status and Task analysis

- ❑Swing phase
  - ❑Limb positioning at Terminal Swing

Initial contact

Functional Status and Task analysis

- ❑Transverse and Coronal Plane findings

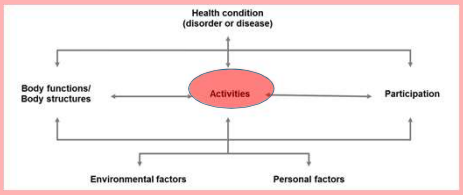
Functional Status and Task analysis

- ❑Developmental Status
  Goals related to movement experiences based on current developmental status.

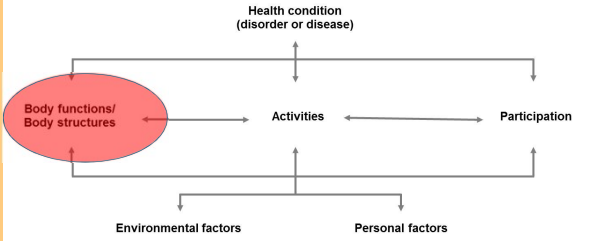
Disney's Moana (2016)

Functional Status and Task analysis

- Findings



Musculoskeletal Findings



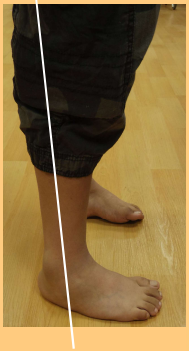
Musculoskeletal Findings

- ❑Altered joint physiology due to health condition
- ❑Altered muscle strength or endurance due to health condition

❒Altered muscle strength or endurance due to health condition

e.g. Reclined shank may be adaptive for stability in stance when knee extensors are compromised.

For those patients who have primary muscle weakness, you must mimic their self-selected shank angle in any orthosis.



Musculoskeletal Findings

- ❑Structural variants
  - ❑Atypical structure
    - Coalitions
    - Vertical talus
    - Presence or absence of structures
    - Altered relative position of structures

Musculoskeletal Findings

- ❑Structural variants
  - ❑Atypical structure
    - Altered length or structure of bones

Musculoskeletal Findings

- ❑Structural variants
  - ❑TC Axis test: TC joint alignment

❑TC Axis test: TC Joint Alignment

❑ TC Axis test: TC Joint Function

- Location of axis

Musculoskeletal Findings

❑Structural variants
❑Structural findings:

	Coronal Plane	Transverse Plane
Knee/ tibia		Torsion - medial

Medial Torsion (masked)

❑Structural variants
❑Structural findings

	Coronal Plane	Transverse Plane
Knee/ tibia		Torsion - lateral

❑Structural variants
❑Structural findings

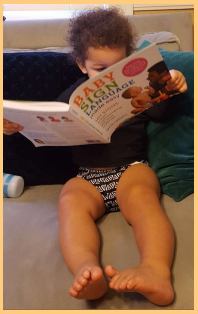
	Coronal Plane	Transverse Plane
Hip/ femur	Valgum	

Structural Variants
Leg
Valgum

❒Structural variants
❒Structural findings

	Coronal Plane	Transverse Plane
Knee/ tibia	Varum	

	Coronal Plane	Transverse Plane
Knee/ tibia	Varum	Medial Torsion



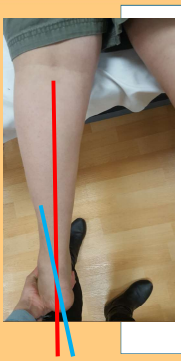
❒Structural variants
❒Structural findings

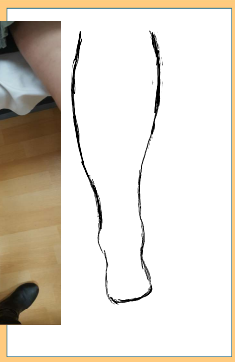
Hindfoot
Altered position or structure of malleoli

	Coronal Plane	Transverse Plane
Hindfoot		

❒Structural Variants
Hindfoot
Calcaneal alignment

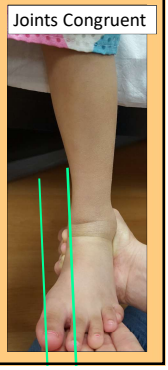
	Coronal Plane	Transverse Plane
Hindfoot	Varus	





❒Structural Variants

	Coronal Plane	Transverse Plane
Midfoot		Metatarsus Adductus



❒Structural Variants

	Coronal Plane	Transverse Plane
Midfoot, Forefoot	Metatatarus Varus	

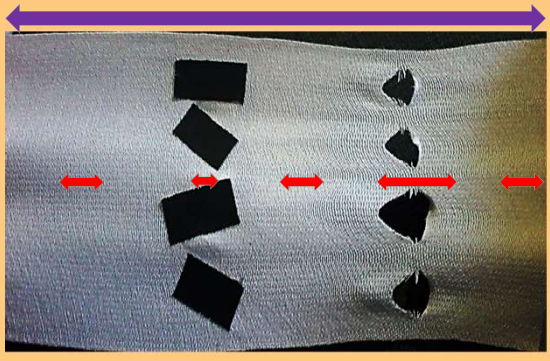
❒Structural variants
❒Structural findings

- Static (structural) variants

Structural Vs. Functional

Musculoskeletal Findings

❑Functional Variants
- ❑DF Stress test, End feel
  - ❒ Neutral hindfoot
  - ❒ Pronated hindfoot
  - ❒ Supinated hindfoot



Musculoskeletal Findings

- ❑Functional Variants
  - ❑DF Stress test
    End feel

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?

Musculoskeletal Findings

- ❑Functional Variants
  - ❑DF Stress test
    - ❒1-Neutral hindfoot

End feel/location:
- often GS/Achilles tendon or TC joint restriction

Musculoskeletal Findings

- ❑Functional Variants
  - ❑DF Stress test
    - ❒2-Pronated hindfoot

End feel/location:
- often anterior lateral talar impingement

Musculoskeletal Findings

- ❑Functional Variants
  - ❑DF Stress test
    - ❒3-Supinated hindfoot

End feel/location:
- often anterior/medial talar impingement or lateral talar subluxing

Musculoskeletal Findings

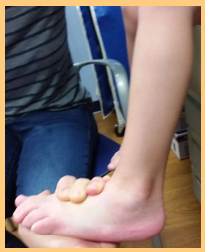
- ❑Joint Function

	Alignment, Joint Mobility, End feel, Arthrokinematics, ROM
Distal tib/fib	
Talo-crual	
Subtalar	
Midtarsals	
Forefoot	
Digits	

❑ TC Axis test: TC Joint Function

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





Position and Mobility of the Distal Tib-Fib, Subtalar Joint, Calcaneous


Ability of the calcaneous to move inferior to allow for posterior talar glide



Position and Mobility of the hindfoot, midtarsal Joints



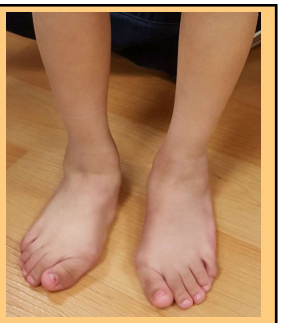
Posture of the MTPs and Digits


Joint assessment of the MTPs and Digits

Musculoskeletal Findings

- Joint Function
  - Maladaptive relative stiffness/flexibility

MTP abdution > flex/ext



Hindfoot, midfoot, MTP pronation > TC DF

Musculoskeletal Findings

- Joint Function
  - Altered line of pull of muscles around joints

Post Tib: no lever arm to invert subtalar and transverse tarsal joints

EHL abducts vs. extends MTP

Musculoskeletal Findings

- 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
  - How much support is required to bring the foot and ankle in into position with the joints congruent?

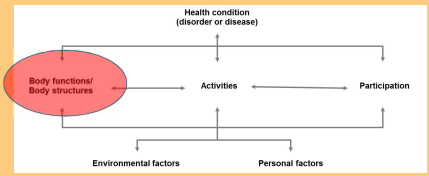
❑WB Corrective force test

- How much 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 when the shank advances over the foot?

❑WB Corrective force test

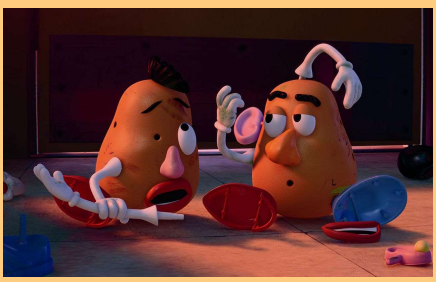
Musculoskeletal Findings

- Findings



Musculoskeletal Findings

- Accommodate or address?



Intervention : Manual Therapy

Research:

Manual Therapy has been shown to improve:

- DF range
- Strength (!)
- Balance
- Functional goals

Intervention : Manual Therapy

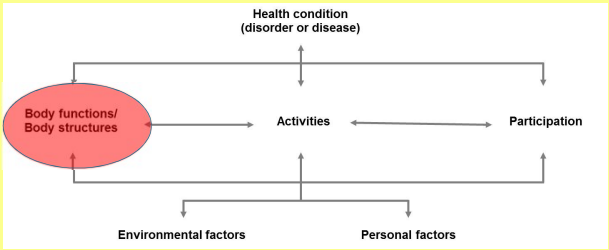
Populations

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

Intervention : Manual Therapy

- ……pediatric health conditions?

Neuromotor Findings



Examination: Neuromotor

Positive signs

versus

Negative signs

Examination: Neuromotor

Ability to:

- Initiate contraction
- Maintain contraction against required force
- Relax
- Time and coordinate movement

Examination: Neuromotor

Balance Strategies: ability to:

- Anticipate balance challenges
- Maintain safe posture
- Stabilize joints to prevent damage
- Adjust to the contact surface
- Coordinate global movers and stabilizers for function

Neuromotor and Motor Control Findings

- ❑Neuromotor MSD
- ❑Muscle contraction – in specific muscles/groups
  - ❑Impaired recruiting
  - ❑Excessive or altered timing of recruiting
  - ❑Tonic contraction
  - ❑Impaired endurance
    - ❑Primary
    - ❑Secondary
  - ❑Impaired or altered timing of relaxation
- ❑Balance Strategies

Altered Patterns of Recruitment

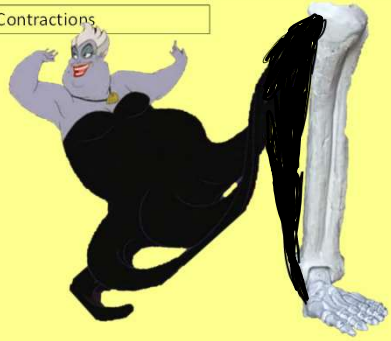
EH & Post Tib > TA

Altered Patterns of Recruitment

EDL > TA

EDL & quad > TA
Tonic TA Contraction

Tonic Contractions

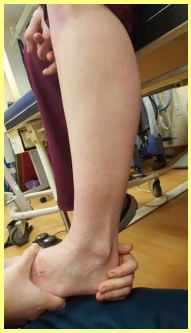


Tonic Muscle Contraction

TA, FDL, Post Tib

EH, Post Tib

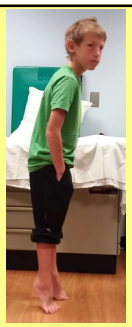
EDL, TA, PL/PB




PL/PB

Post Tib, FDL

Balance Strategies



Hip/Step Strategy

Hip and Toe Strategy

Neuromotor Findings

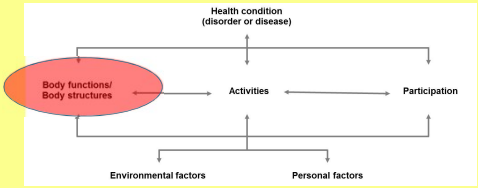
- ❑Atypical habitual patterns of movement
  - ❑Synergies

Neuromotor Findings

- ❑Consistency: does the patient show emerging MN control?

Neuromotor Findings

- Findings



Neuromotor Findings

- Accommodate or address?

Neuromotor Findings

Old Paradigm:

Tonic contractions are a primary result of the health condition

Neuromotor Findings

New Paradigm:

Tonic contractions and tissue stiffness may be an adaptive response to weakness, decreased motor control, and sensory deficits

Intervention: Intrinsic Foot Stability Training

Research:

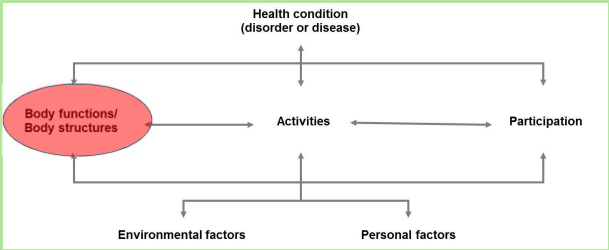
Training foot intrinsic musculature has been shown to impact foot position, static and dynamic balance, and gait dynamics:

- Neurotypical controls
- Ankle instability
- Plantarfasciitis

Intervention: Intrinsic Foot Stability Training

- ……pediatric health conditions?

Sensory Perception and Pain



Sensory Perception and Pain

- ❑Perception of the foot/ankle
  - ❑Hyperperceptive
  - ❑Hypoperceptive

Sensory Perception and Pain

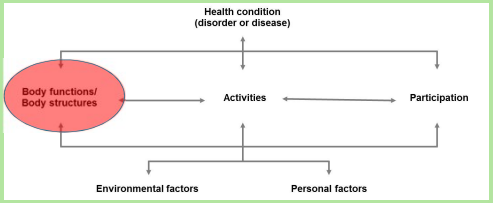
- ❑Altered sensory/perception elsewhere in the greater movement system

Sensory Perception and Pain

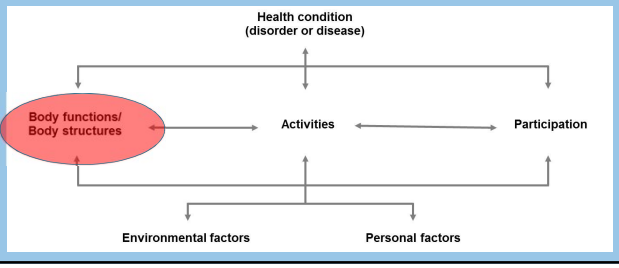
- ❑Pain
  - ❑In foot/ankle/lower leg
  - ❑Elsewhere in kinetic chain

Sensory Perception and Pain Findings

- Findings



Relevant Cardiopulmonary, Integumentary, Neurodevelopmental, Endocrine, Gastrointestinal, Lymphatic System Findings

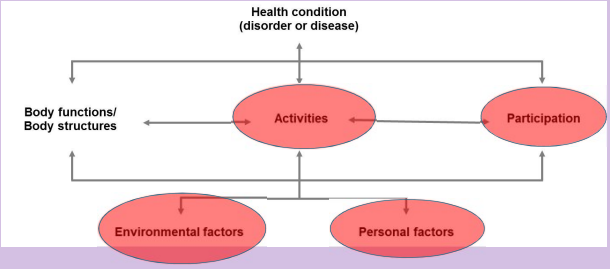


Relevant Systems

Relevant Cardiopulmonary, Integumentary, Endocrine, Neurodevelopmental, Gastrointestinal, Lymphatic System Findings

- ❑GERD
- ❑ASD
- ❑Cardiopulmary
- ❑Integumentary
- ❑Other

Individual Characteristics



Individual Characteristics

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

Key Findings

Task Analysis:
MS:
NM:
Sensory and Pain:
Other Systems:
Individual:

Suspected Drivers:

Limiting Factors:

Goals of Orthotic Intervention:

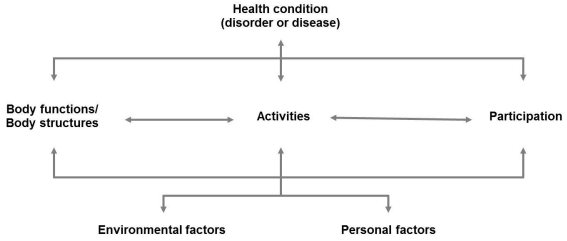
PT's goal:

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

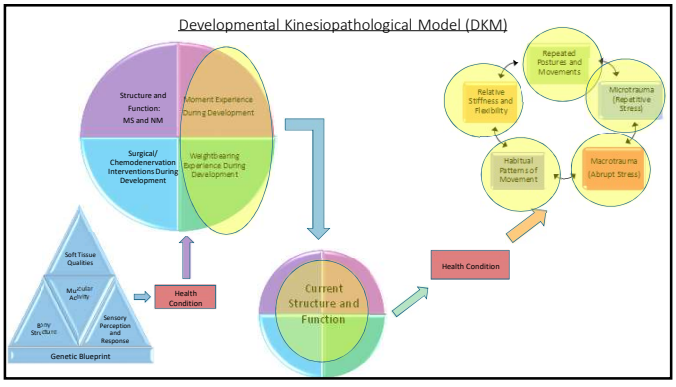
- Improve
  - Function
  - Efficiency
  - Safety

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



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 in the future
- Maximize acceptance of individual differences
- Maximize the ability to self-advocate and access appropriate resources
- Maximize work and social engagement as an adult

Developmental Kinesiopathological Model of the Movement System

Movement System Analysis Framework: Foot and Ankle

Orthotic Design

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: Helping the body interface with the world

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”

- Developed from our Movement System Analysis
- This is a KEY ELEMENT of brace design, apart from style selection, and a key fault of ineffective orthoses.
  - If the style selected is correct, but the movement system has not been captured and supported specifically, the brace will not be appropriate.
  - Appropriate prescription may outweigh appropriate design.

Orthotic Design: Groups

- Group 1: Foot Orthotics (FO)
- Group 2: Supra-Malleolar Orthotics (SMO)
- Group 2+: SMO+
- Group 3: AFO with Movement (AFO-M)
- Group 4: AFO – Solid (AFO-S)
- Group 5: AFO – Sagittal Plane Only (AFO-Sag)

Orthotic Design: Rules

Group 1: Foot Orthotics (FOs)

Group 2: Supra-Malleolar Orthoses (SMOs)

Custom-from casts

Compression-from measurements

Group 2+: Supra-Malleolar Orthoses+ (SMO+)

Group 3: AFOs with Motion

Group 3: AFOs with Motion Flexible Upright (Posterior Leaf Spring)

Group 3: AFOs with Motion Flexible Upright

Group 3: AFOs with Motion Articulated

Free DF

DF Assist

Group 4: AFOs – Solid

Group 4: AFOs – Solid

Group 5: AFOs – Sagittal Only
No Prescription

Anterior Shell | Posterior Shell | A/P (+ false coronal) | Ravenclaw

Orthotic Prescription: Musculoskeletal Findings

- Developing the orthotic prescription

Orthotic Prescription: Musculoskeletal Findings

- ❑Altered joint physiology due to health condition
- ❑Altered muscle strength or endurance due to health condition

Musculoskeletal Findings

- ❑Structural variants
  - ❑Atypical structure
  - ❑TC Axis test: TC joint alignment
  - ❑Structural findings:

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

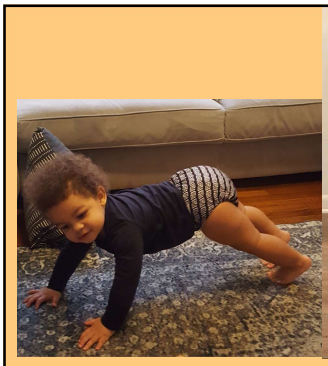
Musculoskeletal Findings

- ❑Functional Variants
  - ❑DF Stress test, End feel
  - ❑Joint Function
- ❒ Neutral hindfoot
- ❒ Pronated hindfoot
- ❒ Supinated hindfoot

	Alignment, Joint Mobility, End feel, Arthrokinematics, ROM
Distal tib/fib	
Talo-crual	
Subtalar	
Midtarsals	
Forefoot	
Digits	

Orthotic Prescription: Musculoskeletal Findings

- Do all individuals with structural or functional variants need orthotics?



Orthotic Prescription: Musculoskeletal Findings

- ❑Joint Function
  - ❑Maladaptive relative stiffness/flexibility
  - ❑Altered line of pull of muscles around joints

❑NWB Corrective force test

What support is required to:

→Bring the foot and ankle in into position with the joints congruent?

❑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?

❑WB Corrective force test

Orthotic Design: Coronal Plane

Support needed: Cueing

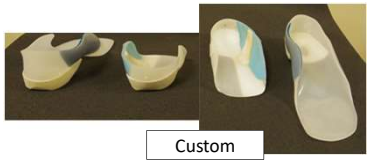
Group 0

- No Intervention
- Monitor
- Stability and foot core training

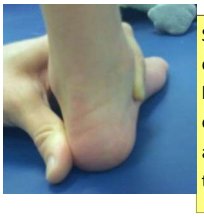
Support at the calcaneous, medial longitunidal arch

Group 1: Foot Orthotics (FOs)

Off The Shelf

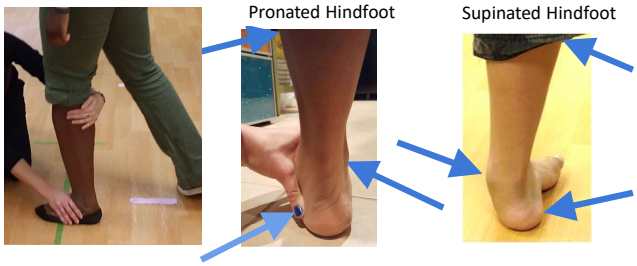


Custom



Support at the calcaneous, medial longitunidal arch, shaft of the 5th metatarsal and around the dorsum of the ankle

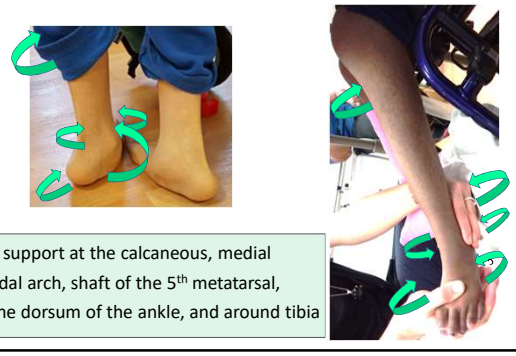
Group 2: Supra-Malleolar Orthoses (SMOs)
Group 2+: Supra-Malleolar Orthoses+ (SMO+)



Support at the calcaneous, medial longitunidal arch, shaft of the 5th metatarsal, around the dorsum of the ankle, at the tibia for a longer lever arm

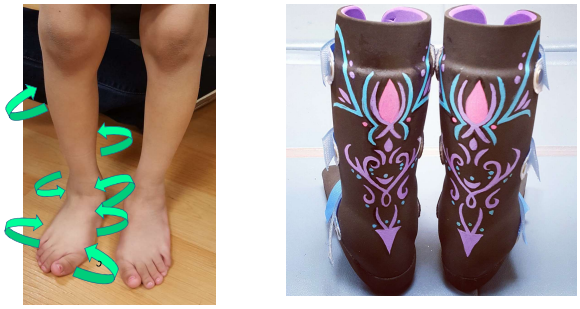
Group 3: AFOs with Motion

Group 5: AFOs – Sagittal Only



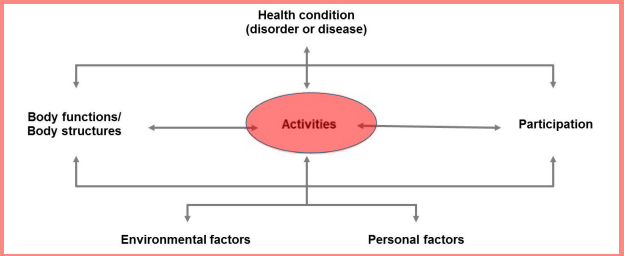
Triplanar support at the calcaneous, medial longitunidal arch, shaft of the 5th metatarsal, around the dorsum of the ankle, and around tibia

Group 4: AFO – Solid



Group 4: AFO – Solid

Functional Status and Task analysis



Orthotic Design: Sagittal Plane
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

What support is required to:

→Support the foot and ankle for safety, weightbearing, and the individual's activities?

Does Not Stand/Limited Standing

Group 0: No Orthotic

Does Not Stand/Limited Standing

Group 4: AFO – Solid

Orthotic Design: Sagittal Plane
Functional Status and Task analysis

- ❑**Initial contact, loading response**

What support is required to:

→Encourage knee flexion versus extension moment during loading response?

or

→Improve eccentric control of tibial advancement during loading response?

Loading Response

Group 1: Foot Orthotics (FOs)
Group 2: Supra-Malleolar Orthoses (SMOs)

Loading Response

Group 2+: Supra-Malleolar Orthoses+ (SMO+)

Loading Response

Group 3: AFOs with Motion

- DF Assist, DF Free

Loading Response

Group 3: AFOs with Motion

Posterior Leaf Spring - Assist in eccentric slowing of the shank

Loading Response

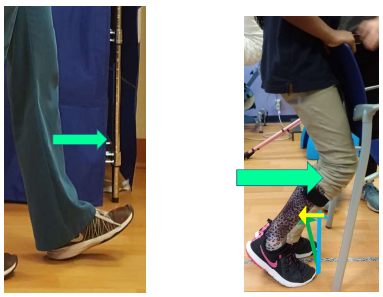
Group 4: AFOs – Solid

Stops progression of shank, chooses one angle and takes you straight there.

Loading Response

Group 4: AFOs – Solid

Stops progression of shank?



Loading Response:
Shank Reversal

Group 5: Sagittal Only AFOs

Anterior Shell

Posterior Shell

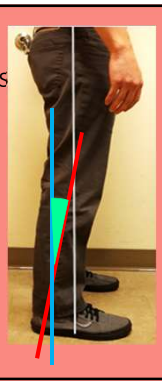
Loading Response:
Impaired Eccentric Control

Group 5: Sagittal Only AFOs

Anterior Shell

Posterior Shell

Orthotic Design: Sagittal Plane Functional Status and Task analysis



❑Midstance

What support is required to:

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

- There *can* be 2 angles in an AFO:
  - Angle of the ankle in the orthosis
  - Angle of the shank (tibia) to the floor

❒1-Shank Angle WFL

Movement system is able to compensate for any changes at the foot/ankle

-or-

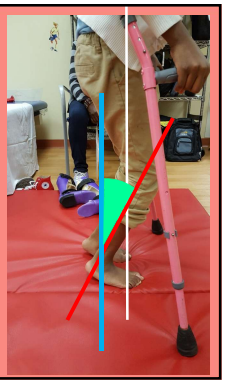
The greater movement system is ***driving*** the change in the foot/ankle

❑ 2-Excessively inclined shank (crouch)

Weight line

- anterior to hip
- posterior to the knee

Shank angle > 15 degrees



❑ 2-Excessively inclined shank (crouch)

Old conventional wisdom: set shank in a reclined angle angle to push the shank backwards. (“Floor reaction AFO”)

In reality, the foot has an inefficient lever arm for this to be effective, and the patient lifts the heel.

❑ 2-Excessively inclined shank (crouch)

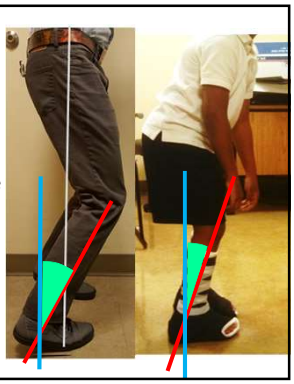
Current theory: Bring the floor up to the heel to provide:

- Heel contact at initial contact and midstance
- Provide a base for the thigh to move from reclined to inclined

❑ 2-Excessively inclined shank (crouch)

Begin to teach the motor system to load through the posterior aspect

Compromise towards the chosen shank angle to get heel contact



❑ 2-Excessively inclined shank (crouch)

- Gradually reduce the shank angle as posterior structures lengthen and motor learning occurs

Excessively Inclined Shank

Group 1: Foot Orthotics (FOs)
Group 2: Supra-Malleolar Orthoses (SMOs)
Group 2+: Supra-Malleolar Orthoses+ (SMO+)

Excessively Inclined Shank

Group 3: AFOs with Motion

- DF Assist, DF Free

Excessively Inclined Shank

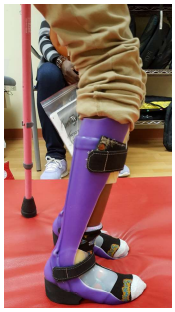
Group 3: AFOs with Motion

Posterior Leaf Spring

Excessively Inclined Shank

Group 4: AFOs – Solid

Removes a degree of freedom—provides a stable base to work on proximal skills for standing and gait alignment.



Excessively Inclined Shank

Group 5: Sagittal Only AFOs

Anterior Shell

Posterior Shell

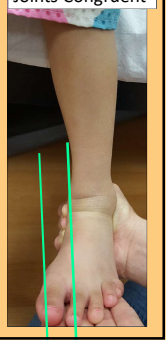
A/P
(+ false coronal)

Ravenclaw

❒Structural Variants

	Coronal Plane	Transverse Plane
Midfoot	Metatatarus Varus	Metatarsus Adductus

Masked



Joints Congruent

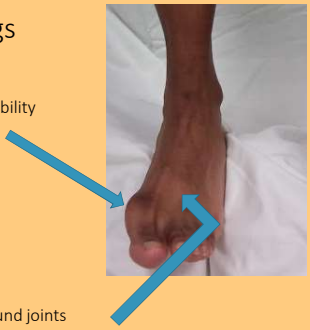
Musculoskeletal Findings

- ❑Functional Variants
  - ❑DF Stress test
    - ❒Pronated hindfoot

End feel/location: often anterior lateral talar impingement

Musculoskeletal Findings

- ❑Joint Function
  - ❑Maladaptive relative stiffness/flexibility



- ❑Altered line of pull of muscles around joints

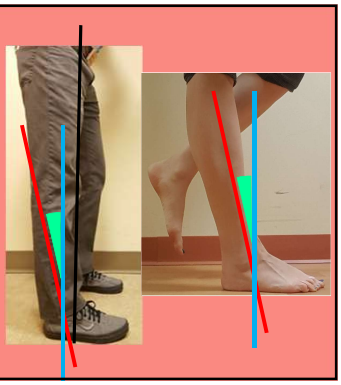
❑ 2-Excessively inclined shank (crouch)

Treatment focuses on learning to bring the thigh from reclined to inclined over a stable base in midstance and quiet stance.

❑ 3-Excessively reclined shank (knee hyperextension)

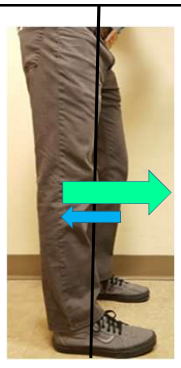
Weight line

- anterior to hip
- anterior to the knee



❑ 3-Excessively reclined shank (knee hyperextension)

- Goal: bring the shank angle forward enough to overcome the tendency for the system to create an extension moment.



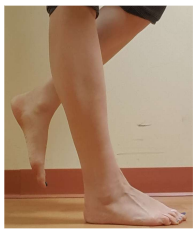
Excessively Reclined Shank

Group 2+: Supra-Malleolar Orthoses+ (SMO+)

Excessively Reclined Shank

Group 3: AFOs with Motion

- DF Assist, DF Free
- If set with a PF block, may overcome reclined shank moment while allowing the gastrocsoleus perform eccentric control of DF.



Excessively Reclined Shank

Group 3: AFOs with Motion

Posterior Leaf Spring

Excessively Reclined Shank

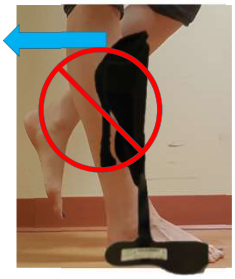
Group 4: AFOs – Solid

- Removes a degree of freedom—provides a stable base to work on proximal skills for standing and gait alignment.
- This stability may assist with motor learning to increase loading through the limb.

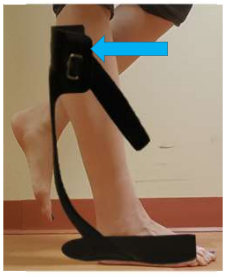
Excessively Reclined Shank

Group 5: Sagittal Only AFOs

Anterior Shell



Posterior Shell



❑ 3-Excessively reclined shank (knee hyperextension)

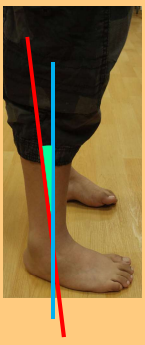
Weight line

- anterior to hip
- anterior to the knee

Musculoskeletal Findings

❑Altered muscle strength or endurance due to health condition

- Weight line is aligned anterior to knee to maintain knee stability
- Shank angle reclined
- Forcing the shank forward will cause uncontrolled knee flexion (buckling) and loss of stability in standing



Excessively Reclined Shank +
Primary lower extremity weakness

Group 4: AFO – Solid

Excessively Reclined Shank +
Primary lower extremity weakness

Group 5: Sagittal Only AFOs

Anterior Shell

Posterior Shell

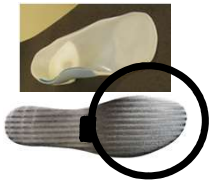
- Terminal Stance
  3rd Rocker

What support is required for:
→Heel contact
→with knee extension
and
→hip extension

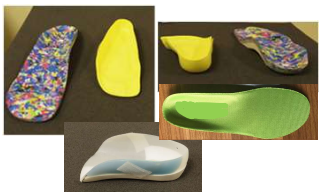
3rd Rocker

Group 1: Foot Orthotics (FOs)

Stiff 3rd rocker



Flexible or free 3rd rocker



3rd Rocker

Group 2: Supra-Malleolar Orthoses (SMOs)
Group 2+: Supra-Malleolar Orthoses+ (SMO+)

Stiff 3rd rocker

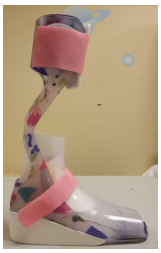
Flexible or free 3rd rocker

- Terminal Stance
  3rd Rocker

What support is required to:
→Store energy to assist with push-off

Energy Storage

Group 3: AFOs with Motion Flexible Upright



Energy Storage



Energy Storage

Group 3: AFOs with Motion Articulated

Free DF

DF Assist

Energy Storage

o 4: AFOs – Solid

Energy Storage

Group 5: Sagittal Only AFOs



Anterior Shell

Posterior Shell

A/P
(+ false coronal)

Functional Status and Task analysis

Swing phase
- ❑Foot clearance

What support is required for:
→Foot clearance

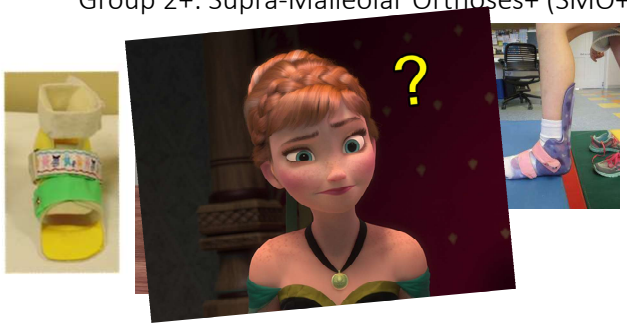
→Limb positioning at terminal stance

Swing

Group 1: Foot Orthotics (FOs)
Group 2: Supra-Malleolar Orthoses (SMOs)

Swing

Group 2+: Supra-Malleolar Orthoses+ (SMO+)



Swing

Group 3: AFOs with Motion
Flexible Upright

Swing

Group 3: AFOs with Motion
Articulated

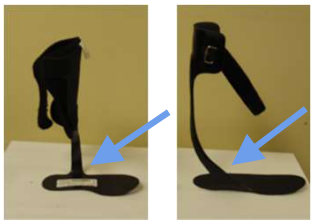
Free DF

DF Assist

Group 4: AFOs – Solid

Swing

Group 5: Sagittal Only AFOs



2 points of control, depend on shoe for the 3rd.

Effective to support clearance and pre-positioning with
- Weakness
- Cueing

not against active resistance.

Functional Status and Task analysis

❑Transverse and Coronal Plane findings

Functional Status and Task analysis

❑Developmental Status
Goals related to movement experiences based on current developmental status.

Orthotic Design: Neuromotor

- What external support is needed for mass practice of target motor skills?
- What external support decreases tonic contractions which lead to sustained alignments that would contribute to pathoanatomical changes?

→Foot and ankle
→Elsewhere in kinetic chain

Sensory Perception and Pain

Informs
- Orthotic design

What support is needed for the foot intrinsics to receive relevant balance information?

Relevant Systems

Informs
- Orthotic decision
- Orthotic design

Individual Characteristics

Informs
- Orthotic decision
- Orthotic design
- Orthotic aesthetics
- Orthotic dosage

Minimizing Negative Impacts of Orthotic Intervention on Activities and Participation

Individual Characteristics: Aesthetics

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

- Fault
- 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 Treatment 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

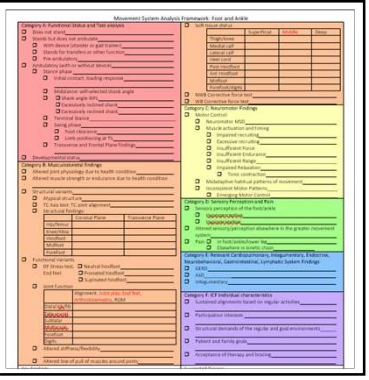
Comprehensive Treatment Plan

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

Physical Therapy:
Home Program:
Community Exercise Activity:

- Case Studies

Movement System Analysis Framework: Foot and Ankle



Case Study 1

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 _____
    - ❒Loading response_____
    - ❒Midstance: self-selected shank angle
    - ❒ ❒1-Shank angle WFL_____
    - ❒2-Excessively inclined shank_____
    - ❒3-Excessively reclined shank_____
  - ❒ Terminal Stance_____
    - ❒Swing phase_____
      - ❒Foot clearance_____
      - ❒Limb positioning at TS (location of Initial contact)
      - _____
    - ❒Transverse and Frontal Plane findings_____
      - _____

Developmental status_____

Functional Status and Task Analysis

- ❒Ambulatory (with or without device)
  - ❒Stance phase _____
    - ❒1-Shank angle WFL_____
  - ❒Swing phase_____
    - ❒Foot clearance_____
    - ❒Limb positioning at TS (location of Initial contact)
  - ❒Transverse and Frontal Plane findings_____
  - ❒Developmental status_____

Musculoskeletal Findings

- ❑Altered joint physiology
- ❑Altered muscle strength
- ❑Structural variants
  - ❑Atypical structure
- ❑TC Axis test: TC joint alignment
- ❑Structural findings:

	Coronal	Transverse
Hip/femur		
Knee/tibia		
Hindfoot		
Midfoot		
Forefoot		

Musculoskeletal Findings

- ❑Functional Variants
- ❑DF Stress test: 1-Neutral hindfoot
  - End feel: active resistance/GS/heelcord
- ❑Joint function
  - Distal tib/fib
  - Talo-crural --25/-30 L, 0 R
  - Subtalar
  - Midtarsals
  - Forefoot
  - Digits
- ❑Altered relative stiffness/flexibility

Musculoskeletal Findings

- ❑Altered line of pull around joints
- ❑Soft tissue status
- ❑NWB Corrective force test
- ❑WB Corrective force test

Neuromotor and Motor Control Findings

- ❑Muscle activation and timing
  - ❑Impaired recruiting
  - ❑Excessive recruiting
  - ❑Insufficient Force
  - ❑Insufficient Endurance
  - ❑Insufficient Range
  - ❑**Impaired Relaxation**
    - ❑Tonic contraction

Neuromotor and Motor Control Findings

- ❑Atypical habitual patterns of movement
- ❑ Inconsistent Motor Patterns
  - ❑Emerging Motor Control
- ❑Balance Strategies

Sensory Perception and Pain

Sensory perception of the foot/ankle

- ❑**Hyperperceptive**
- ❑Altered sensory/perception elsewhere in the movement system
- ❑Pain
  - ❑**In foot/ankle/lower leg**

Relevant Cardiopulmonary, Integumentary, Endocrine, Neurodevelopmental, Gastrointestinal, Lymphatic System Findings

❑**Integumentary**

Individual Characteristics

❑Sustained alignments based on regular activities

❑Participation interests

❑Structural demands of the regular and goal environments

❑Patient and family goals

❑Engagement with therapy and orthoses

Key Findings

Task Analysis: Shank WFL

MS: Lacking TC PROM range L >> R

NM: tonic contraction of GS, peroneals, post tib, long toe extensors

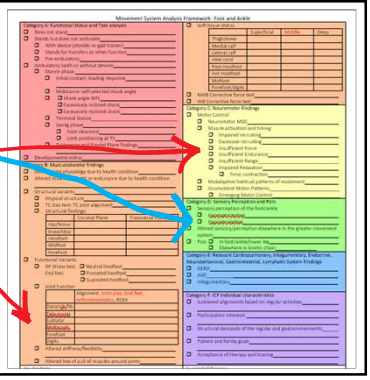
Sensory and Pain: hyperperceptive and prone to pain in the foot/ankle

Other Systems: Reactive skin

Individual: Participates in many sports

Suspected Drivers:

Limiting Factors:



Goals of Orthotic Intervention:

PT's goal:

- Decrease frequent experience of pain with daily movements
- increase access to more stable base of support and greater access to balance strategies to improve function for sports
- Prevent pain as an adult

Patient's goal: ?

Family's goal: prevent long-term problems

Other team member's goals: PM&R "I don't refer toe walkers for PT"

Comprehensive Treatment Plan

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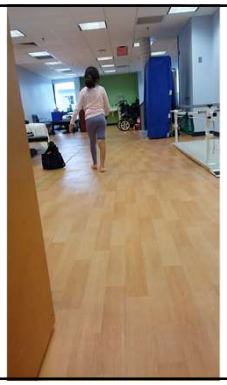
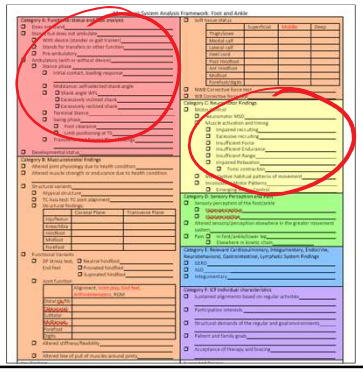
Device 2		
Device 3		

Physical Therapy:
Home Program:
Community Exercise Activity:





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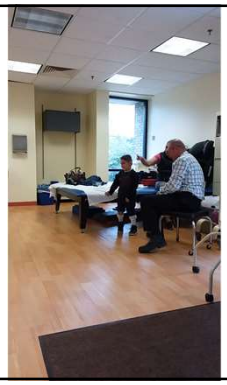

Comprehensive Treatment Plan

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Comprehensive Treatment Plan

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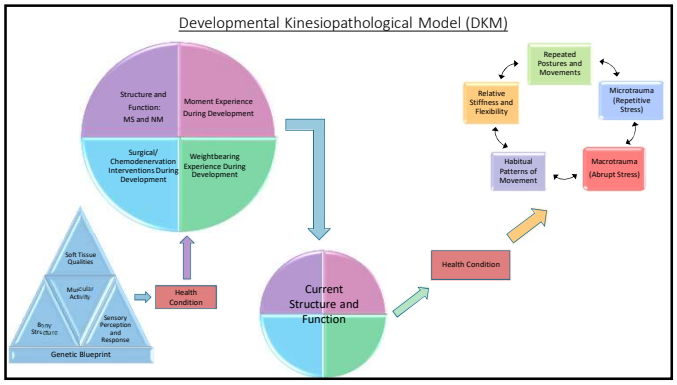
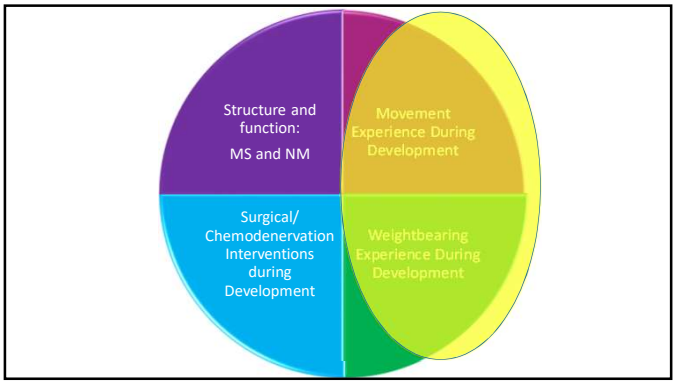
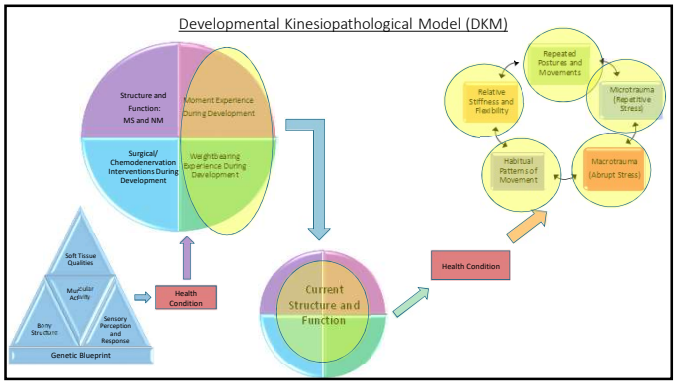
The Developmental Kinesiopathological Model of the Movement System

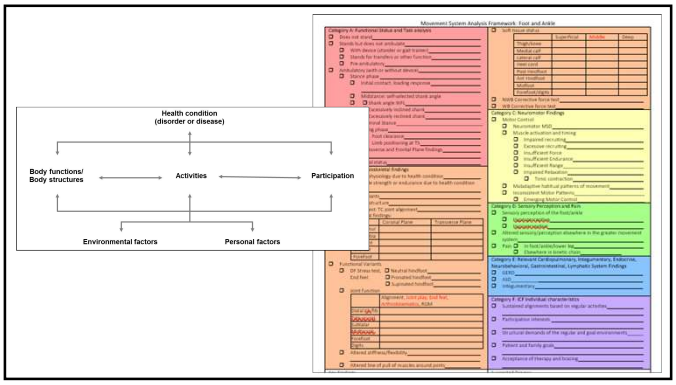
Movement System Analysis Framework: Foot and Ankle

Orthotic Design









Thank you!

Movement System Analysis Form
amandahallpt.com/APPTAC-2019