AMBULATION, ACTIVITY, AND AFOs

Addressing the Ankle to Improve Gait and Function
Hands-On Course

Developed and Instructed by:
Amanda Hall, PT, MPT, PCS
Board-Certified Pediatric Clinical Specialist

Course Logistics

Lab Clothing:	Please have the legs available from the knee through the foot for lab portions. Cover-ups are recommended between lab portions, as room temperatures may vary.
Fingernails:	Short fingernails are recommended for manual therapy techniques.
Individual Responsibility:	This course is a hands-on learning environment in which participants will be performing challenging techniques and will be evaluated by and treated by other course participants. It is not possible for the instructor to monitor all participants at all times. It is the responsibility of each participant to monitor and limit their participation as need, both in delivering and receiving techniques.

Course Description

This in-person course focuses on hands-on advanced evaluation and treatment of the foot and ankle to improve gait and function for patients with pediatric, neurologic, and orthopedic health conditions. Participants will practice an organized system to evaluate ankle function using a kinesiopathologic approach, determining key findings to develop a clinical hypothesis. Multiple labs will include the latest evidence-based interventions to improve foot and ankle function for individuals across the movement spectrum, including joint and soft tissue mobilizations, improving strength and motor control of the "foot core", and addressing pain. Participants will also learn hands-on skills for orthotic design as well as foot/ankle taping techniques.

Course Objectives:

At the conclusion of the course, participants should be able to:

1. Analyze foot and ankle exam findings including gait kinematics, neuromotor function, and musculoskeletal findings to design individualized treatment plans
2. Apply advanced manual mobilization skills to joint and soft tissues to improve foot and ankle mobility and function
3. Design a progressive strengthening program to improve motor control of the foot and ankle
4. Design a comprehensive orthotic plan to improve function and gait for patients with identified foot/ankle dysfunction
5. Take a mold for a shoe-insert orthotic to support a structural and functional foot impairment.

Faculty:

This course was developed and is instructed by **Amanda Hall, PT, MPT, PCS,** who received her MPT from the University of Washington in 2001. She re-certified as a Pediatric Clinical Specialist in 2020. She has developed a framework based on movement system analysis for differential diagnosis, developmental movement system analysis, neuroplasticity, manual therapy, and alignment for therapeutic gait. Her framework has a strong focus in patient-centered treatment and adaptive design. Amanda's clinical practice is at the HSC Pediatric Center in Washington, DC, where she provides therapeutic casting, orthotic evaluations, and foot and ankle intervention, as well as clinical consultation and private practice for adult casting, orthotics, and foot/ankle management. Amanda has presented her work internationally, including at APTA's Combined Sections Meetings (CSM), American Academy of Pediatric PT's Annual Conference (APPTAC), and at the National Institutes of Health (NIH).

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<u>Outline (May change based schedule and participant needs)</u>

- Foot and Ankle Terminology
    - Worksheet

- Foot and Ankle Function
    - Efficient ankle function: structure and function
    - Ankle dysfunction: impact of structural and functional variants using the kinesiopathologic model in pediatric, neurologic, and orthopedic patients

- MS evaluation Lab: Musculoskeletal Foot and Ankle Examination
    - Weightbearing functional assessment
    - Special tests: Dorsiflexion Stress test and Talocrural Axis Test
    - Lab: Musculoskeletal Examination: Establishing the structural anatomy and current functional status of the foot and ankle
    - NWB, WB corrective force tests

- Neuromotor Exam
    - Tests for foot intrinsic function
    - Balance tests
    - Test to determine contributors to atypical patterns of tonic contraction

- Ankle mobilizations
    - Joint Mobilizations: Subtalar and talocrural
    - Mobilizations: midfoot, forefoot, 1st ray, digits
    - Soft tissue mobilizations to improve ankle mobility and relative flexibility

- Gait: elements of efficient and therapeutic gait
    - Taping techniques for the foot and ankle: stability, alignment, and facilitation
        - Supination
        - Pronation
        - Shortening the medial arch
        - Spiral foot core
        - Longitudinal foot core
        - Correction of abducted first ray
        - Correction of forefoot supination in chronically pronated foot
        - Taping for stability and proprioception
    - Progressive resisted exercises for the foot intrinsics
    - Improving motor control for the key elements of therapeutic gait: loading response, midstance, and terminal stance

- The role of neuroplasticity in foot and ankle function in orthopedic and neurologic dysfunction
    - Lab: Sensory/Perceptual and Pain Exam
        - Hypo/hyper altered sensation
        - Pain: perception and communication

    - Applied neuroplasticity interventions for foot and ankle function

        - Short foot
        - Paper grip test for foot intrinsics
        - Intrinsic positive test
        - Toe splaying

- Comprehensive exam and application of treatment techniques
    - Advanced mobilizations
        - Addressing talar rotation during hindfoot mobilizations
        - Mobilizations with tonic contractions/tone in neurologic and pediatric patients
        - Muscle energy techniques
        - Supination and pronation joint and soft tissue progressions

- Orthotics
    - Evidence related to ankle dysfunction through the kinetic chain
    - Framework for orthotic prescription, design, and dosing
    - Coronal, sagittal, and transverse plane design
    - Posting worksheets
    - Taking molds for orthoses
    - Lab: case studies and applied orthotic trials
    - Shoe selection and design

Movement System Analysis--Foot and Ankle

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
      - ❒ Shank angle WFL_______________________________
      - ❒ Excessively inclined shank_______________________
      - ❒ Excessively reclined shank_______________________
    - ❒ Terminal Stance____________________________________
    - ❒ Swing phase______________________________________
      - ❒ Foot clearance_________________________________
      - ❒ Limb positioning at TS (location of Initial contact) ____
    - ❒ Transverse and Frontal Plane findings_______________ ____
- ❒ Lifespan status_______________________________________

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	
Talo-crural	
Subtalar	
Midtarsals	
Forefoot	
Digits	

  - ❒ Altered relative 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______________________________________

Neuromotor and Motor Control Findings

- ❒ Neuromotor MSD____
- ❒ Muscle activation and timing
  - ❒ Impaired recruiting_____________________________________
  - ❒ Excessive recruiting____________________________________
  - ❒ Insufficient Force______________________________________
  - ❒ Insufficient Endurance__________________________________
  - ❒ Insufficient Range______________________________________
  - ❒ Impaired Relaxation____________________________________
    - ❒ Tonic contraction_________________________________
- ❒ Atypical habitual patterns of movement______________________
- ❒ Inconsistent Motor Patterns_________________________________
  - ❒ Emerging Motor Control_______________________________
- ❒ Balance Strategies____

Sensory Perception and Pain

- ❒ Sensory perception of the foot/ankle
  - ❒ Hyperperceptive_______________________________________
  - ❒ Hypoperceptive____
- ❒ Altered sensory/perception elsewhere in the greater movement system____
- ❒ Pain ❒ In foot/ankle/lower leg______________________________
  - ❒ Elsewhere in kinetic chain___________________________

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

- ❒ GERD____
- ❒ ASD____
- ❒ 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: ____

MS: ____

NM: ____

Sensory and Pain: ____

Other Systems: ____

Individual: ____

Suspected Drivers:

Limiting Factors:

Goals of Intervention:

System Resources:

Movement System Analysis--Foot and Ankle

Functional Status and Task Analysis

- ❒ Does not stand____________________
- ❒ Stands but does not ambulate____________________
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    - ❒ Swing phase____________________
      - ❒ Foot clearance____________________
      - ❒ Limb positioning at TS (location of Initial contact)
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    - ❒ Transverse and Frontal Plane findings____________________
      ____
- ❒ Developmental status____________________

Musculoskeletal Findings

- ❒ Altered joint physiology due to health condition____________________
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    - ❒ Tonic contraction____________________
- ❒ Atypical habitual patterns of movement____________________
- ❒ Inconsistent Motor Patterns____________________
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- ❒ Balance Strategies____________________

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  ❒ Elsewhere in kinetic chain____________________

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- ❒ NWB Corrective force test__________________________________
- ❒ WB Corrective force test____________________________________

Neuromotor and Motor Control Findings	
❒ Neuromotor MSD____	

❒ Muscle activation and timing	*Musculoskeletal/Neuromotor:*
	• Identifying stiff, short, and tonic contraction vs. "tight"
	•
	• What structures are pulling the ankle complex off axis?
	• Is the pull passive or active?
	• What input decreases or increases this pull?
	• What input turns off the patient's involuntary and voluntary contractions?
	• Techniques to address patient stress, guarding, and tonic muscle contraction
	  ○ unweighting
	  ○ deep pressure
	  ○ contact on the active structures
	  ○ movement into tone-inhibiting positions
	  ○ NOT yelling at them to relax

❒ Impaired recruiting____________________________________	
❒ Excessive recruiting___________________________________	
❒ Insufficient Force_____________________________________	
❒ Insufficient Endurance_________________________________	
❒ Insufficient Range_____________________________________	
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❒ Atypical habitual patterns of movement_____________________	
❒ Inconsistent Motor Patterns_____________________________	
❒ Emerging Motor Control_________________________________	
❒ Balance Strategies_____________________________________	

Individual Goal Development: Using ICF and DMSM

Key Findings

Task Analysis: ____

MS: ____

NM: ____

Sensory and Pain: ____________________________________

Other Systems: ______________________________________

Individual: ____

Suspected Drivers:

Limiting Factors:

Goals of Intervention:

Goals: Body Structure and Function: Short Term

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

Goals: Body Structure and Function: Developmental Movement System 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: Environment: Short Term

- Increase direct access to goal environments and structures

Goals: Activities: Short Term

- Improve
  - Function
  - Efficiency
  - Safety

Goals: Environment and Activities: Developmental Movement System Model. For the patient as an **adult**:

- Maximize the environments and activities the patient can access with their movement system in the future

Goals: Participation & Personal Factors: Short Term

- Social Acceptance
- Self-Acceptance
  - Fit In
  - Stand Out
  - Appear Neurotypical
  - Celebrate differences
  - Be Cool

Goals: Participation & Personal Factors: Developmental Movement System Model. For the patient as an **adult**:

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

Team member goals:

PT's goals:

Patient's goals:

Family's goals:

Other team member's goals:

Terminology Worksheet

Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Medial Torsion – Lateral Torsion Adductus – Abductus	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus (-a, -um) – Valgus (-a, -um)	Invert – Evert Adduct – Abduct
Sagittal	Sagittal Plane bowing	Flex – Extend Dorsiflex – Plantarflex
Triplanar		Supinate(d) (add + inv + PF) – Pronate(d) (abd + eve + DF)

Fill in the blanks with the following words:

Eversion	Pronation	Genu (knee) valgum
Hindfoot varus	Forefoot varus	Inversion
Medial tibial torsion	Tibial vara	MTP abduction
Supination	Forefoot adductus	Lateral tibial torsion

1. Structure: Twist of tibia in the transverse plane away from midline—distal aspect more laterally oriented than proximal aspect.

   ____

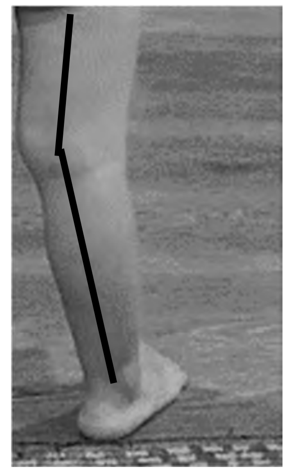
2. Structure: Twist of the tibia in the transverse plane toward midline—distal aspect more medially oriented than proximal aspect.

   ____

3. Structure: Net orientation of the femur/tibia in the coronal plane away from midline (distal part is more lateral)

   ____

Right LE, view from posterior in standing



4. Structure: Curve of the tibia in the coronal plane toward the midline (distal part is more medial)

   ____

Right LE, view from posterior in standing

5. Structure: With the talocrual and subtalar joints congruent, the calcaneous is oriented medially in the coronal plane.

____

Left LE, view from posterior in prone

6. Motion/position: Medial orientation of the hindfoot toward midline in the coronal plane

____

Left LE, view from posterior in prone

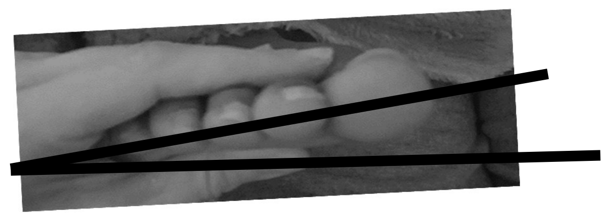
7. Motion/position: Lateral orientation of the hindfoot away from midline in the coronal plane

____

Left LE, view from posterior in prone

8. Structure: Medial orientation of the metatarsals in the transverse plane
   ____

9. Structure: With joints congruent, the MTPs are angled such that the 5th MTP is lower than the 1st MTP (medial rotation in the coronal plane)
   ____



10. Motion/position: lateral orientation of MTP in the transverse plane
   ____

11. Triplanar motion or position of joint in eversion, dorsiflexion, abduction

____

12. Triplanar motion or position of joint in inversion, plantarflexion, adduction

____

Individual Goal Development: Using ICF and DMSM

<table>
<tr>
<td>
Key Findings
Task Analysis: ____
MS: ____
NM: ____
Sensory and Pain: _____________________________________
Other Systems: _______________________________________
Individual: ____
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<td>
Suspected Drivers:

Limiting Factors:

Goals of Intervention:
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Goals: Body Structure and Function: Short Term

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
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Minimize pain
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Goals: Environment: Short Term

Increase direct access to goal environments and structures

Goals: Activities: Short Term

Improve
Function
Efficiency
Safety

Goals: Environment and Activities: Developmental Movement System Model. For the patient as an adult:

Maximize the environments and activities the patient can access with their movement system in the future

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Goals: Participation & Personal Factors: Short Term

Social Acceptance
Self-Acceptance
Fit In
Stand Out
Appear Neurotypical
Celebrate differences
Be Cool

Goals: Participation & Personal Factors: Developmental Movement System Model. For the patient as an adult:

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

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Team member goals:
PT’s goals:

Patient’s goals:

Family’s goals:

Other team member’s goals:
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DF Stress Test

Dorsiflexion Stress Test

Where does DF occur when a general force is applied?

Where does ankle “dorsiflexion” (foot toward tibia) “want” to occur with PROM (direction susceptible to motion)? Does the ankle move primarily with TC dorsiflexion, or does compensatory motion occur?

What and where is the end feel of gross DF if you do not guide the motion?

Classify in one of these 3 groups:

1. Neutral Hindfoot
2. Pronated Hindfoot
3. Supinated Hindfoot

TC Axis Test

Talo-Crural Axis Test

- Move the ankle through dorsiflexion and plantarflexion at different points along the transverse plane.
- Assess what is limiting further dorsiflexion from occurring
    - Quality of end feel
    - Location of end feel
- Move your position to be in line with the axis of motion of the TC joint
- Identify point where the end feel is in the Achilles tendon or TC joint

Musculoskeletal Examination: Soft tissue extensibility

Does each layer of fascia glide over the underlying tissue? Where are the restrictions?

Muscle bellies
Heel cord and tendons
Superficial fascia
Skin

- local
- winding and twisting

Check for:
Tissues that are over-stretched or damaged

Tissues that feel blocked or have a tough end feel

Hyper- or hypo-mobility of plantar fascia and medial foot structures

Excursion and end feel of soft tissues

Movement of the soft tissues of the GS, over and of the heel cord, around the ankle

Where are the restrictions?

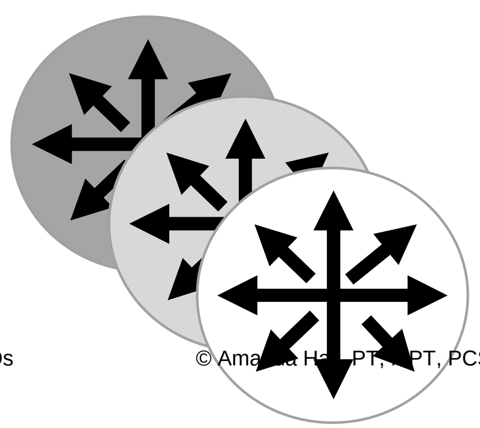
What is the end feel?

Extensibility/Stiffness

Ability to lengthen, ability to fold

Multi-layer assessment

Multi-directional assessment



Manual Therapy Activity

not a linear treatment approach

Constantly seeking and clearing the next limiting structure

"Tone," posturing, and muscle length

What input decreases the patient's involuntary and voluntary muscle contractions?

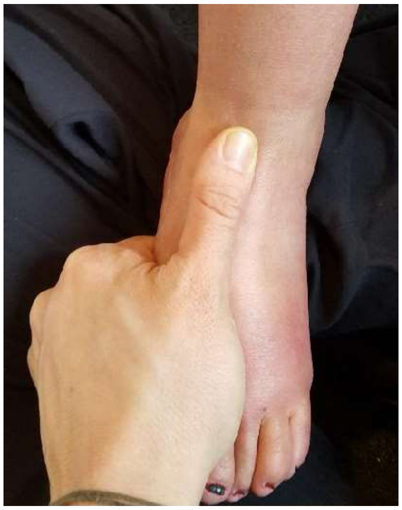
Strategies:

-unweighting

-deep pressure

-contact on the active structures-movement into tone-inhibiting positions

-NOT yelling at them to relax



TC DF Axis Test – Line up to be in line with TC DF throughout treatment.

Dorsiflexion should always be "for free"

Gravity and physics provide stretch

Hands guide alignment

DF Force through therapist's knee into patient's 5th MTP

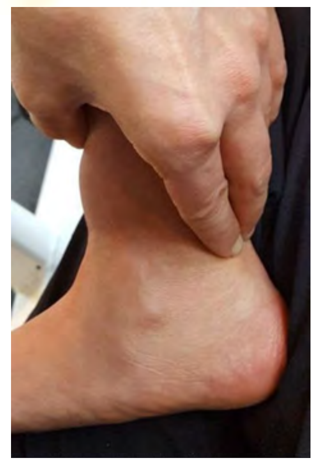
Therapist in line with patient's TC joint, typically across the patient's midline.

Soft tissue extensibility

Glide each layer of fascia glide over the underlying tissue. Find are the restrictions and mobilize them.

Move the system into further correction, and look for restrictions as you move further into the range.

Mobilize tissues that feel blocked or have a tough end feel.

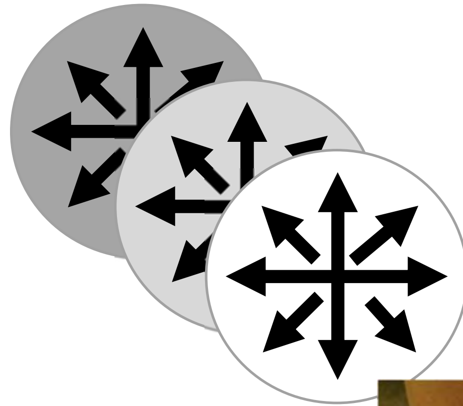


Trace around boney prominences.

Address the mobility as needed of:

Muscle bellies
Heel cord and tendons
Superficial fascia
Skin
-local
-winding and twisting

- Multi-layer
- Multi-directional
- Overall-twisting and gliding
- Identify and address restricted spots
    - Hindfoot
    - Proximal
    - Distal

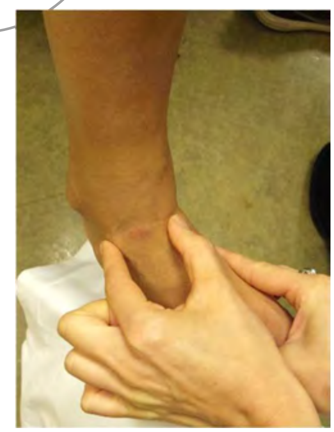


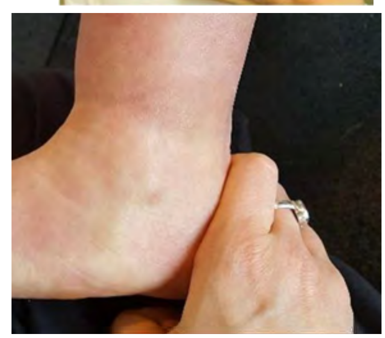
Joint Motion
Alignment of the talus

Techniques to improve joint alignment and mobility

Distal tib-fib mobilization
Calcaneal Distraction
Transverse and coronal talus mobilization
Posterior talus mobilization
- Direct
- Through anterior navicular and cuboid

Navicular rotation superior and inferior
Midfoot mobilizations
Forefoot mobilizations
- Forefoot varus versus stiffness





“Pronated” foot: Correct the alignment of the navicular and midfoot to create an arch

Supinated foot: mobilize the cuneiforms and navicular medially

As you work, bring the foot into more dorsiflexion and see where the restrictions. Pay attention to where the foot “wants” you to go, and where it “should” go. You are looking for a healthy end feel as you continue to work into restrictions and move further into the range. Don’t let the foot trick you.

AMBULATION, ACTIVITY, & AFOs

Hands-On Course

Amanda Hall, PT MPT, PCS

Disclosures

- Amanda Hall, PT receives a speaking honorarium from Education Resources Inc. for this course.
- No other relevant financial or non-financial relationships exist.

Ankle Form & Function

What's unique about the ankle?

The Ankle

- For those of us who stand or ambulate, the foot and ankle are the **interface of our bodies with the world** for function.
- Altered function of this Body Structure can contribute significantly to Activity limitations and Participation restrictions.

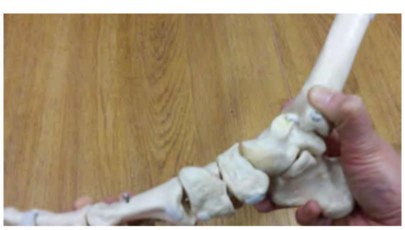
What's unique about the ankle?
The ankle is uniquely biased to lose functional ROM

- Intrinsic resistance in posterior structures due to passive-elastic properties of the gastrocsoleus soleus complex
- Allows the system to store energy at terminal stance to power swing to maximize efficiency of gait/minimize energy expenditure.

What's unique about the ankle?
The resting position of the ankle when non-weightbearing is in plantarflexion.

What's unique about the ankle?
The key range of motion for *gait* is at end of the range in the direction of DF, not mid-range

What's unique about the ankle?
15 degrees of plantarflexion is the position of minimal tension at the talo-crural joint



DF Restriction: Causes

- Why ***don't*** we have restricted DF?

What's unique about the ankle? Therapeutic Gait

Functional dorsiflexion and healthy gastrocsoleus function are achieved

not just ***for***

but ***through***

regular ambulation

"Therapeutic Gait" (Elaine Owen MBE MSc SRP MCSP)

Therapeutic Gait

- Functional DF range and tissue mobility are achieved through regular ambulation with certain key gait dynamics
- Anyone lacking this movement experience is at risk for restricted DF
- Shift: foot and ankle impairments in cerebral palsy may be sequelae of the ***lack of therapeutic gait***, NOT a primary sign of the cerebral palsy
- Establishing key gait dynamics isn't just the goal of treatment, it is the long-term treatment itself.

4

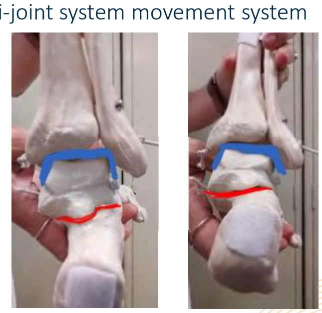
Therapeutic Gait: Functional mobilization

LOADING RESPONSE | MIDSTANCE | TERMINAL STANCE

What's unique about the ankle? Ankle is a complex, multi-joint system movement system

What's unique about the ankle? Ankle is a complex, multi-joint system movement system

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



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Subtalar neutral → Talus on axis

"Clinical fiction" Talocrural dorsiflexion *TC DF*

Epigenetics & modern phenotypes: **the biological nonsense of sub-talar neutral**. Journal of foot and ankle research.(Quinn 2010)

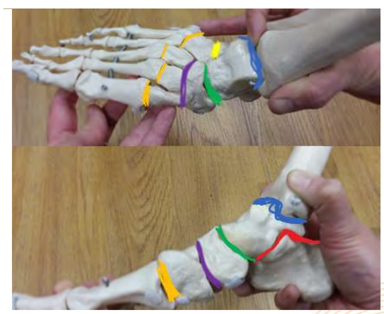
Challenging the foundations of the clinical model of foot function: further evidence that the **Root Model assessments fail to appropriately classify foot function.** (Jarvis 2017)

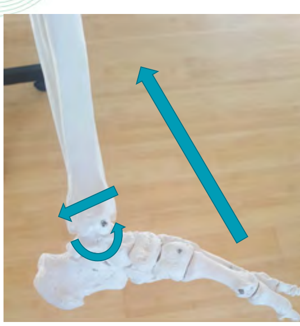
If it doesn't work, why do we still do it? **The continuing use of Subtalar Joint Neutral Theory in the face of overpowering critical research.** (Harradine 2018)

Ankle is a complex, multi-joint system movement system

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

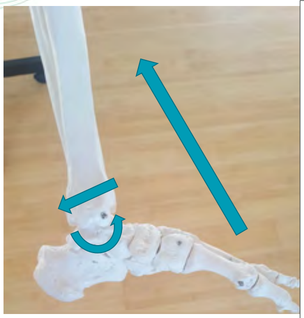
Midfoot
- Talus-Navicular
- Calcaneous-cuboid
- Navicular-cuneiforms
- Cunieforms/cuboid-metatarsals





<u>Talocrural Dorsiflexion</u>
- Posterior slide of talus
- Roll of talus
- Lengthening of posterior capsule
- Inferior movement of calcaneous
- Shortening of anterior capsule, anterior talofibular ligament

6



Talocural Dorsiflexion
- Lengthening of
- gastrocnemius
- Soleus
- Tibialis posterior
- Fibularis brevis and longus
- Flexor hallucis longus
- Flexor digitorum longus plantaris
- Movement and glide of fascia and skin

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.

Movement System: Kinesiopathologic Model
Shirley Sahrmann, PT, PhD, FAPTA

- Movement System
- Kinesiopathology

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.*

Movement System: Kinesiopathologic 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

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.*

Movement System: Kinesiopathologic Model

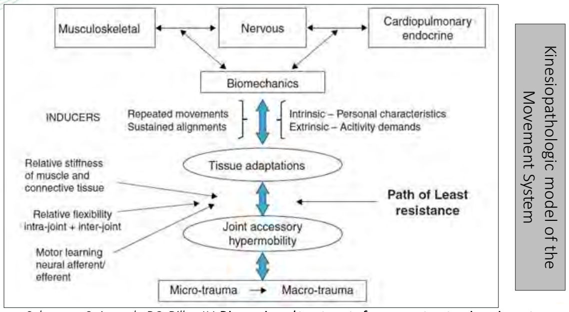
- Repetitive movement and sustained alignments can induce pathoanatomical changes in tissues and joint structures

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.*

Movement System: Kinesiopathologic Model

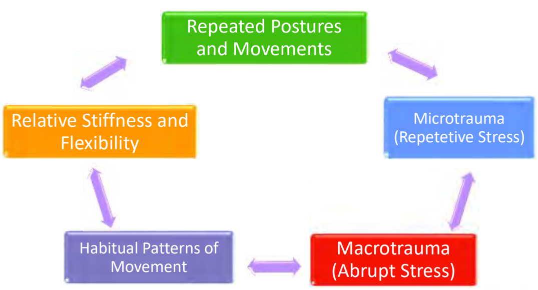
- Sustained alignments and repeated movements associated with daily activities induce tissue adaptations as well as impaired alignment and movement.
- Micro-instability
  → tissue micro-trauma
  → macro-trauma

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.*

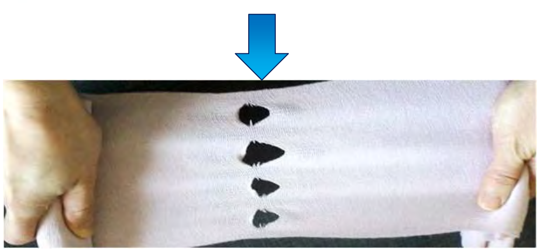


Sahrmann S, Azevedo DC, Dillen LV. ***Diagnosis and treatment of movement system impairment syndromes.*** *Braz J Phys Ther. 2017 Nov - Dec;21(6):391-399.*

Movement Systems: Kinesiopathologic Model



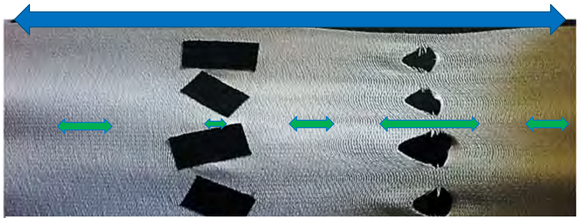
Movement Systems: Kinesiopathologic Model



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

9

Kinesiopathologic Model: Relative Flexibility **(In Series)**

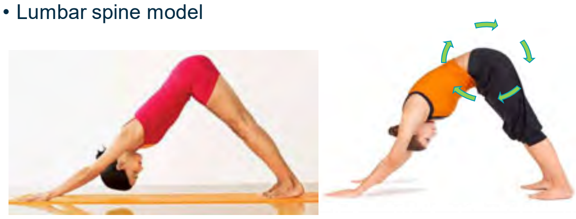


If there is a stiff segment and a more flexible segment, the flexible segment will move most, and the stiff segment will not stretch until all the slack has been taken out of both the flexible segment and the other less-stiff segments.

Kinesiopathologic Model: Relative Flexibility **(In Parallel)**

Kinesiopathologic 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.

Kinesiopathologic Model: Relative Flexibility

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

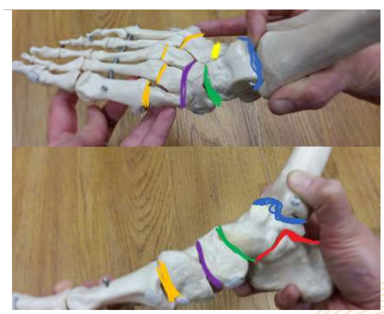
Kinesiopathologic Model: The Ankle As A Movement System

Hindfoot

- Talo-crural (talus-tibia/fibula)

Midfoot

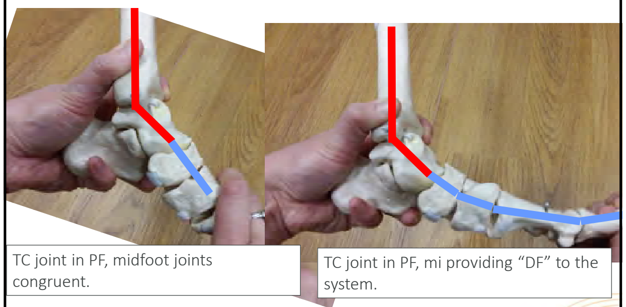
- Talus-navicular
- Calcaneous-cuboid
- Navicular-cuneiforms
- Cunieforms/cuboid-metatarsals



Kinesiopathologic Model: The Ankle As A Movement System

11

Kinesiopathologic Model: The Ankle As A Movement System

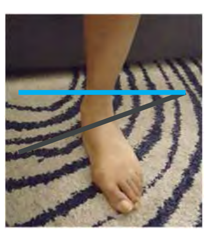


TC joint in PF, midfoot joints congruent.

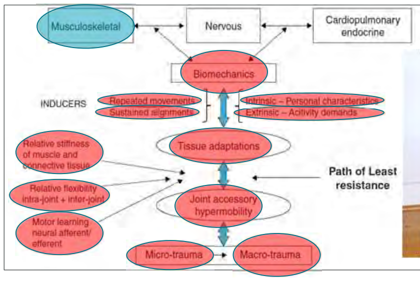
TC joint in PF, mi providing "DF" to the system.

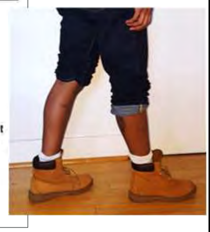
Kinesiopathologic Model: Relative Flexibility **(In Parallel)**

Kinesiopathologic Model: The Ankle As A Movement System

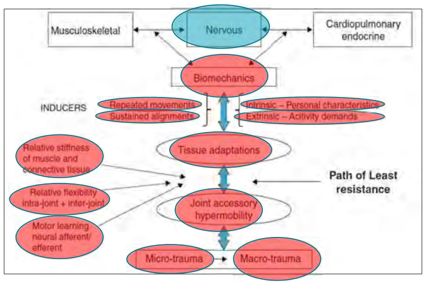


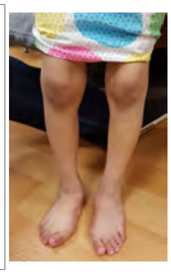
Forces are mechanically directed to relatively more flexible structures and away from TC dorsiflexion.





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





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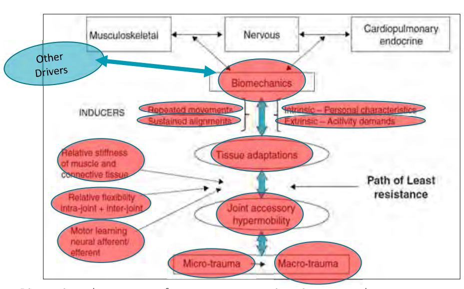
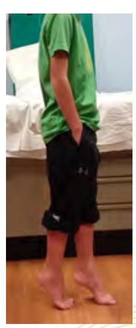
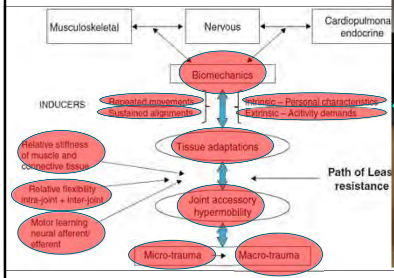




Diagnosis and treatment of movement system impairment syndromes. (Sahrmann 2017)

- Limiting Factors vs. Drivers



What's unique about the ankle?
Heterogeneity: Interface with the world

What's unique about the ankle?
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**

14

Outline

- Terminology
- Model of Ankle Function
- Do We Need to Intervene?
  - A. Theories of Intervention
  - B. Relevant Evidence
  - C. Impact on Developing Systems
    - Developmental Movement System Model
- Goals
- Ankle Exam
- Gait Analysis
- Interventions
  - Range motion
  - Strength and motor control
  - Neuroplasticity
  - External supports

Evidence-Based Practice: Challenges

The Roast, the Parachute, and the One-Legged Stool

Evidence-Based Practice: Challenges

The Parable of the Roast

Challenges to EBP

The Parable of the Roast

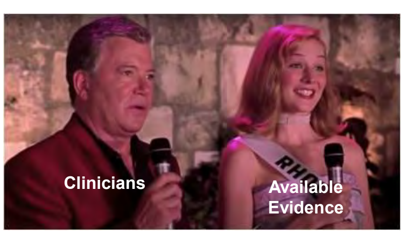
- Rigidity
- Institutional practices
- Regional practices
- Health-condition based decision making
- Lack of flexibility
- Lack of clinical problem solvi

Evidence-Based Practice: Challenges

Evidence-Based Practice: Challenges

Marc Lawrence, Katie Ford, Caryn Lucas. Miss Congeniality. Warner Bros. Pictures, 2000.

Evidence-Based Practice: Challenges



Marc Lawrence, Katie Ford, Caryn Lucas. Miss Congeniality. Warner Bros. Pictures, 2000.

Evidence-Based Practice

Challenges

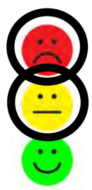
1. Defining "effective"

Evidence-Based Practice: Challenges

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 & Pell, BMJ 2003)

- Unable to identify any randomized controlled trials of parachute intervention.



- Conclusion: The perception that parachutes are a successful intervention is based largely on observation (anecdotal evidence).

Approaches to Intervention: Evidence-Based Practice

The Systematic Review of the Parachute

Novak: Systematic review of interventions for children with cerebral palsy, 2013

Evidence-Based Practice: Challenges
Outcomes: Cerebral Palsy

- Chronic conditions: higher rates of asthma, heart disease, stroke, emphysema, and arthritis
- Pain: remarkably higher prevalence of pain
  70% vs 20% in the general population
- Accelerated functional losses
- Lower levels of participation
- Higher risk of depression and anxiety

van der Slot 2021, Peterson 2015, Smith 2018, Jacobson 2019, Frisch 2013

Evidence-Based Practice
Challenges

1. Defining "effective"
2. Cohorts (heterogeneity)

X intervention was effective for 60% of patients with Y health condition.

- What is the difference between the responders and non-responders?
- How do I know if my patient is similar to the 60% or the 40%?
- RCTs guide treatment for the "average" patient, but give little guidance for the individual patient

Challenges to EBP: Approaches to Intervention

Kaplan et al. Evaluating treatments in health care: The instability of a one-legged stool. *BMC Medical Research Methodology*. 2011;11(1):65.

Evaluating treatments in health care: The instability of a one-legged stool. Kaplan et al 2011.

Over-reliance on RCTs:

- has ***been influenced in part by market pressures relevant to pharmaceutical companies***
- was stimulated significantly by the 1962 amendments to the American Food, Drug, and Cosmetic Act
- is not scientifically sound
- has fostered a less critical form of thinking in the evaluation of health care treatments.

Evaluating treatments in health care: The instability of a one-legged stool. Kaplan et al 2011.

- What clinicians really want to know is whether or not the person sitting before them is likely to benefit.
- The averaged results derived from RCTs offer insufficient or even incorrect guidance on how to approach ***a specific case***.
- Additional forms of evidence that ***explicitly include individual and context characteristics*** are needed to assist clinicians in choosing a course of action regarding specific patients.

Evaluating treatments in health care: The instability of a one-legged stool. Kaplan et al 2011.

- Observational studies often include patients with coexisting illnesses and a wide spectrum of disease severity, which gives much more clinical information in determining treatment for the ***individual patient*** versus the ***average patient***.
- The premise that RCTs are the only form of evidence capable of providing an unbiased estimate of treatment effects is false.
- We must use critical thinking when designing and consuming studies, and know that RCTs are just one tool.

Challenges to EBP: Approaches to Intervention

Rules

1. We do not talk about foot club
2. We use relevant orthopedic research to benefit more complex patients

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    2. Excessive Pronation
    3. Weakness
    4. Neuroplastic Changes
  - C. Impact on Developing Systems

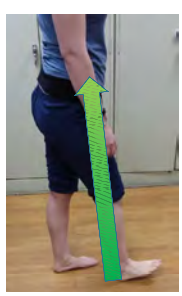
Impacts of Limited DF: Athletes, Neurotypical adults with chronic ankle stability, Neurotypical controls:

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

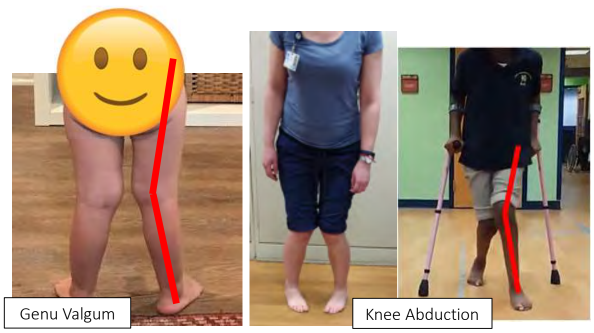
- Increased vertical ground reaction force
- Decreased shock absorption



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**

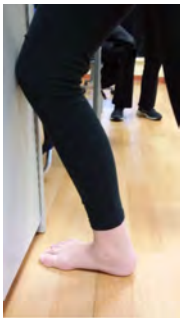
Impact of Limited DF Range

Neurotypical adults with chronic ankle stability:

- Decreased performance on ***balance*** testing

☑ Poll 4:

- What indicates "limited" DF?



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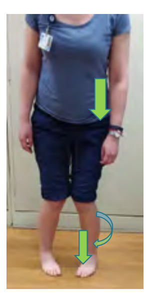
Impact of Excessive Pronation in Asymptomatic controls, runners

- 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:

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)

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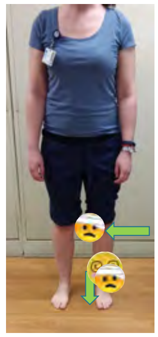
Impact of Impaired Strength in Neurotypical Adults:

- 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:

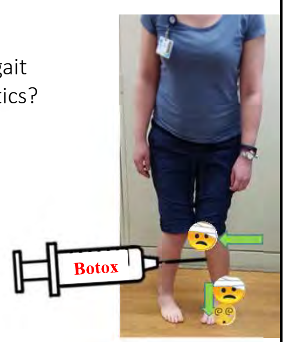
Neurotypical adults :

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



Impact of Insufficient **Plantar Flexor** Strength:

Should we treat patients with gait impairments with neuroparalytics?

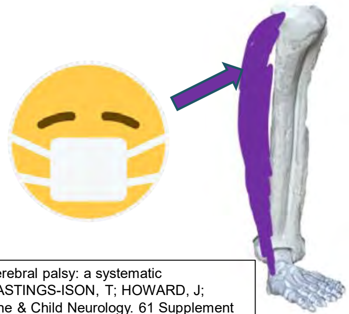


Old Paradigm:
Tonic contractions are a primary result of the health condition

Kill the Beast!

New Paradigm:

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



Sarcopenia, botulinum toxin a and cerebral palsy: a systematic review. GRAHAM, K; MULTANI, I; HASTINGS-ISON, T; HOWARD, J; HERZOG, W. Developmental Medicine & Child Neurology. 61 Supplement 3:33, October 2019.

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

Neurotypical controls :

- Navicular drop

.

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  - C. Impact on Developing Systems

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

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

Neuroplastic Changes: Causes

- Paucity of motor experience
- Task failure
- Negative verbal/social feedback
- Altered motor strategies
- Paucity of sensory experience
- Decreased sensory feedback during motor tasks
- Chronic microinjuries
- Abrupt injuries (e.g. falls, sprains)
- Pain
- Fear/anxiety
- Low self-efficacy

Neuroplastic Changes: Self-Efficacy

Athletes, elite athletes, neurotypical adults, older adults

Low self-efficacy

- Worry, kinesiophobia, anxiety, fear of injury
- Impaired:
  - Motor skill performance
  - Postural control
  - Gait parameters
  - Range of motion
- Increased falls

High self-efficacy: associated with

- higher performance
- Return to previous activity

Nott 2021, Jones 2011, Korpershoek 2011

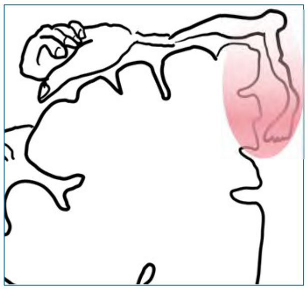
Neuroplastic Changes: Self-Efficacy

Verbal suggestion can be more powerful than conditioning for performance.

- Corsi, N, Andani, ME, Sometti, D, Tinazzi, M, Fiorio, M. When words hurt: Verbal suggestion prevails over conditioning in inducing the motor nocebo effect. Eur J Neurosci. 2019; 50: 3311– 3326.

Neuroplastic Changes: Sensory

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



Neuroplastic Changes: Sensory

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

Neuroplastic Changes: Sensory

Changes Impact:
- Perception of environmental information
- Perception of body information
- Feedback during motor tasks & proprioception
- Perception of pain

Neuroplastic Changes: Motor

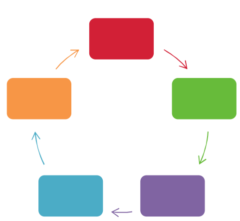
Changes Impact:

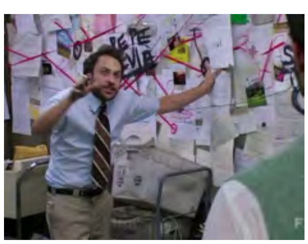
- Readiness for motor learning
- Motor control
- Postural control
- Fall frequency
- Motor skill performance

Neuroplasticity: Neuromotor Health Conditions

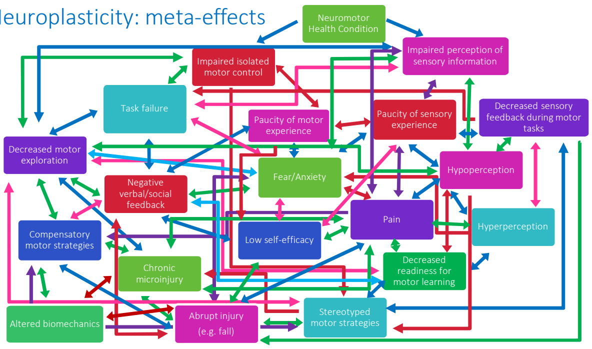
- When a patient experiences a neuromotor health condition, their motor skills are often impacted not only by the primary health condition, but also by experience-dependent cortical reorganization.

Neuroplasticity in Neuromotor Health Conditions





Neuroplasticity: meta-effects



Neuroplasticity: meta-effects on neuromotor health conditions

Impaired isolated motor control | Impaired sensory perception

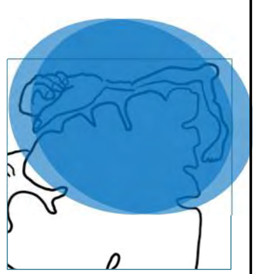
- Paucity of motor experience
- Task failure
- Low self-efficacy
- Decreased motor exploration
- Negative verbal/social feedback
- Pain
- Fear/anxiety
- Compensatory motor strategies
- Stereotyped motor strategies

- Paucity of sensory experience
- Decreased sensory feedback during motor tasks
- Hypoperception
- Hyperperception
- Chronic microinjuries
- Abrupt injuries (e.g. falls)
- Decreased readiness for motor learning

Neuroplasticity: Neuromotor Health Conditions

Neuromotor Health Condition
- Impaired isolated motor control
- Impaired perception of sensory information

Neuroplastic Changes
- Motor function
- Sensory perception



Neuroplasticity: meta-effects on neuromotor health conditions

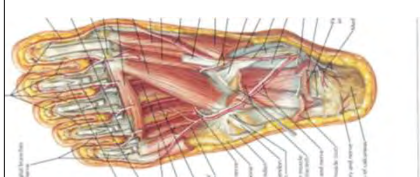
- Natural history: neuroplastic changes will magnify the effects of neuromotor health conditions

- Impaired motor control and related sequelae that we traditionally attribute to neuromotor health conditions are actually amplified by ***experience-dependent*** neuroplastic changes.

Neuroplasticity: meta-effects
Example: Foot Intrinsics ("foot core")

- 4 layers of plantar intrinsic muscles that originate and he foot.

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.



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

Neuroplasticity: meta-effects
Example: Foot Intrinsics ("foot core")

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

Neuroplasticity: meta-effects

NM health condition →
→Altered LE NM functioning
→Altered foot posture
→ Loss of key afferent information from the foot intrinsics
→ Negative neuroplastic changes
→ Additional balance/gross motor impairment

Outline

- Terminology
- Model of Ankle Function
- **Do We Need to Intervene?**
  - A. Theories of Intervention
  - B. Relevant Evidence
    1. Limited DF
    2. Excessive Pronation
    3. Weakness
    4. Neuroplastic Changes
  - **C. Impact on Developing Systems**

Manual Page

Who's Afraid of Wolff's Law?
Inter-systemic Kinesioplasticity During Development
--CSM 2023
--Wired On Development Clinical Excellence Summit 2024

Evidence-Based Practice

Evidence-Based Practice

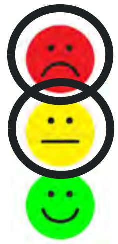
Marc Lawrence, Katie Ford, Caryn Lucas. Miss Congeniality. Warner Bros. Pictures, 2000.

Evidence-Based Practice
1. Defining "Effective"

Evidence-Based Practice

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

- Unable to identify any randomized controlled trials of parachute intervention.



- Conclusion: The perception that parachutes are a successful intervention is based largely on anecdotal evidence.

Outcomes: Cerebral Palsy

- Chronic conditions: higher rates of asthma, heart disease, stroke, emphysema, and arthritis
- Pain: **remarkably** higher prevalence of pain
  - 70% vs 20% in the general population
- Accelerated functional losses
- Lower levels of participation
- Emotional well-being: higher risk of depression and anxiety

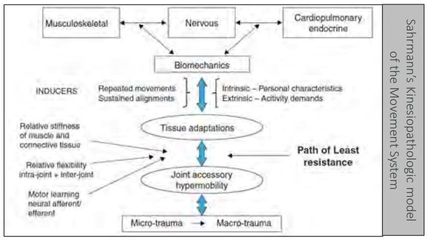
van der Slot 2021, Peterson 2015, Smith 2018, Jacobson 2019, Frisch 2013

Experienced-based plasticity

- What do we know about how experience shapes the movement system?

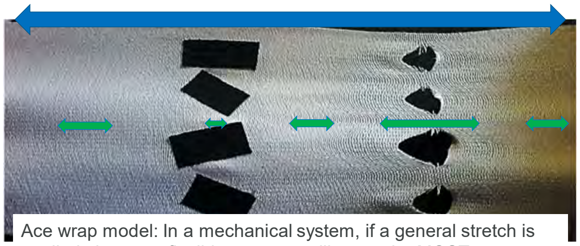
Experience-Based Plasticity
Musculoskeletal

Shirley Sahrmann, PT, PhD, FAPTA
→Regular movements and postures lead to adaptations in body tissues.



Sahrmann, 2017. Diagnosis and treatment of movement system impairment syndromes.

Experience-Based Plasticity
Musculoskeletal



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

The fibers of a stiff segment won't stretch until the slack is taken up in the more flexible segments

Experience-Based Plasticity
Musculoskeletal

Multiple paths of movement, body follows the laws of physics

Intrinsic differences matter! If we study: does a certain stretch or activity like yoga help individuals with back pain—the answer will be different for #1 and #2

Experience-Based Plasticity
Musculoskeletal

Experienced-Based Plasticity
Musculoskeletal

Excessive pronation in neurotypical adults, runners, baseball players:

- Medial shank rotation
- Medial column stress
- Altered pelvic alignment and motion
- Altered trunk alignment
- Lateral trunk lean
- Ankle, knee, low back, and shoulder stress and injuries

Hornestam 2021, Resende 2016, Buldt 2014, Resende 2015, Newman 2013, Feigenbaum 2013

Experienced-Based Plasticity
Neuromotor

Negative Neuroplastic Changes: Causes

- Paucity of motor experience
- Task failure
- Negative verbal/social feedback
- Altered motor strategies
- Paucity of sensory experience
- Decreased sensory feedback during motor tasks
- Chronic microinjuries
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- Pain
- Fear/anxiety
- Low self-efficacy

Experience-Based Plasticity
Neuromotor

NM health condition →
→Altered neuromotor function
→Excessive pronation
→ Loss of key afferent information from the foot intrinsics
→ Negative neuroplastic changes
→ Additional balance/gross motor impairment

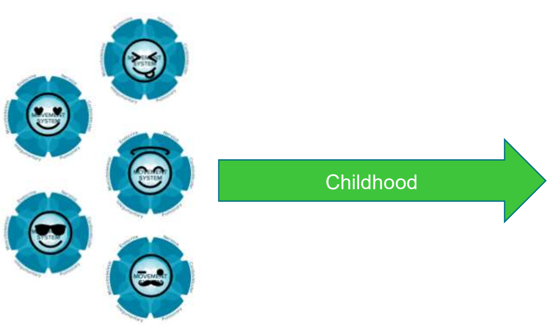
Experienced-Based Plasticity
Neuromotor

Neuroplastic Changes: Self-Efficacy

Verbal suggestion can be more powerful than conditioning for performance.

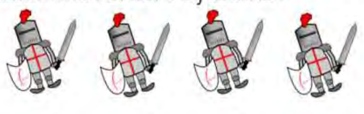
Corsi, 2019

- When words hurt: Verbal suggestion prevails over conditioning in inducing the **motor nocebo effect.**



Inter-systemic Kinesioplasticity
During Development

- How do kinesiopathologic and neuroplastic influences impact individuals with pediatric health conditions?
- Do children with pediatric health conditions have special protections against the forces that impact adult movement systems?



Inter-systemic Kinesioplasticity
During Development

Kinesiopathologic Model
- Repeated movements and sustained alignments influence structure and function

Developmental Kinesio~~pathologic~~ Model
- Repeated movements and sustained alignments during development will influence structural and functional outcomes

Inter-systemic Kinesioplasticity
During Development

Kinesiopathologic Model
- Repeated movements and sustained alignments influence structure and function

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

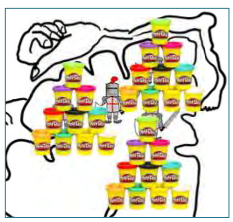
Neuroplasticity
During Development

Causes of negative neuroplastic change:

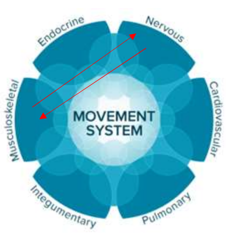
Paucity of motor experience Task failure Low self-efficacy Negative verbal/social feedback Altered motor strategies Paucity of sensory experience	Decreased sensory feedback during motor tasks Chronic microinjuries Abrupt injuries (e.g. falls, sprains) Pain Fear/anxiety

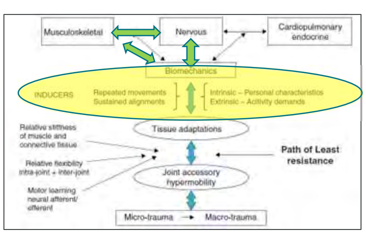
Neuroplasticity
During Development

- Growing brains are by definition more plastic, and therefore even ***more*** susceptible to neuroplastic changes based on experiences.



Experience-Based Plasticity
Interdependent Plasticity Between Systems





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

Inter-systemic Kinesioplasticity

Inter-systemic Kinesioplasticity

Excessive pronation:

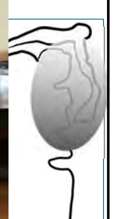
- Medial shank rotation
- Medial column stress
- Altered pelvic alignment and motion
- Altered trunk alignment
- Lateral trunk lean
- Increased ankle, knee, low back, and shoulder stress

Hornestam 2021, Resende 2016, Buldt 2014, Resende 2015, Newman 2013, Feigenbaum 2013

Inter-systemic Kinesioplasticity

NM health condition →
→Altered neuromotor function
→Excessive pronation
→ Loss of key afferent information from the foot intrinsics
→ Negative neuroplastic changes
→ Additional balance/gross motor impairment

- How developing in the context of overstretched foot intrinsics impact the **development** of the cortical matrix for balance?



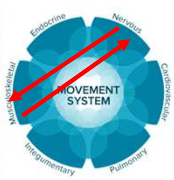
Inter-systemic Kinesioplasticity

- On EMG studies, individuals vary widely in the contribution of neural (enhanced stretch reflex) and non-neural (soft tissue changes) to "spasticity"
- This variability is found before age 3

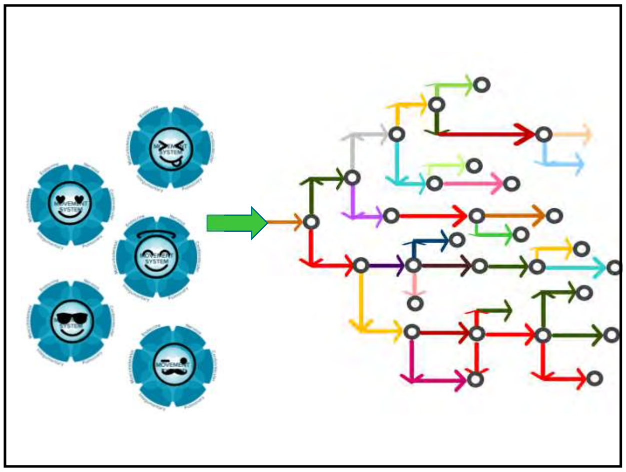
  Willerslev-Olsen, 2013. *Passive muscle properties are altered in children with cerebral palsy before the age of 3 years and are difficult to distinguish clinically from spasticity..*

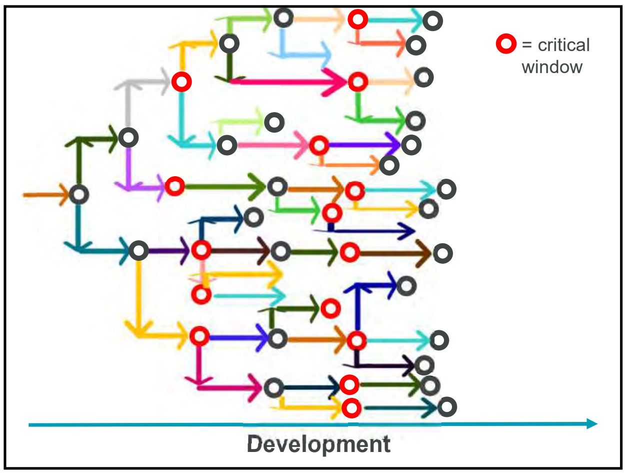
  - 80% had soft tissue changes

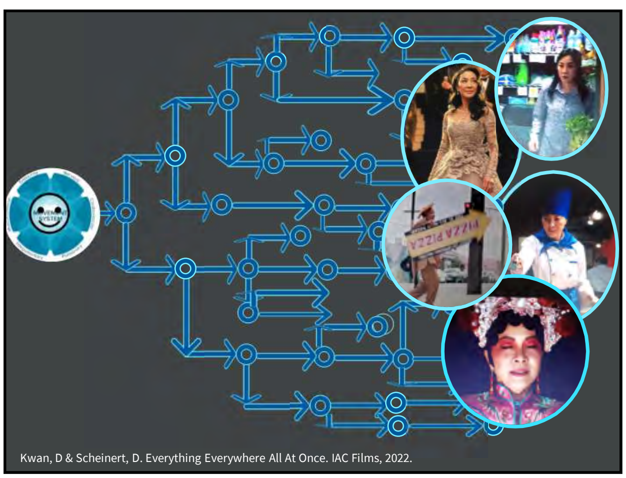
Inter-systemic Kinesioplasticity



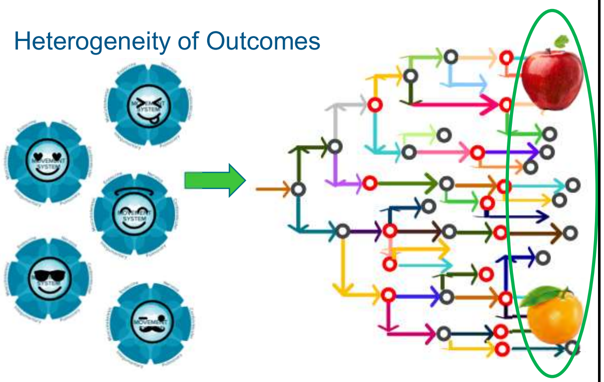
Inter-systemic Kinesioplasticity



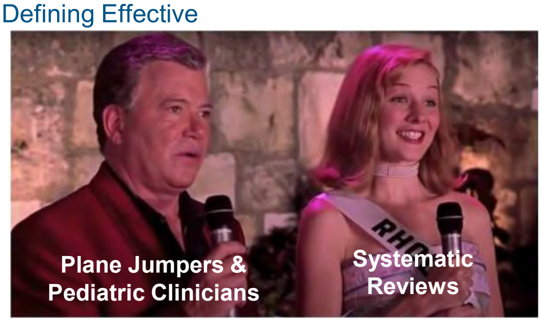

= critical
window
Development


Kwan, D & Scheinert, D. Everything Everywhere All At Once. IAC Films, 2022.

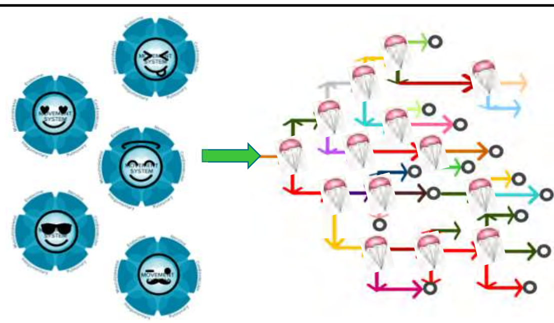
Heterogeneity of Outcomes



Defining Effective



Marc Lawrence, Katie Ford, Caryn Lucas. Miss Congeniality. Warner Bros. Pictures, 2000.



Experience-Based Negative Outcomes in CP

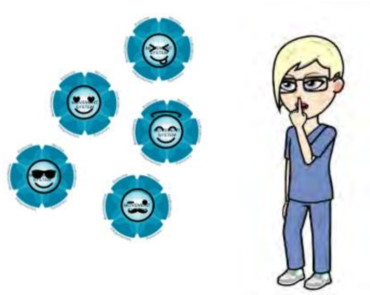
- Chronic health conditions
- Pain
- Accelerated functional losses
- Lower levels of participation
- Depression and anxiety

Evidence Informed Practice
Precision Health and Rehabilitation

- "Everything that a person experiences… as well as what their parents and grandparents experienced… from childhood stress, to educational opportunities, to lifestyle habits—converges on their genetic code through the epigenome to influence health, disease, and quality of life."
  Precision Rehabilitation: How Lifelong Healthy Behaviors Modulate Biology, Determine Health, and Affect Populations (Shields 2022)
- "Physical therapy stands at the intersecting frontiers of biologic, behavioral, and population health research, making it an ideal environment for precision rehab to thrive."
  PTJ Issue on Precision Rehab: Four Big Takeaways. https://www.apta.org/article/2022/01/19/ptj-precision-rehab-collection

Physical Therapy, Volume 102, Issue 1, January 2022, Featured Collection: Precision Rehabilitation

The Precision Health Model © Prof Elina Hyppönen 2018



How do we apply this clinically?

Long-Term Goals

- Set LONG term goals for adult outcomes

  →Build a lifespan plan of care based on:
  - critical windows for experiences
  - critical longitudinal experiences

Long-Term Goals

For the patient as an adult:

- Minimize **pain**
- Maximize overall **wellness**
- Maximize **structural resilience** of the movement system
- Maximize neuromotor function and **access to varied movement** options

Long-Term Goals

For the patient as an adult:

- Maximize the **environments and activities** the patient can access
- Maximize **self-acceptance, self-determination,** and **self-efficacy**
- Maximize the ability to **self-advocate** and access appropriate resources
- Maximize work and social **engagement** as an adult

Minimize negative sequelae of developing in the context of a pediatric health condition.

Short-Term Goals

- Musculoskeletal: Lessen the impact of cumulative micro-trauma
  - Support hypermobile/at-risk structures
  - Direct healthy stress toward target structures
- Provide critical experiences during appropriate windows of development
- Support regular fitness and wellness behaviors
- Neuromotor: Support motor learning and positive neuroplastic change
- **Support self-determination and high-self efficacy**

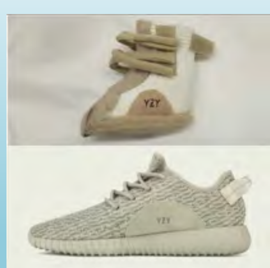
Clinical Application
Examination

Shift from deficit perspective to resource perspective
- Other-efficacy impacts self-efficacy

Examination:
- Resources of the individual
- Opportunities to add resource to the movement system

- Manual: Goal setting tool

Discussion



Terminology

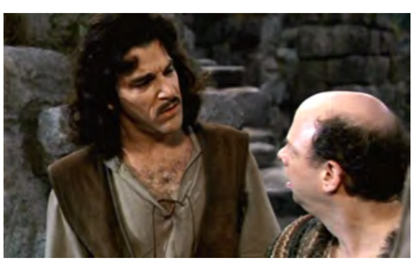
Terminology: Inconsistency - Neuromotor

*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



Challenges to EBP: Terminology

Inconsistency - Neuromotor

Passive muscle properties are contributing to perceived hyperreflexia in:

- Cerebral palsy
- Traumatic brain injury
- Hemiplegia
- Stroke

Terminology: Inconsistency - Neuromotor

Willerslev-Olsen et al. **Passive muscle properties are altered in children with cerebral palsy before the age of 3 years and are difficult to distinguish clinically from spasticity**. Dev Med Child Neurol 2013;55(7):617-623.

- 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.
- **Changes in passive muscle properties** were much more frequently contributing.

Terminology: Inconsistency - Neuromotor

De Gooijer-van de Groep et al. Differentiation between non-neural and neural contributors to ankle joint stiffness in cerebral palsy. J Neuroeng Rehabil. July 2013:1743-0003.

- "**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 **had cohorted for their similarities** and **were relatively mildly affected**.

Terminology: Inconsistency - Neuromotor

Bar – On et al. The relationship between medial gastrocnemius lengthening properties and stretch reflexes in cerebral palsy. Front Pediatr. 2018 Oct 4;6:259.

- Altered muscle lengthening properties and stretch reflex hyperactivity of children with CP was found to be ***highly variable between individuals***.
- Authors suggested muscle stiffness may actually be a protective mechanism.

Terminology: Inconsistency - Neuromotor

Clin Biomech (Bristol, Avon). 2003 Feb;18(2):157-65. Velocity dependent passive plantarflexor resistive torque in **patients with acquired brain injury**. Singer BJ1, Dunne JW, Singer KP, Allison GT.

Harlaar et al, Passive stiffness characteristics of ankle plantarflexors in **hemiplegia**. Clin Biomech 2000

Dietz. Spastic **Movement Disorder**: Impaired Reflex Function and altered muscle mechanics. Lancet Neurol 2007

de Vlugt. The Relation Between Neuromechanical Parameters and Ashworth Score in **Stroke Patients**. J Neuroeng Rehabil 2010

Terminology: Inconsistency - Neuromotor

Assumptions → Observations

Terminology

Assumption/Unclear		Specific/Observation
Tight		Short
		Stiff
	→	Increased density
		Increased response to stretch
		Tonic contraction

Terminology

Assumption/Unclear		Specific/Observation
Tight		Short
Spasticity		Stiff
Hypertonia	→	Increased density
Hyperreflexia		**Altered response to stretch**
Guarding		**Tonic contraction**
Fixing		Muscle contraction in
		________ (muscles) with
		________ (circumstance)

Terminology: Historical

☑ Poll 1:

Which clinical presentation is best described by the term:

Flatfoot

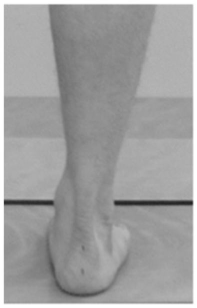
(Pes Planus)

4

Terminology: Inconsistency
"Flatfoot" *(Pes Planus)*
- #1

Terminology: Inconsistency
"Flatfoot" *(Pes Planus)* #2

Terminology: Inconsistency
"Flatfoot" *(Pes Planus)* #3



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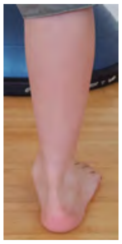
☑ Poll 1:

"Flatfoot" *(Pes Planus)*



#1

#2

#3

Terminology

Incompatible definitions → Differentiation

Terminology: Historical

☑ Poll 2:

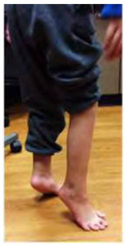
Which clinical presentation is best described by the term:

Equinus Deformity

6

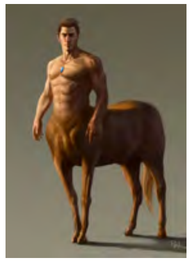
Terminology: Inconsistency and Jargon

"Equinus Deformity"



#1

#2



#3

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

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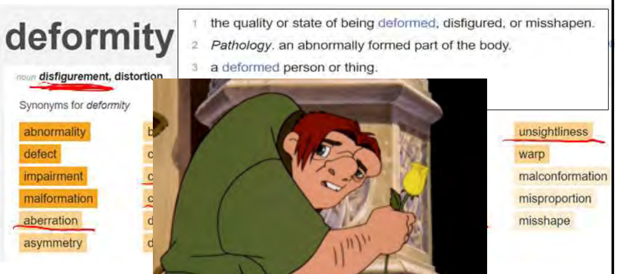
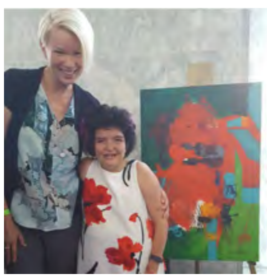


Dictionary.com/Thesaurus.com

Terminology: Words Have Power

Terminology: Words Have Power

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

8

restriction [ri-strik-shuhn]

SEE DEFINITION OF rest

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			
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

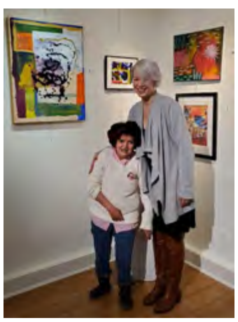
Terminology: Words Have Power

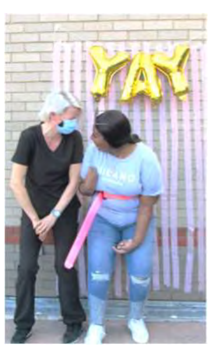
Terminology: Words Have Power

9

Terminology: Words Have Power

Terminology: Words Have Power



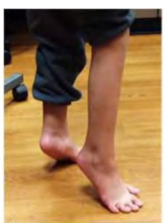


10

Terminology

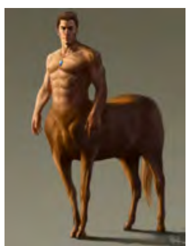
Equinus	→	Plantarflexion
Deformity Contracture	→	Structural variance Restriction Limiting structure Quality of end feel
Flatfoot	→	Everted Pronated

Terminology: Specificity



DF Restriction

Structural Variance



Magical Creature[1]

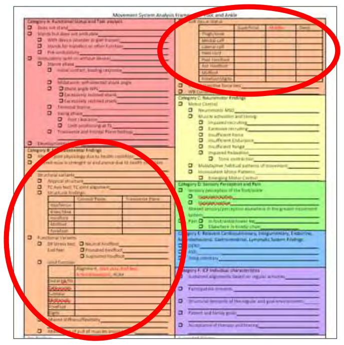
[1]N. Scamander. **Fantastic beasts and where to find them.** New York, NY : Arthur A. Levine Books ; London : Obscurus Books, 2001.

Terminology: Structure vs. Function

☑ Poll 3:

Which term describes the following patient's clinical presentation?

Movement System Analysis: Foot and Ankle



Exam: Structure vs. Function

Structure vs. Function

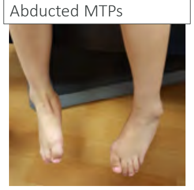
12

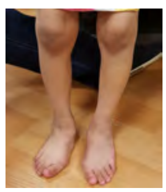
Terminology: Distinguishing Structure from Function

Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Med Torsion – Lat Torsion Adductus – Abductus	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus (-a, -um) – Valgus (-a, -um)	Invert – Evert Adduct - Abduct
Sagittal	Sagittal Plane bowing	Flex – Extend Dorsiflex – Plantarflex
Triplanar		Supinate(d) (add + inv + PF) – Pronate(d) (abd + eve + DF)

Structure:
Hindfoot varus
Metatarsus adductus, varus

Function:
Supination of hindfoot
Abducted MTPs





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

1. Structure: Twist of tibia in the transverse plane away from midline—distal aspect more laterally oriented than proximal aspect.

Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Medial Torsion – Lateral Torsion Adductus – Abductus	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus (-a, -um) – Valgus (-a, -um)	Invert – Evert Adduct – Abduct
Sagittal	Sagittal Plane bowing	Flex – Extend Dorsiflex – Plantarflex
Triplanar		Supinate(d) (add + inv + PF) – Pronate(d) (abd + eve + DF)

Manual worksheet

2. Structure: Twist of the tibia in the transverse plane toward midline—distal aspect more medially oriented than proximal aspect.

Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Medial Torsion – Lateral Torsion Adductus – Abductus	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus (-a, -um) – Valgus (-a, -um)	Invert – Evert Adduct – Abduct
Sagittal	Sagittal Plane bowing	Flex – Extend Dorsiflex – Plantarflex
Triplanar		Supinate(d) (add + inv + PF) – Pronate(d) (abd + eve + DF)

3. Structure: Net orientation of the femur/tibia in the coronal plane away from midline (distal part is more lateral)

Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Medial Torsion – Lateral Torsion Adductus – Abductus	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus (-a, -um) – Valgus (-a, -um)	Invert – Evert Adduct – Abduct
Sagittal	Sagittal Plane bowing	Flex – Extend Dorsiflex – Plantarflex
Triplanar		Supinate(d) (add + inv + PF) – Pronate(d) (abd + eve + DF)

4. Structure: Curve of the tibia in the coronal plane toward the midline (distal part is more medial)

Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Medial Torsion – Lateral Torsion Adductus – Abductus	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus (-a, -um) – Valgus (-a, -um)	Invert – Evert Adduct – Abduct
Sagittal	Sagittal Plane bowing	Flex – Extend Dorsiflex – Plantarflex
Triplanar		Supinate(d) (add + inv + PF) – Pronate(d) (abd + eve + DF)

14

5. Structure: With the talocrual and subtalar joints congruent, the calcaneous is oriented medially in the coronal plane.

Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Medial Torsion – Lateral Torsion Adductus – Abductus	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus (-a, -um) – Valgus (-a, -um)	Invert – Evert Adduct – Abduct
Sagittal	Sagittal Plane bowing	Flex – Extend Dorsiflex – Plantarflex
Triplanar		Supinate(d) (add + inv + PF) – Pronate(d) (abd + eve + DF)

6. Motion/position: Medial orientation of the hindfoot toward midline in the coronal plane

Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Medial Torsion – Lateral Torsion Adductus – Abductus	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus (-a, -um) – Valgus (-a, -um)	Invert – Evert Adduct – Abduct
Sagittal	Sagittal Plane bowing	Flex – Extend Dorsiflex – Plantarflex
Triplanar		Supinate(d) (add + inv + PF) – Pronate(d) (abd + eve + DF)

7. Motion/position: Lateral orientation of the hindfoot away from midline in the coronal plane

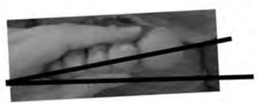
Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Medial Torsion – Lateral Torsion Adductus – Abductus	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus (-a, -um) – Valgus (-a, -um)	Invert – Evert Adduct – Abduct
Sagittal	Sagittal Plane bowing	Flex – Extend Dorsiflex – Plantarflex
Triplanar		Supinate(d) (add + inv + PF) – Pronate(d) (abd + eve + DF)

15

8. Structure: Medial orientation of the metatarsals in the transverse plane

Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Medial Torsion – Lateral Torsion Adductus – Abductus	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus (-a, -um) – Valgus (-a, -um)	Invert – Evert Adduct – Abduct
Sagittal	Sagittal Plane bowing	Flex – Extend Dorsiflex – Plantarflex
Triplanar		Supinate(d) (add + inv + PF) – Pronate(d) (abd + eve + DF)

9. Structure: With joints congruent, the MTPs are angled such that the 5th MTP is lower than the 1st MTP (medial rotation in the coronal plane)



Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Medial Torsion – Lateral Torsion Adductus – Abductus	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus (-a, -um) – Valgus (-a, -um)	Invert – Evert Adduct – Abduct
Sagittal	Sagittal Plane bowing	Flex – Extend Dorsiflex – Plantarflex
Triplanar		Supinate(d) (add + inv + PF) – Pronate(d) (abd + eve + DF)

10. Motion/position: lateral orientation of MTP in the transverse plane

Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Medial Torsion – Lateral Torsion Adductus – Abductus	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus (-a, -um) – Valgus (-a, -um)	Invert – Evert Adduct – Abduct
Sagittal	Sagittal Plane bowing	Flex – Extend Dorsiflex – Plantarflex
Triplanar		Supinate(d) (add + inv + PF) – Pronate(d) (abd + eve + DF)

11. Triplanar motion or position of joint in eversion, dorsiflexion, abduction

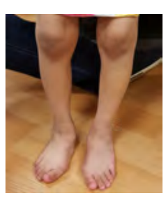
Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Medial Torsion – Lateral Torsion Adductus – Abductus	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus (-a, -um) – Valgus (-a, -um)	Invert – Evert Adduct – Abduct
Sagittal	Sagittal Plane bowing	Flex – Extend Dorsiflex – Plantarflex
Triplanar		Supinate(d) (add + inv + PF) – Pronate(d) (abd + eve + DF)

12. Triplanar motion or position of joint in inversion, plantarflexion, adduction

Plane	Bone Structure (Adjectives)	Movements & Postures (Verbs) (-ed, -ion, -ing)
Transverse	Medial Torsion – Lateral Torsion Adductus – Abductus	Adduct (-ed, -ion, -ing) – Abduct (-ed, -ion, -ing)
Coronal	Varus (-a, -um) – Valgus (-a, -um)	Invert – Evert Adduct – Abduct
Sagittal	Sagittal Plane bowing	Flex – Extend Dorsiflex – Plantarflex
Triplanar		Supinate(d) (add + inv + PF) – Pronate(d) (abd + eve + DF)

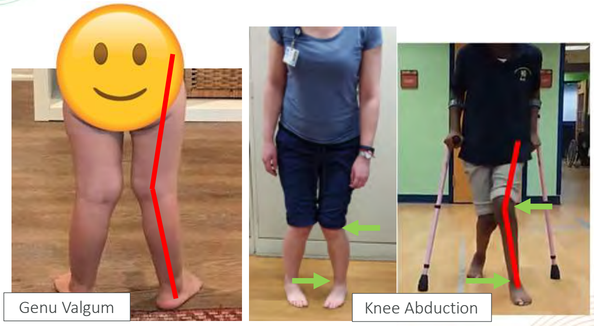
Structure:
Hindfoot varus
Metatarsus adductus, varus

Function:
Supination of hindfoot
Abducted MTPs



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

17

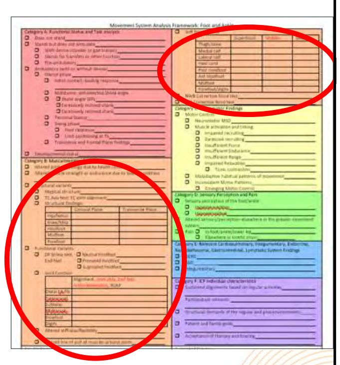


- Limiting Factors vs. Drivers

Suspected drivers:

Limiting factors:

System resources:



18

Deficits → Resources

- Shift from deficit perspective to resource perspective

- Resources of the system
- Opportunities to add resource to the system

Terminology discussion?

Exam: Musculoskeletal

Key Tests

1. Dorsiflexion Stress Test: **Function**
2. TC Axis Test (Talocrural Axis Test): **Structure**

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?

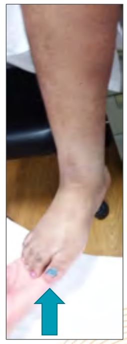
Dorsiflexion Stress Test

20

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____

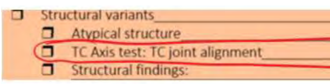
3. Supinated hindfoot
   End feel/location:
   - Anterior-medial talar impingement
   - Lateral talar subluxing

21

Dorsiflexion Stress Test

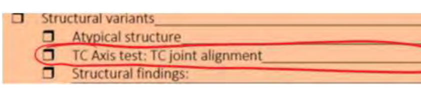
Helps to determine
- path of least resistance for DF
- intra- and inter-joint relative flexibility
  - relative stiffness of muscle and connective tissue

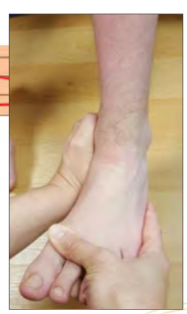
Talocrural Axis Test



Helps to Determine
- Location of the axis of talo-crural motion (Replaces STN)
- Structural versus functional variant

Talocrural Axis Test





- Allows you to assess “pure” TC motion without accessory joint motion
- Quality and quantity of motion specifically of the TC joint without contribution of accessory motion
- Limiting structures for TC DF to guide intervention

22

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

Force goes through 5th ray, with closed-packed position of midfoot joints

Talocrural Axis Test

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

LAB/DEMO SPECIAL TESTS

Musculoskeletal Findings

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

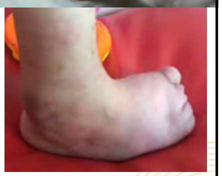
❑Altered muscle strength or endurance due to health condition

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

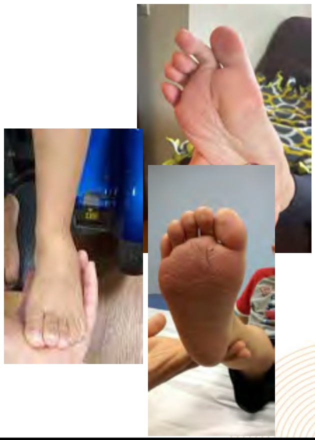
- ❑Structural variants
  - ❑Atypical structure
  - Coalitions
  - Presence or absence of structures
  - Altered relative position of structures
  - Altered shape of structures



24

Musculoskeletal Findings

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



Musculoskeletal Findings

- ❑Structural variants
  - ❑TC Axis test: TC joint alignment
  - ▪ Location, alignment of axis

Musculoskeletal Findings

- ❑Structural variants
  - ❑Structural findings:

	Coronal Plane	Transverse Plane
Knee/ tibia		Torsion - medial

25

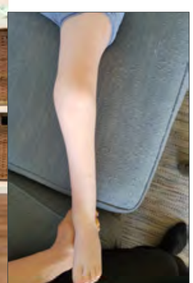
Medial Torsion (masked)

- 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

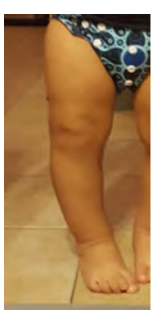
Valgum

❒Structural variants

❒Structural findings

	Coronal Plane	Transverse Plane
Knee/ tibia	Varum	

	Coronal Plane	Transverse Plane
Knee/ tibia	Varum	Medial Torsion



27

- Structural variants
  - Structural findings

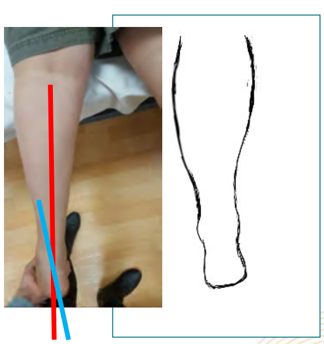
Hindfoot
Altered position or structure of malleoli

	Coronal Plane	Transverse Plane
Hindfoot		

- Structural Variants

Hindfoot
Calcaneal alignment

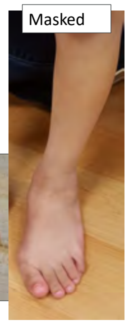
	Coronal Plane	Transverse Plane
Hindfoot	Varus	



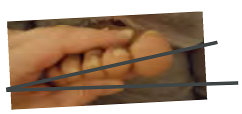
28

❒Structural Variants

	Coronal Plane	Transverse Plane
Midfoot		Metatarsus Adductus



❒Structural Variants



	Coronal Plane	Transverse Plane
Midfoot, Forefoot	Metatatarus Varus	

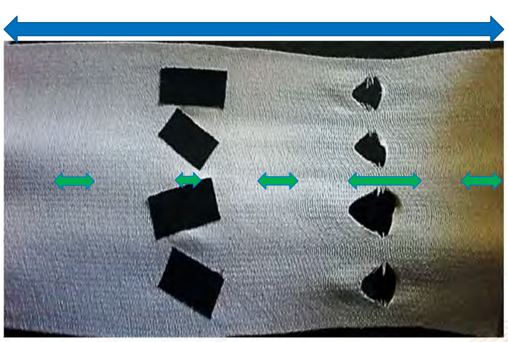
❒Structural variants
❒Structural findings

- Static (structural) variants

Structural Vs. Functional

Musculoskeletal Findings

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



30

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

31

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-crural	
Subtalar	
Midtarsals	
Forefoot	
Digits	

Musculoskeletal Findings

❑Joint Function

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

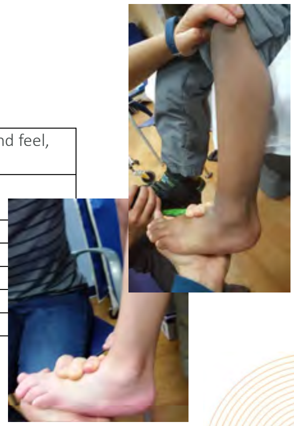
- Range – DF ***and*** PF
- Limiting structures
- End feel
  - Location
  - Quality

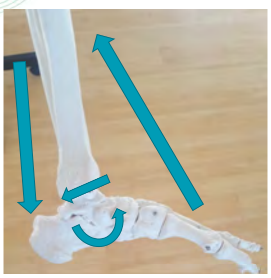
32

Musculoskeletal Findings

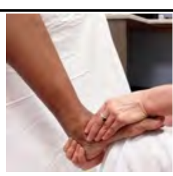
❑Joint Function

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





Ability of the calcaneous to move inferiorly 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

33

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

34

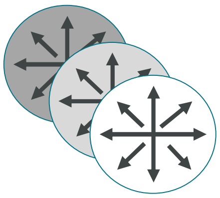
Musculoskeletal Findings

- Soft Tissue Status

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

Soft Tissue Assessment

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



35

Intervention

- Range of motion
- Strength and motor control
- Neuroplasticity
- External supports

Rules

1. We do not talk about foot club
2. We use relevant orthopedic research to benefit more complex patients

Impacts of Limited DF: Neurotypical controls, Athletes, Neurotypical adults with chronic ankle stability

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

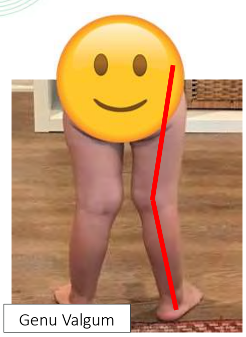
Impact of Limited DF Range

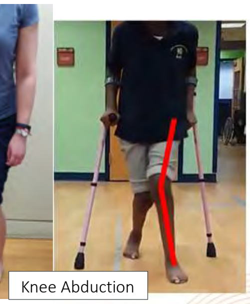
Asymptomatic controls & athletes:
- Increased vertical ground reaction force
- Decreased shock absorption

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**

Neurotypical adults with chronic ankle stability:
- Decreased performance on ***balance*** testing





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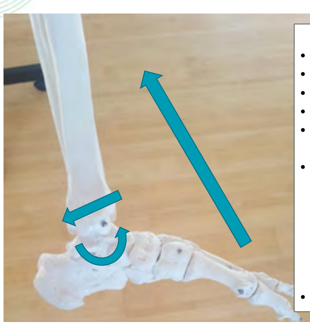
Impact of Limited DF Range

Asymptomatic controls & athletes:
- Increased vertical ground reaction force
- Decreased shock absorption

- What indicates "limited" DF?



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

Interventions
Limited Range of Motion

Manual therapy of ankle joints and soft tissues has been shown to improve:
- DF range
- Balance
- Functional goals

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

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

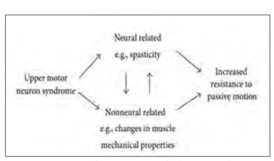
Interventions
Limited Range of Motion

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

……..Pediatric health conditions?

A wide body of literature is suggesting that passive muscle properties (tissue stiffness and viscosity) are contributing to perceived hyperreflexia in cerebral palsy.

Literature is suggesting that the nonneural component is as important as, and possibly more important than spasticity for function.



Bar-On L, Molenaers G, Aertbeliën E, et al. **Spasticity and Its Contribution to Hypertonia in Cerebral Palsy. BioMed research international**. 2015;2015:317047-10.

4

Ratios between the contribution of neural (stretch reflex hyper activity) and non-neural (soft tissue resistance) components to ankle joint stiffness **varies substantially between individuals with CP**.

- de Gooijer-van de Groep KL, de Vlugt E, de Groot JH, et al. Differentiation between non-neural and neural contributors to ankle joint stiffness in cerebral palsy. J Neuroeng Rehabil. 2013;10:81.
- Bar-On L, Kalkman BM, Cenni F, et al. The Relationship Between Medial Gastrocnemius Lengthening Properties and Stretch Reflexes in Cerebral Palsy. Front Pediatr. 2018;6:259.

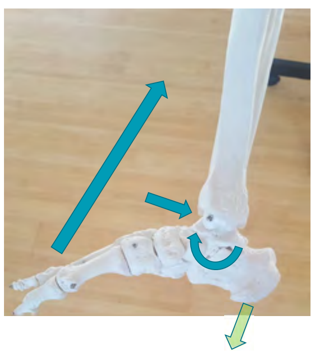
Willerslev-Olsen M, Lorentzen J, Sinkjaer T, Nielsen JB. Passive muscle properties are altered in children with cerebral palsy before the age of 3 years *and are difficult to distinguish clinically from spasticity*. *Dev Med Child Neurol*. 2013;55(7):617-623.

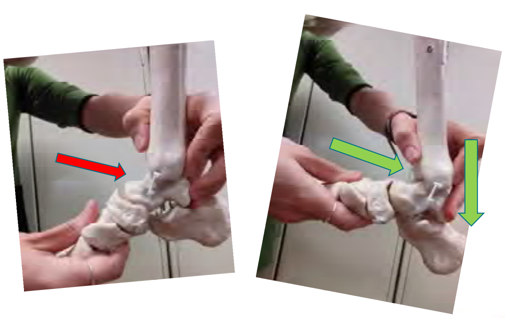
- Only **7/35** children determined as having spasticity via MAS/Tardieu had enhanced stretch reflexes with EMG.
- Enhanced stretch reflexes contributed to muscle stiffness in a minority of cases.
- Changes in passive muscle properties (stiffness and viscosity) were much more frequently contributing.
- Large variation of the ratio of neural/nonneural contributions to increased resistance between individuals.

- Clin Biomech (Bristol, Avon). 2003 Feb;18(2):157-65. Velocity dependent passive plantarflexor resistive torque in **patients with acquired brain injury**. Singer BJ1, Dunne JW, Singer KP, Allison GT.
- Harlaar et al, Passive stiffness characteristics of ankle plantarflexors in **hemiplegia**. Clin Biomech 2000
- Dietz. Spastic **Movement Disorder**: Impaired Reflex Function and altered muscle mechanics. Lancet Neurol 2007
- de Vlugt. The Relation Between Neuromechanical Parameters and Ashworth Score in **Stroke Patients**. J Neuroeng Rehabil 2010

5

TC Axis Test → Mobilization

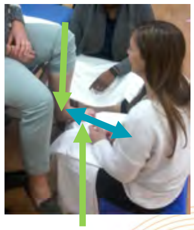




6

Body mechanics of hindfoot mobs

Dorsiflexion "for free"
- Gravity and physics provide stretch
  - Heel in air, MTPs on knee
  - Vertical tibia
  - PT in line with TC joint
- Hands guide alignment

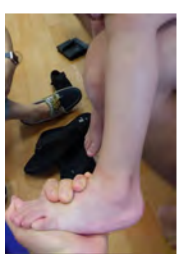


Body position of hindfoot mobs: Posterior Talar Glide

Interventions

Manual Therapy: Posterior Talar Glide

with:
- inferior glide of calcaneous/talar complex
- joint distraction



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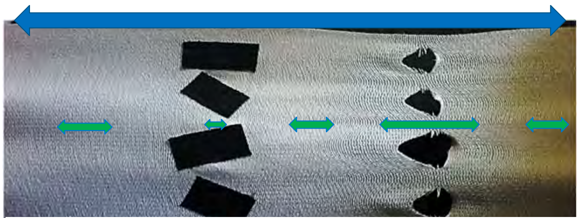
Interventions

Manual Therapy: Posterior Talar Glide

with:

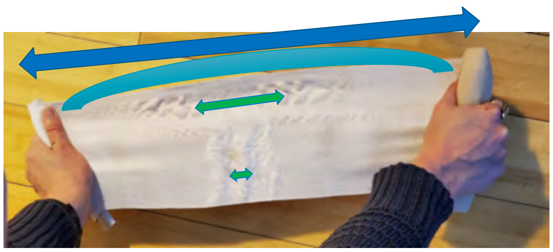
- inferior glide of calcaneous/talar complex
- joint distraction

Kinesiopathological Model: Relative Flexibility **(In Series)**



If there is a stiff segment and a more flexible 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.

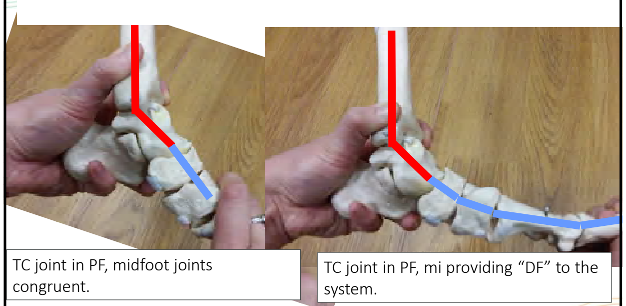
Kinesiopathological Model: Relative Flexibility **(In Parallel)**



8

Relative Flexibility: The Ankle As A Movement System

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.

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

9

Talo-crural mobilization for the pronated hindfoot

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



Talo-crural mobilization for the pronated hindfoot

Interventions

Posterior Talar Glide with:

Calcaneal inferior glide and triplanar guidance

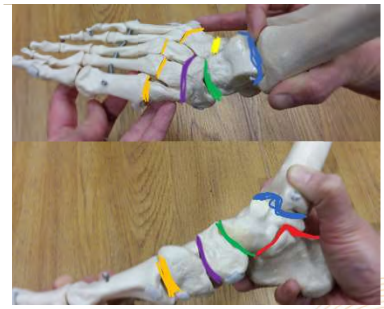
- Guidance through navicular and cuboid


10

Ankle is a complex, multi-joint system movement system

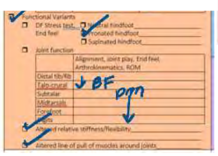
Hindfoot
- Talo-crural (talus-tibia/fibula)
- Subtalar (talus-calcaneous)

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



☐ Soft tissue status

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



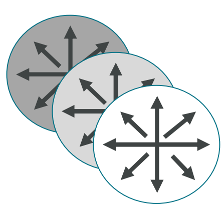
✓ Functional Variants
☐ DF Stress test__ ☐ Neutral hindfoot___
End feel ✓ Pronated hindfoot___
☐ Supinated hindfoot___
☐ Joint function

	Alignment, joint play, End feel, Arthrokinematics, ROM
Distal tib/fib	
Talo-crural	↓ BF
Subtalar	pqn
Midtarsals	↓
Forefoot	
Digits	

✓ Altered relative stiffness/flexibility___
✓ Altered line of pull of muscles around joints___

Soft Tissue Mobilization to Increase DF

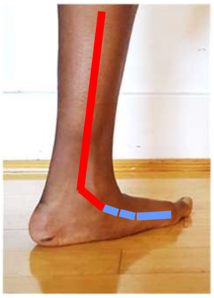
- Ability of tissues to lengthen, shorten, fold, glide and slide
- Multi-layer
- Multi-directional

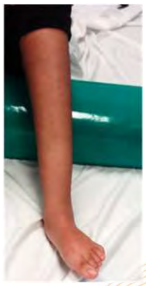


11

Manual Therapy Progression

Pronated Posture

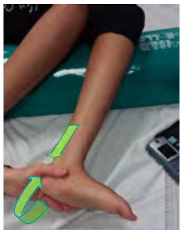




Manual Therapy Progression

Pronated Posture

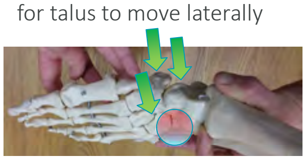
- Inferior/ inversion mobilization of calcaneus
- Lateral/superior mobilization of navicular



Manual Therapy Progression

Pronated Posture

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



13

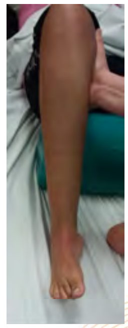
Manual Therapy Progression
Pronated Posture
- PF of 1st ray and midfoot with hindfoot stablized

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

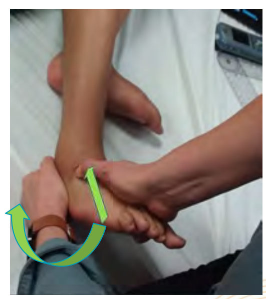
14

Manual Therapy Progression
Supinated Posture

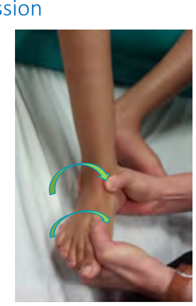
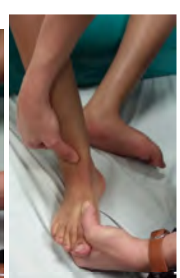
Manual Therapy Progression
Supinated Posture

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



Manual Therapy Progression
Supinated Posture

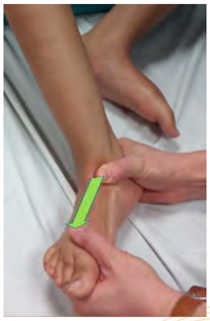
- Anterior hindfoot – medial soft tissue mobilization
- 1st ray: plantarflexion mob
- TC plantarflexion with elongation of TA/EHL

Manual Therapy Progression

Supinated Posture

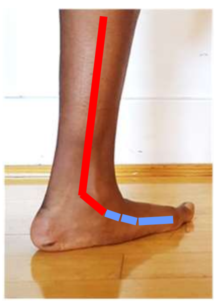
- Distraction with PF mobilization for midfoot and first ray
- Extension of MTPs
- Elongation of plantar fascia

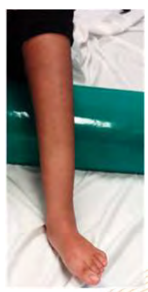


Instrument Assisted Soft Tissue Mobilization (IASTM)

Instrument Assisted Soft Tissue Mobilization

Mobilization With Movement





Mobilization With Movement (MWM)

HEP:
- Taping
- Therapeutic casting

17

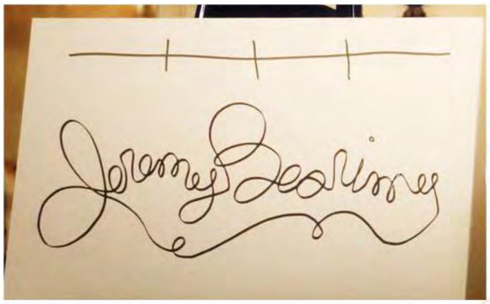
Constantly investigating and clearing the next limiting structure

- Skin
- Fascia
- Tendons
- Muscle bellies
- Joint mobility
- Joint motion

Mobilization

Addressing
-arthokinematics
-range
-limiting structures
-end feel
Dorsiflexion should always be "for free"

18



- Limiting Factors vs. Drivers

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

19

Manual therapy and casting

Musculoskeletal Assessment and Manual Therapy Lab

1. Weightbearing functional assessment

   Standing

   Assessment of standing alignment

   Apparent structural variants (varus/valgus)

   Shank/thigh angles (sagittal plane)

   Resting weightbearing positions (coronal and transverse planes)

   - ❒ Knees
   - ❒ Hindfoot
   - ❒ Toe-in/Toe-out
   - ❒ Midfoot
   - ❒ Digits
   - ❒ Pelvis
   - ❒ Spine
   - ❒ Shoulders

   Knee tracking with mini-squatting

   - ❒ Knees
   - ❒ Functional axis of dorsiflexion

   - ❒ Balance strategies
   - ❒ DF lunge test (knee to desk test)

2. Mat eval

   - ❒ Mechanics: position of the patient, position of the therapist
   - ❒ Integumentary Assessment

     Scars

     Color

     Temperature

     Wrinkles/creases

     Dryness

     Edema

     Blanching, especially with corrected position
   - ❒ Response to handling, touch

     Techniques to address patient stress, guarding, and tonic muscle contraction

     Unweighting

     Deep pressure

     Contact on the active structures

     Movement into tone-inhibiting positions

(NOT yelling at them to relax)

- ❒ Soft tissue:
    - Winding of the tissues
    - Gastrocsoleus/med/lateral muscle groups: length, extensibility, elasticity, trigger points
    - Superficial fascia
    - Achilles tendon
    - Stiff points
    - What structures are limiting more DF?
- ❒ Joint assessment
  Mechanics: position of the patient, position of the therapist
    - ❒ DF Stress test
    - ❒ TC axis test
      Positioning yourself to be in line with the patient's TC joint
      identifying structural and functional variants of your lab partner
    - ❒ Midfoot
    - ❒ Digits

- ❒ Goniometry
    - ❒ For participants appropriate for mobilization: pre-test of PROM
    - ❒ Functional DF vs. hindfoot DF

3. Mobilizations
   Mechanics: position of the patient, position of the therapist
   - Positioning yourself to be in line with the patient's TC joint
   - Identifying structural and functional variants of your lab partner (new partner)
   - DF Stress test: tells you how to modify the mobilization to protect fragile structures

   Soft tissue mobilizations
   - Investigation of the layers
   - NM: what relaxes the person?
   - How do they respond to touch, to manual therapy?
   - What decreases their guarding/tonic contractions?
   - How do they respond to touch, to manual therapy?
       - Winding of the tissues
       - Gastrocsoleus/med/lateral muscle groups: length, extensibility, elasticity, trigger points
       - Layers of fascial restrictions

Superficial fascia

Achilles tendon

Stiff points

What structures are limiting more DF?

Midfoot, digits

Instruments: vibration, percussion, dynamic cupping

Joint mobilizations

- Distal Tib-fib
- Talocrual
  - TC axis test: becomes the mobilization
  - DF Stress test: tells you how to modify the mobilization to protect fragile structures
  - Modifications:
    - Anterior talar impingement
    - Supinated hindfoot
    - Pronated hindfoot
    - Mobilization through the navicular
- Subtalar
  - Inferior calcaneal
  - Inversion/eversion
- Midfoot
  - Calcaneal-cuboid
  - Pronated foot: Lateral navicular
  - Midfoot joints
  - Supination/PF of the midfoot to allow for MTP extension mobility
- MTPs
  - Distraction, safe lateral glides
  - MTP extension
- Digits

Goniometry

- For participants appropriate for mobilization: post-test of PROM

Intervention

- Range of motion
- Strength and motor control
- Neuroplasticity
- External supports

Impact of Excessive Pronation:

Asymptomatic controls, runners:

- Increased medial tibial 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)

1

Tonic & Phasic Motor Control

In efficient systems,

Tonic (local, deep postural) muscles are recruited automatically to:

- Provide stability to withstand environmental or task demands
- Protect and guide joints to prevent shearing
- Stabilize locally and across the kinetic chain

Phasic muscles (global movers) are recruited for **action**:

- Contract concentrically, eccentrically, or isometrically in a task-appropriate way

Tonic & Phasic Motor Control

In less efficient systems, we might see:

1. Phasic muscles tonically (sustained) contracting to compensate for lack of efficient deep postural muscle recruitment
2. Isometric or concentric versus eccentric function of muscles

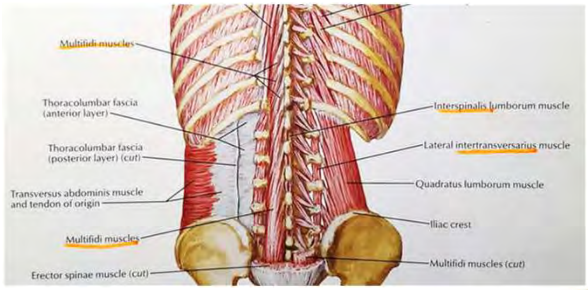
Example:

Tonic hamstring contraction to stabilize pelvis when deep core muscles are under-recruited

What's this got to do with the foot?!?!?!

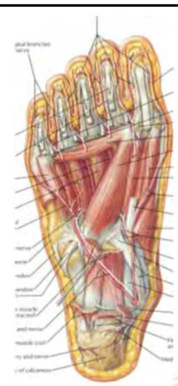
Kaling, M & Gordon, B. 2006. "The Injury." The Office. Season 2 Episode 12

Lumbopelvic Core



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

Foot Core



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

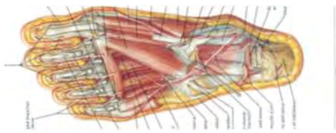
The Foot Has A Core?

3

Foot Core

Mckeon, 2015. **The foot core system: a new paradigm for understanding intrinsic foot muscle function.** British Journal of Sports Medicine.

- Arch of the foot is controlled by both local stabilizers and global movers of the foot, similar to the lumbopelvic core.



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

What's unique about the ankle? Foot Core: Active Subsystem

- 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? 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, leading to functional impairments:
  - Decreased balance responses
  - Negative neuroplastic changes

4

What's unique about the ankle?
Foot Core

- The gastrocsoleus complex modulates tension in the plantar fascia based on the common connection to the calcaneus
- As tension in the gastrocsoleus complex increases, so does the tension in the planar fascia; the gastrocsoleus complex modulates the function of the foot intrinsics

Myers, Thomas W. Anatomy Trains. London: Urban & Fischer; 2014.

In neuromotor health conditions,

Foot intrinsic (core) muscles are under-recruited for tonic stabilization

↓

Gastroc-soleus complex (+ posterior tibialis, anterior tibialis):

- Contraction pattern changes

Phasic → tonic

Heel contact is a vital sensory cue to stimulate **eccentric** gastroc-soleus function

- Lack of initial contact at the posterior aspect of the calcaneus

↓

Gastroc-soleus complex

- Contraction pattern changes

Eccentric → isometric/concentric

5

Neuromotor Examination

Instead of thinking muscles as bad (inhibit!) or good (facilitate!), we can look to increase the efficiency of muscle recruitment for function:

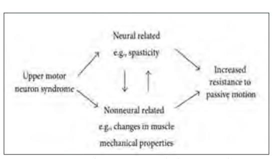
1. Facilitate automatic recruitment of deep postural (tonic) muscles to *reduce tonic demand on phasic muscles.*
   - Ankle: reduce tonic demand on the gastrocsoleus, posterior tibialis, and other global movers by increasing the capacity of the foot core
2. Facilitate task-appropriate contractions, *concentrically, eccentrically, or isometrically* in a task-appropriate way
   - Ankle: improve the capacity of the gastrocsoleus complex and other global movers to fire eccentrically when they have been habitually been firing concentric or isometrically

Terminal stance

Functional Elongation of the GS

Functional dorsiflexion is achieved
not just ***for***
but ***through***
regular ambulation!
"Therapeutic Gait" (Elaine Owen)

A wide body of literature is suggesting that passive muscle properties (tissue stiffness and viscosity) are contributing to perceived hyperreflexia in cerebral palsy.



Bar-On L, Molenaers G, Aertbeliën E, et al. **Spasticity and Its Contribution to Hypertonia in Cerebral Palsy. BioMed research international**. 2015;2015:317047-10.

Literature is suggesting that the nonneural component is as important as, and possibly more important than spasticity for function.

The Tone Fallacy in CP

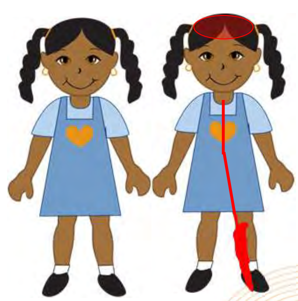
Willerslev-Olsen M, Lorentzen J, Sinkjaer T, Nielsen JB. Passive muscle properties are altered in children with cerebral palsy before the age of 3 years *and are difficult to distinguish clinically from spasticity*. *Dev Med Child Neurol*. 2013;55(7):617-623.

- 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.
- Changes in passive muscle properties (stiffness and viscosity) were much more frequently contributing.
- Large variation of the ratio of neural/nonneural contributions to increased resistance between individuals.

Examination: Neuromotor

What do we think is the problem with the ankle when the there is a NM health condition?

PLANTARFLEXOR TONE

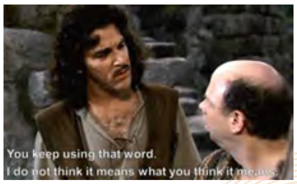


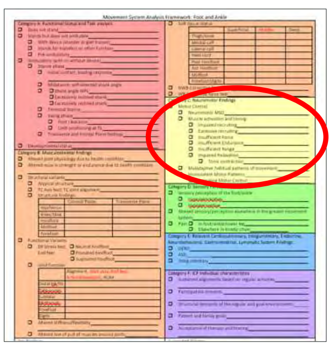
- Clin Biomech (Bristol, Avon). 2003 Feb;18(2):157-65. Velocity dependent passive plantarflexor resistive torque in **patients with acquired brain injury**. Singer BJ1, Dunne JW, Singer KP, Allison GT.
- Harlaar et al, Passive stiffness characteristics of ankle plantarflexors in **hemiplegia**. Clin Biomech 2000
- Dietz. Spastic **Movement Disorder**: Impaired Reflex Function and altered muscle mechanics. Lancet Neurol 2007
- de Vlugt. The Relation Between Neuromechanical Parameters and Ashworth Score in **Stroke Patients**. J Neuroeng Rehabil 2010
- Nielsen JB, Willerslev-Olsen M, Christiansen L, Lundbye-Jensen J, Lorentzen J. **Science-Based Neurorehabilitation: Recommendations for Neurorehabilitation From Basic Science.** Journal of motor behavior. 2015;47(1):7-17.

7

Examination: Neuromotor

- Okay so "tone" is more complex than we thought, and might not be the driver of dysfunction…





Deficits → Resources

- Shift from deficit perspective to resource perspective
- Resources of the system
- Opportunities to add resource to the system

8

Examination: Neuromotor

Positive signs: "added on"
versus
Negative signs: "taken away"

Instead of just looking for "tone" (the positive sign)
→Let's investigate for the negative signs

Examination: Neuromotor

- *More than just "tone"*

Selective Motor Control

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

Examination: Neuromotor

- *More than just "tone"*

Automatic Motor Control
- Automatic recruitment of appropriate stabilizing (tonic) muscle groups to stabilize locally and across the kinetic chain.

9

Neuromotor and Motor Control Findings

- ❑Muscle activation and timing
  - ❑Impaired recruiting
  - ❑Excessive recruiting
  - ❑Insufficient Force
  - ❑Insufficient Endurance
  - ❑Insufficient Range

Neuromotor and Motor Control Findings

Tests for Foot Core Function

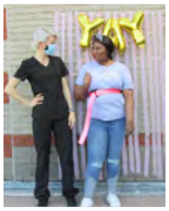
- Paper grip test for foot intrinsics
  - 1st digit
  - Digits 2-5
- Intrinsic positive test
  - Lift 1st toe without 2-5 lifting
  - Lift 2-5 without 1st toe lifting
- Toe splaying: spread the toes laterally

Neuromotor and Motor Control Findings

- ❑Impaired Relaxation
  - ❑Tonic contraction
    In which muscle groups?
    Under what conditions?

Neuromotor Findings

- ❑(Atypical) habitual patterns of movement
  - ❑Synergies



Neuromotor Findings

- ❑(Atypical) habitual patterns of movement
  - ❑Synergies

Neuromotor Findings

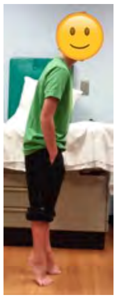
❑Consistency: does the patient show emerging MN control?

❑ 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

11

Balance Strategies

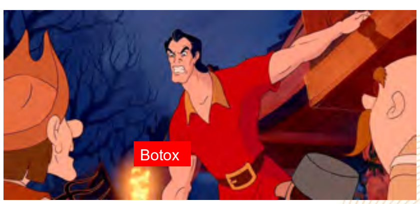

Hip/Step Strategy


Hip and Toe Strategy

Neuromotor Findings

- Accommodate or address?

Old Paradigm:
Tonic contractions are a primary result of the health condition



Neuromotor Findings

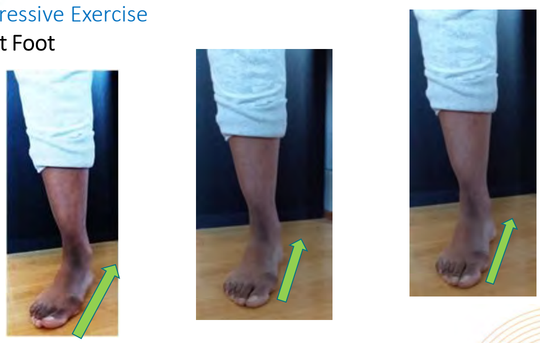
New Paradigm:
Tonic contractions and tissue stiffness may be an adaptive response to weakness, decreased motor control, and sensory deficits

12

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.

Progressive Exercise
Short Foot



Progressive Exercise
Short Foot

13

Improving Foot and Ankle Motor Control

Foot intrinsics
- Paper grip test → activity
- Great toe
- Digits 2-5
- Approximating through the knee to avoid excess PF

Foot intrinsics
- Intrinsic positive test
- Lift great toe without lesser toes lifting
- Lift digits 2-5, keep 1st on surface
- Toe splaying

Progressive Exercise

Short Foot, Intrinsic activities

- But….

Improving Motor Control: Observation and Imagery

Progression
- Action observation
  - Adult model
  - ***Peer*** model
    - Live
    - Video
    - Avatar
  - ***Self*** model: mirror therapy
  - Video editing for self-modeling
    APPTAC 2021: Liliane Savard, PT, DPT, PCS, PhD(c), Melissa Houser, MD
- Motor imagery
- Motor performance

14

Improving Foot and Ankle Motor Control
Electric Stimulation

Progression
- Non-weightbearing
- Weightbearing in sitting
- Semi-standing
- Sit to stand
  - Progression within controlled range

Improving Foot and Ankle Motor Control
Welcome to The Resistance

Use of resistance to improve motor response

15

Improving Foot and Ankle Motor Control
Taping

Improving Foot and Ankle Motor Control
Enhanced Feedback for Motor Exploration

Use of technology to increase:
- Feedback
- Opportunities for success

Novel activities
- Placement
- Timing

Improving Foot and Ankle Motor Control
Enhanced Feedback for Motor Exploration

Novel activities
- Placement
- Timing

Feopardy

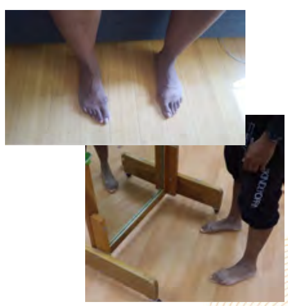
16

Improving Foot and Ankle Motor Control
Enhanced Feedback for Motor Exploration

Low tech

Improving Foot and Ankle Motor Control
Progressive Exercise

Short foot
- Sitting
- Semi-standing
- With visual feedback



Improving Foot and Ankle Motor Control
Progressive Exercise

Resisted rotation in split stance

17

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

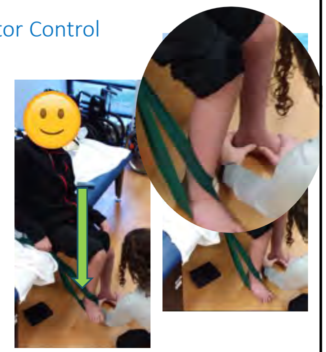
18

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

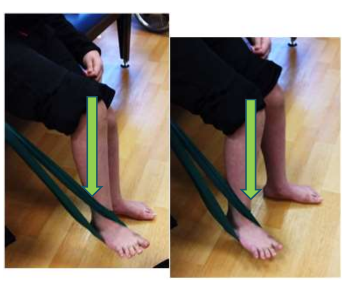
- Sitting, semi-standing
  - Indirect assist to align stance limb

Improving Foot and Ankle Motor Control

Progressive Exercise

Resisted diagonal step-down

- Sitting, semi-standing
  - No assist



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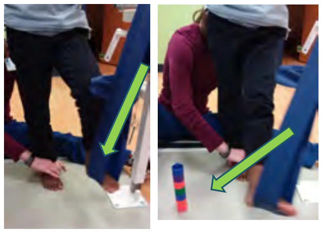
Improving Foot and Ankle Motor Control
Progressive Exercise

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

20

Improving Foot and Ankle Motor Control
Progressive Exercise

Resisted diagonal step-down
- Standing
  - Demi pointe
  - Pointe

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 (1st ray stabilization)
- Progression toward SLS

21

Lab

1. Resisted rotation in splint stance
2. Resisted side step
3. **Resisted diagonal step down ***
4. Resisted hip flexion/extension
5. Resisted hip abduction/adduction
6. Resisted hip flexion/extension

- Re-test short foot

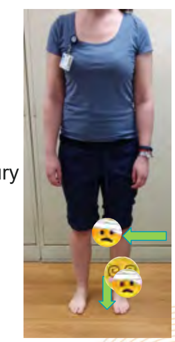
Intervention

- Range of motion
- Strength and motor control
- Neuroplasticity
- External supports

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:

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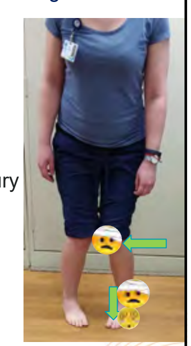
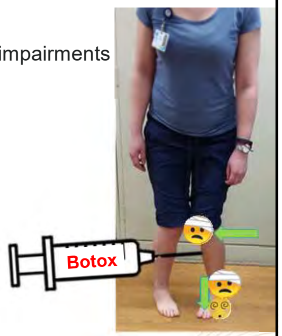


1

Impact of Insufficient Plantar Flexor Strength:

Should we treat patients with gait impairments with neuroparalytics?



Sarcopenia, botulinum toxin a and cerebral palsy: a systematic review. GRAHAM, K; MULTANI, I; HASTINGS-ISON, T; HOWARD, J; HERZOG, W. Developmental Medicine & Child Neurology. 61 Supplement 3:33, October 2019.

What's unique about the ankle?
Therapeutic Gait

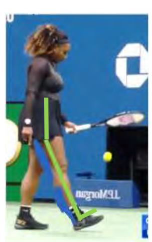
Terminal stance
- Dorsiflexion
- Knee extension
- Hip extension

Functional elongation of:
- GS
- Hip flexors

What's unique about the ankle?
Therapeutic Gait

Initial contact
- Dorsiflexion
- Knee extension
- Hip flexion

Functional elongation of:
- GS
- HS



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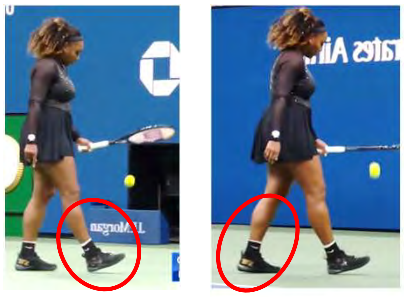


Muscles - Plantarflexors

- **Gastrocnemius, Soleus** (complex)
  - plantarflexes ankle
  - flexes knee (gastrocnemius)
  - **extends knee! (closed chain)**
  - *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

- **Gastrocnemius, Soleus** (complex)
  - *eccentrically controls dorsiflexion for descending stairs*

3

Best predictors of GMFM 66 scores:
- Hip abductor strength
- Ankle plantar flexor strength

Ross SA, Engsberg JR. Relationships between spasticity, strength, gait, and the GMFM-66 in persons with spastic diplegia cerebral palsy. Arch Phys Med Rehabil. 2007;88(9):1114-1120.

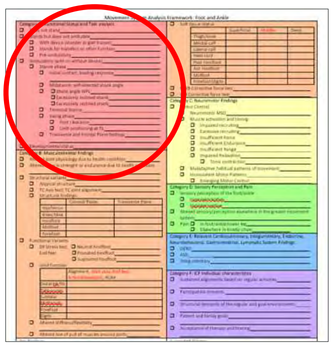
Eek MN, Beckung E. Walking ability is related to muscle strength in children with cerebral palsy. Gait Posture. 2008;28(3):366-371.

Locomotor functions

Perry J, Burnfield JM. Gait Analysis : Normal and Pathological Function. 2nd ed. SLACK; 2010.

Gait Function	MVP
• Shock absorption	• Hip abd, extensors, quad, GS, TA
• Stance stability	• Gastrocsoleus
• Propulsion	• Gastrocsoleus
• Energy conservation	• Gastrocsoleus

End lecture day 1 3/11

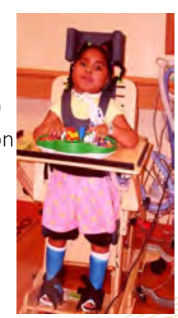


Functional Status and Task analysis

- ❑ Does Not Stand/Limited Standing

Functional Status and Task analysis

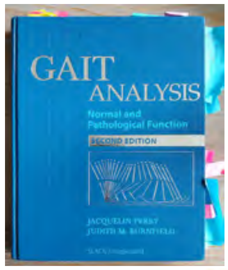
- ❑ Stands but does not ambulate
  - ❑ With device (stander or gait trainer)
  - ❑ Stands for transfers or other function
  - ❑ Pre-ambulatory



Functional Status and Task analysis

- ❑Ambulatory (with or without device)
- Locomotor functions
  - Shock absorption
  - Stance stability
  - Energy conservation
  - Propulsion

  (Perry)



GAIT EVAL

Let's go to the tape

Let's go to the tape

Positive signs: "added on"
versus
Negative signs: "taken away"

Instead of looking for "tone" (the positive sign)
→Let's investigate for the negative signs

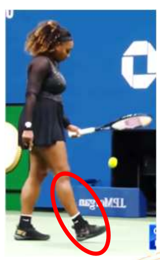
6

LOADING RESPONSE | MIDSTANCE | TERMINAL STANCE

loading response

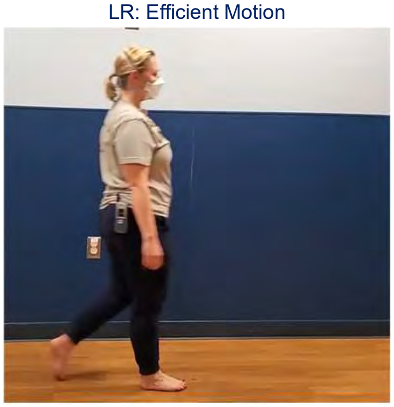
Efficient LR

- GS, knee extensors, hips extensors/external rotators control Ground Reaction Force (shock absorption)
- GS, ankle mms, and foot intrinsics support foot posture and position



LOADING RESPONSE

LR: Efficient Motion



Loading Response: (1) Control ground reaction forces (2) Foot stabilization

7

LR: Less Efficient Motion: Hemiplegia

Loading Response: (1) Control ground reaction forces (2) Foot stabilization

LR Less Efficient Motion: Diplegia

Loading Response: (1) Control ground reaction forces (2) Foot stabilization

LR Less Efficient Motion: Diplegia

Loading Response: (1) Control ground reaction forces (2) Foot stabilization

8

LR: Foot Stabilization


Functional Status and Task analysis

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


9

❒Stance phase

❒Loading response

Lack of deceleration of tibial (shank) advancement

❒Stance phase

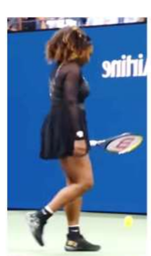
❒Loading response

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

Midstance

Efficient Midstance

- Graded tibial progression
- Knee stability
- Foot posture



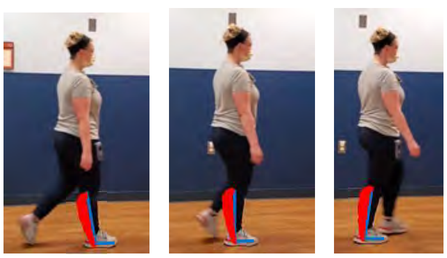
MIDSTANCE

10

Midstance: Efficient Motion

Midstance: 1) Graded tibial progression, 2) Knee stability, 3) Support foot posture

Midstance: Efficient Motion



Midstance: 1) Graded tibial progression, 2) Knee stability, 3) Support foot posture

Midstance: Less Efficient Motion: Hemiplegia

Midstance: 1) Graded tibial progression, 2) Knee stability, 3) Support foot posture

11

Midstance: Less Efficient Motion: Diplegia

Midstance: 1) Graded tibial progression, 2) Knee stability, 3) Support foot posture

Midstance

Midstance Drills

1) Graded tibial progression
   Knee stability

2) Foot posture

MIDSTANCE

MIDSTANCE

- Stabilize the knee by slowing tibia motion relative to femur motion

12

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

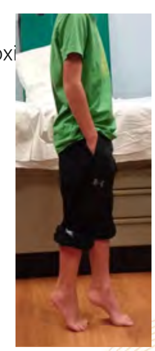
Posterior to hip

Mild incline of the shank

❑1-Shank Angle WFL

Movement system not impacted proxi
foot/ankle

e.g. Toe Walking



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❑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

Midstance

Midstance Drills

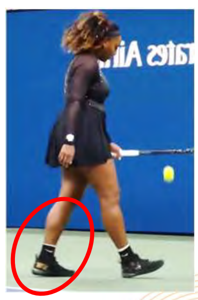
1) Graded tibial progression
   Knee stability

2) Foot posture

MIDSTANCE

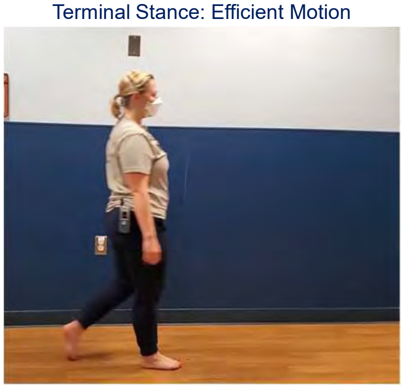
LOADING RESPONSE

MIDSTANCE



TERMINAL STANCE

Terminal Stance: Efficient Motion



1) Decelerate tibial advancement 2) Enable forefoot rocker by stabilizing the ankle 3) Maintain the height of the COM 4) Achieve maximal functional elongation

15

Terminal Stance: Less Efficient Motion: Hemiplegia

1) Decelerate tibial advancement 2) Enable forefoot rocker by stabilizing the ankle 3) Maintain the height of the COM 4) Achieve maximal functional elongation

Terminal Stance: Less Efficient Motion: Diplegia

1) Decelerate tibial advancement 2) Enable forefoot rocker by stabilizing the ankle 3) Maintain the height of the COM 4) Achieve maximal functional elongation

Terminal Stance

Dorsiflexion with hip and knee extension?

*Requisite of Therapeutic Gait. (Owen)

MTP extension with pre-swing?

16

Terminal stance
Functional Elongation of the GS

Functional dorsiflexion is achieved
not just ***for***
but ***through***
regular ambulation!
"Therapeutic Gait" (Elaine Owen)

Willerslev-Olsen 2013:
Passive muscle properties are altered in children with cerebral palsy before the age of 3 years *and are difficult to distinguish clinically from spasticity. Dev Med Child Neurol.*

Terminal stance
Functional Elongation of the GS

- Functional DF range and GS muscle extensibility is achieved through regular ambulation
- Anyone lacking this movement experience is at risk for restricted DF and tissue changes
- Foot and ankle impairments in most pediatric health conditions are sequelae of the lack of therapeutic gait

TERMINAL STANCE

Functional Status and Task analysis

❑Swing phase
- Foot clearance
- Step Length

Functional Status and Task analysis

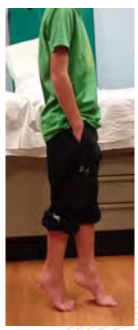
- ❑Swing phase
  - ❑Limb positioning at Terminal Swing

    Initial contact at heel with hip flexion a extension?

*Requisite of Therapeutic Gait.

Functional Status and Task analysis

- ❑Swing phase
  - ❑Limb positioning at Terminal Swing



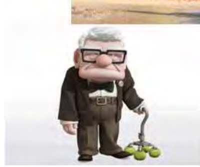
Functional Status and Task analysis

- ❑Transverse and Coronal Plane findings

18

Functional Status and Task analysis

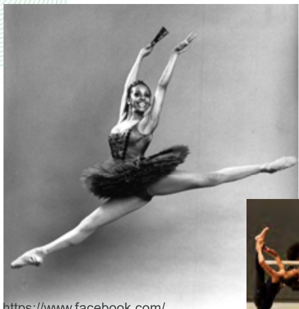
❑Lifespan Status
Goals related to movement experiences based on current lifespan status and expected changes.



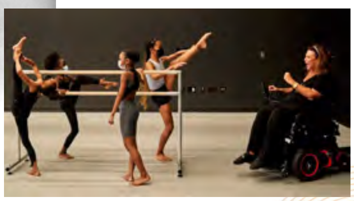
INCREASING MOBILITY
Let's go to the tape

Terminal stance
Functional Elongation of the GS

19

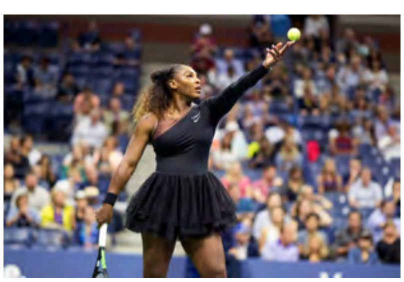


https://www.facebook.com/oregonballettheatre/posts/elena-carters-tremendous-influence-on-the-growth-and-vitality-of-ballet-in-orego/10158412628561100/



https://www.latimes.com/entertainment-arts/story/2022-05-08/debbie-allen-shonda-rhimes-performing-arts-center

MOTOR CONTROL



20

Form check: Gait

Old Paradigm:

- Tonic contractions are a primary result of the health condition and are the limiting factor for functional progress

New Paradigm:

- Tonic contractions and tissue stiffness are often a (mal)adaptive response to weakness, decreased motor control, and sensory deficits

Sarcopenia, botulinum toxin a and cerebral palsy: a systematic review. GRAHAM, K; MULTANI, I; HASTINGS-ISON, T; HOWARD, J; HERZOG, W. Developmental Medicine & Child Neurology. 61 Supplement 3:33, October 2019.

Form check: Gait

New Paradigm:

- Tonic contractions are a therapeutic opportunity
- "Rather than being a pathological condition by necessity, spasticity could also be seen as a therapeutic opportunity. After all, the main problem for the patients (and the therapist) is to activate the muscles and the increased sensory drive to the spinal motorneurones that spasticity reflects provides an opportunity for providing such activation."
  Nielsen 2015

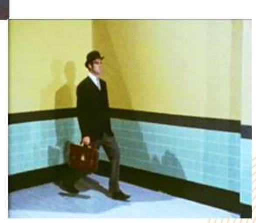
Loading Response Drills

21

Loading response: Eccentric Drills
Contraction to control GRF

MIDSTANCE:
improve CONTROL OF TIBIAL PROGRESSION

Drills: midstance



22

Midstance
Improve Control of Tibial Progression

Midstance
Improve Control of Tibial Progression

DRILL:

Resisted midstance