The Conservative Management of Idiopathic Toe Walking Utilizing an Evidence-Based Algorithm and Sensory-Motor Treatment Approach

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Idiopathic Toe-Walking: Background and Natural History

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Disclosure Information
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Objectives

• Define toe-walking and idiopathic toe-walking
• Review the natural history of idiopathic toe-walking
• Compare normal development of gait with deviations seen in idiopathic toe-walking in young children

Definitions of Toe-Walking

• First described in 1967 as “Congenital Short Achilles” (Hall 1967)
• Toe-toe gait pattern in which there is normal mobility and tone of the ankles and is generally symmetrical and intermittent (Newman 2006)
• Inability to heel strike at the initial contact of gait (Morrissy 2001)

Common Etiologies of Toe-Walking

– Neuromuscular disorders:
  – Central Nervous System:
    – Cerebral palsy (perinatal injury, brain malformation, vascular accident)
    – Spinal cord abnormalities (congenital, traumatic, acquired)
    – Dystonia (usually asymmetrical)
    – Peripheral Nervous System:
      – Peripheral neuropathies
  – Paralytic Muscle Disease
  – Muscular Dystrophy (Duchenne)
  – Congenital myopathy
– Behavioral disorders (Autism, Cognitive Disability)
– Musculoskeletal disorders
  – Club foot
  – Leg length difference (Stricker 1998, Pernet, 2010)
Idiopathic Toe Walking

- Bilateral, persistent toe-walking without other discernible etiology in children older than 2 years (may or may not present with ankle equinus contracture)
- Diagnosis of exclusion
  - Neurological, musculoskeletal, or psychiatric etiology has been ruled out.

Idiopathic Toe-Walking

- Toe walking that is variable, shows symmetry, can be modified under demand with good balance and appropriate muscular activity is probably idiopathic

Natural History of ITW

- First report of natural history at ≥ 2 years old.
- 48 children (average age 3.2 years)
  - Observation only
  - Ankle DF > 0 in all but 2 children
  - Follow up on average: 36 months later
    - 7 (14.5%) children gained at least 5° ankle DF ROM
    - 6 (12.5%) children lost ankle DF ROM (none < 0)
    - 25% reported satisfaction with gait pattern

ITW in Physical Therapy

- With a reported prevalence of idiopathic toe walking of up to 24% in children, this is a frequent concern seen in a pediatric physical therapy setting

Why Address ITW in PT?

- Persistent toe-walking can lead to loss of ankle dorsiflexion ROM (Sobel 1997, Kogan 2001)
  - Predisposes children to future orthopedic maladies
  - Secondary changes in gait and posture (Solan 2010)
Normal Progression of Gait

New walkers (9-18 months)
- Widened base of support
- Increased hip and knee flexion
- Flat foot or plantar-flexed at initial contact
- Decreased stride length
- Increased cadence
- Plantar-flexed foot

position in swing phase
- Hips in abduction, flexion, and external rotation
- Internal tibial torsion
- Genu varus
- Ankle everted (due to structure of ankle mortise)
- Higher COG (thoracic)

Campbell 2012

Normal Progression of Gait

- By 18 months- genu varus resolves
- 18-24 months- improving hip extension ROM
- 18-24 months- COG lowers to lumbar levels
- By 24 months- consistent heel strike present. If not, consider:
  - Lack of motor control
  - Stability strategy- flat foot to have greater surface area for initial contact, toe first to lock degrees of freedom at ankle

Campbell 2012

Observations During Play

- Difficulty modulating force and pace
- Frequent running instead of walking
- Avoids stooping
- Avoids use of eccentric control

Clark 2010

Common Impairments in ITW

- Child may have:
  - Decreased motor control
  - Decreased postural control
  - Decreased ankle DF and/or PF strength
  - Over or under responsiveness to touch

Physical Therapy Evaluation of Idiopathic Toe-Walking

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Objectives

• Describe at least 3 conditions that present with toe walking in children
• Utilize a screening tool to assist with determining the need for further medical evaluation for a child referred for toe walking
• Understand the role of the physical therapist in evaluating a child referred for toe walking

Differential Diagnosis of ITW

• Cerebral Palsy
• Muscular Dystrophy
• Tethered Spinal Cord
• Hip Dysplasia
• Leg Length Discrepancy
• Autism

➢ If it is suspected that the child has an underlying medical concern, they would be referred to a specialist or back to their pediatrician for further evaluation.

➢ The child may still receive physical therapy services, but would not be appropriate to be treated using the ITW treatment algorithm being presented today

Differential Diagnosis

Cerebral Palsy (CP)

• Toe walking may present as unilateral or bilateral
  – May present with a leg length discrepancy
• Birth history: prematurity, in-utero brain injury, anoxia
• Examination:
  – There may be spasticity or clonus in response to passive movement into ankle dorsiflexion
  – Range of motion may be asymmetrical (hemiplegia)
• Persistent toe walking
  – Idiopathic toe walkers have a more variable gait than children with CP (Hicks 1988)

Muscular Dystrophy

• Primary impairment is weakness due to progressive loss of myofibrils

Clinical Presentation

• In Duchenne’s Muscular Dystrophy, weakness is generally noted by 3-5 years of age (Campbell 2012)
• Pseudohypertrophic calf muscle
  – Fatty tissue infiltration
• Contractures
• Bilateral toe walking
• Gower’s sign

Tethered cord

• The spinal cord becomes caught or tethered and is stretched
• Signs and symptoms:
  – Altered gait pattern
  – Changes in bowel/bladder function
  – Leg and/or back pain
  – Lower extremity weakness
  – Scoliosis
  – Spasticity

Hip dysplasia

• A range of developmental hip disorders, from mild dysplasia to severe dysplasia with dislocation
• Clinical presentation may include:
  – Limping
  – Toe walking
  – Asymmetry of thigh crease
  – Leg length discrepancy
➢ Although hip dislocation may be associated with delayed walking, one study found no significant difference in age of onset of walking (Kamath 2004)
Differential Diagnosis

Leg length discrepancy: >2.5cm discrepancy in leg length

• Causes:
  – Trauma: Epiphyseal or diaphyseal fractures
  – Congenital, neuromuscular or acquired diseases: Hemihypertrophy, hip dysplasia, hemiplegia, poliomyelitis, LCPD, SCFE
  – Infections causing physeal growth disturbances
  – Tumors
  – Vascular disorders

Campbell 2012

Differential Diagnosis

Leg length discrepancy: >2.5cm discrepancy in leg length

• Clinical Presentation:
  – Increased energy expenditure with gait
  – Pelvic obliquity
  – Functional scoliosis
  – Pelvic tilt
  – Contralateral knee flexion
  – Ipsilateral equinus

Campbell 2012

Differential Diagnosis

• Autism
  – As many as 50% of 5 year olds with autism have an intermittent equinus gait
  – May be correlated with the language component of autism
  – In children with autism, toe walking was associated with an earlier diagnosis of autism, along with:
    • Severe language deficit
    • Hand flapping
    • Sustained odd play

Williams 2010b

Physical Therapy Evaluation of Toe Walking

• Screening for underlying causes
  – Toe Walking Tool
  – Sensory Processing Measure (SPM) and (SPM-P)

• Musculoskeletal
  – Range of motion
  – Strength

• Posture/Gait
  – Ability to static stand flat footed
  – Ability to walk with heel strike with cueing
  – Presence of gait compensations
  – % of steps without heel strike

Williams 2010b

Screening for Underlying Causes

• Toe Walking Tool
  – Developed by Williams et al. and published in 2010
  – A screening tool used to help determine if toe-walking is idiopathic or may have an underlying medical cause that requires further medical examination

Williams 2010b

Toe Walking Tool

• Made up of a series of exclusionary questions that progress in a successive order

• The Toe Walking Tool has been found to be valid and reliable
  – No child with an underlying medical cause of toe-walking was able to progress through the tool

Williams 2010b
Case Study – Part 1

3 y.o. girl referred to physical therapy for evaluation and treatment of toe-walking

• History
  – No significant past medical history, child began walking at 15 months of age, toe-walking since initiation of walking, no parental concerns related to gross motor skill acquisition

• Clinical presentation
  – Absent heel strike >80% of gait, able to static stand with foot flat posture

Case Study - Part 2

• Clinical presentation
  – ROM assessment:
    • Ankle DF with knee extension:
      – Left: +20 degrees
      – Right: +5 degrees with sustained clonus
    • Ankle DF in weight bearing:
      – Left: + 38 degrees
      – Right: + 15 degrees

Sensory Screening

• In children with ITW (Williams 2012b, Williams 2013b):
  – Altered vibration perception
  – Hypersensitivity to tactile stimuli

• Screening for sensory needs
  – At NCH, we are utilizing the Sensory Processing Measure (SPM) to screen for sensory contributions in children referred to physical therapy for toe walking
Sensory Processing Measure (SPM)

- The SPM is a parent questionnaire.
  - Reliable and valid in children 5-12 years of age.
- The Sensory Processing Measure – Preschool (SPM-P) is used for children ages 2-5 years who are not currently enrolled in kindergarten.
  - The SPM is used for children age 5 who are enrolled in kindergarten and children over the age of 5

Scoring the SPM and SPM-P

 Provides 8 scaled scores:
  - Social Participation
  - Vision
  - Hearing
  - Touch

Results of the SPM/SPM-P:
  - Scores fall into 1 of 3 categories:
    - Typical, Some Problems, Definite Dysfunction
  - Used to guide PT treatment
  - Used to determine appropriateness of referral to occupational therapy to address sensory issues

Range of Motion

- Persistent ankle plantar flexion
  - 50-70% of children with ITW have equinus contracture
    - Can lead to gait compensations
    - Prolonged equinus contracture may be associated with adult acquired flatfoot, metatarsalgia, and plantar fasciitis

Range of Motion

- Ankle DF ROM Assessment
  - Standardized methods for assessing ankle DF ROM:
    - Non-weight bearing, assessed in prone
    - Weight bearing using the Lunge Test

Non-Weight Bearing Ankle DF

- Child placed in prone with feet extending over the exam table
- Using a goniometer, measure PROM of ankle DF in subtalar neutral with the knee extended.
  - A long shaft of the goniometer is directed parallel to the fibula, while the other shaft is placed on the lateral side of the foot along the fifth metatarsal bone.

Note: If child cannot lay in prone, use an alternative method to obtain PROM DF measure.

WB Ankle DF: Lunge Test

- Child stands tall with knees straight.
- Place the inclinometer on the anterior surface of the tibia at mid-shaft.
  - Zero out the inclinometer with knee in 0 degrees of flexion/extension.
- Cue the child to lunge their knee towards the wall until maximum ankle DF WITHOUT heel lift off is achieved and record the angle displayed on the inclinometer.

Note: If the child cannot stand with foot flat without compensations, this test cannot be performed
Evaluation – Posture

- Assess leg length due to differential diagnosis of hip dysplasia/dislocation
- Postural compensations common with decreased ankle DF ROM:
  - External rotation of the foot
  - Knee hyperextension in stance phase
  - Lower extremity external rotation, external tibial torsion

Gait Deviations in ITW

-Toe first or foot flat at initial contact
-Abnormal ankle motion
  - Increased PF during stance and swing phase
  - Variability in ankle DF/PF between cycles
- Knee hyperextension in stance phase
- Increased foot external rotation/tibial torsion
  - This compensation for contracted triceps surae may mimic “outgrowing” of toe walking
- Often able to correct to heel-toe gait pattern with verbal prompting or when child is aware that gait is being assessed

Quantifying Toe Walking

- Currently no gold standard feasible for clinical use
- Various methods have been used:
  - Gait analysis to classify severity of toe walking: (Alvarez 2007)
    - Based on initial contact, percentage of gait cycle on forefoot, timing of plantarflexion moment
      - Type 1 (mild), Type 2 (mod), Type 3 (severe)
    - Observational gait analysis with use of video
    - Parent perception of percentage of toe walking
      - 25% for at least 3 months (Engstrom 2012a, 2013)
      - 83% on tip toes (Armand 2006)
      - Heel strike 15-92% of the time (Crenna 2005)

Summary

- When a child is referred for a physical therapy evaluation for toe walking, a thorough history and examination which may include the Toe Walking Tool is needed to determine if there may be an underlying cause for the child’s toe walking requiring further medical referral or if it is idiopathic.
- Objective and standardized assessments are important for tracking outcomes
  - ROM assessment
  - Quantify percentage of time without heel strike at initial contact
Objective: ITW Algorithm

- Review the key components of the ITW algorithm
  - Please see the algorithm

ITW Algorithm Inclusion Criteria

- 24 months of age or older
- The origin of the toe walking is idiopathic
- Toe walking >20% of the time

Why 24 Months of Age?

- The algorithm is to be used with children 24 months of age and older
  - ITW is defined as persistent toe walking present at >2 years of age (Oetgen 2012)
  - Intermittent toe walking at less than 24 months of age can be part of typical development
  - Heel strike occurs at 18 months of age or on average 22.5 weeks after onset of walking (I) (Sala 1999)
  - Critical window of time before a decrease in ROM occurs between 2-4 years of age (Sobel 1997)

Toe Walking in Children < 24 Months of Age

- Toe walking 100% of the time after the onset of (I) walking will not be considered normal in children < 24 months of age
- However, they don’t fit the inclusion criteria for use of the ITW algorithm
  - Discontinue use of algorithm and refer to a physician as needed
  - Use clinical judgment for PT recommendations

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Screening for Non-Idiopathic Causes

- **Toe Walking Tool**  
  - Rule out non-idiopathic origin to toe walking  
  - If it is suspected that toe walking is non-idiopathic in origin:  
    - Discontinue use of algorithm and refer to a physician as needed  
    - Use clinical judgment for PT recommendations

Screening for a Sensory Contribution to Toe Walking

- **Sensory Processing Measure (SPM)**  
  - Screen for a sensory contribution to toe walking  
  - SPM is considered abnormal if:  
    - The child has a definite difference in any category on the SPM  
    - Refer for OT evaluation  
    - Continue on with the algorithm

ITW Algorithm General Concepts

- **Concept #1: ROM Requirements**  
  - Is ankle dorsiflexion range of motion within functional limits in a weight bearing and non-weight bearing position?  
  - No  
    - Primary goal of initial treatment intervention is to improve ROM into dorsiflexion  
  - Yes  
    - Treat with orthoses and 6-8 weeks of PT using a sensorimotor treatment approach

Why Measure DF in Weight Bearing (WB) and Non-Weight Bearing (NWB)

- WB and NWB measures of ankle DF  
  - Produce significantly different results  
  - Should not be used interchangeably  
  - Standard clinical practice is to measure in a NWB position  
  - Children with ITW is often have difficulty with weight bearing positions  
    - i.e.: tip toes during initial contact and/or stance phase of gait, difficulty descending stairs, hopping, and squatting.

Definition of WFL’s for Ankle Dorsiflexion

- Non-weight bearing (NWB) cutoff for WFL’s  
  - ≥ 10º DF with knee extension  

- Weight bearing (WB) lunge test cutoff for WFL’s  
  - ≥ 25º  

Rationale for NWB Cutoff of 10º DF

- Limitations of PROM into DF with knee extension in a NWB increases the risk of childhood injury (Tabrizi 2000)  
  - Limited DF group: 5.7º DF  
  - Control group: 12.8º DF  
- Peak DF during stance phase of gait is 13.6-17.2º (Dixon 2012)  
  - Measured during weight bearing  
- Thus  
  - PROM into DF with knee extension in NWB needs to be at least 12º to reduce risk of injury and allow for heel to toe gait pattern
Rationale for WB Lunge Test Cutoff of 25° DF

• Pediatric weight bearing DF ROM values range from 8.5° to 29.2° during functional activities
  – Stance phase of gait:
    • 13.6-17.2° DF (Dixon 2012)
  – Mean ankle DF with ½ kneel to stand in 5-7 years old:
    • 29.2° (VanderLinden 1991)
  – Sit to stand: (DaCosta 2013)
    • 17.5° in 12 month olds
    • 8.5° in 18 month olds

ITW Algorithm General Concepts

• Concept #2: Interventions to improve ankle DF ROM
  – If the child’s ROM into ankle DF is not within functional limits, what interventions should be used to improve ROM?
  – Conservative options include:
    • Serial casting
    • Night splinting
    • Traditional stretching/physical therapy

Interventions to Improve PROM into DF

• Traditional stretching/physical therapy: Adult literature
  – 2 systematic review articles on improving PROM into DF using stretching found minimal improvements
    • Increase in PROM DF by 2.1°-3.0° after 5-60 minutes of stretching (total dose) vs. no stretching (Radford 2006)
    • 12 studies showed no difference between stretching and not stretching and manual therapy was not effective (Young 2013)
    • Stretching in combination with warming up, superficial moist heat, diathermy, diathermy and ice, and heel raise exercises
      – Associated with greater increases in ankle DF when compared to controls (Young 2013)

Rationale for WB Lunge Test Cutoff of 25° DF

• Adult weight bearing DF ROM values range from 11.21°-21.11°
  – Stairs: (Protopapadaki 2007)
    • Ascending mean maximum DF: 11.21°
    • Descending mean maximum DF: 21.11°
  – Squatting:
    • When ankle joint flexibility is reduced, the heels rise off the floor
      – Can result in compensatory joint movements at the ankle, knee, hips, and spine which can potentially lead to injury (Schoenfeld 2010)
    – No exact cut off criteria given
    – As people age, they lose ROM so it is likely that children have even more DF ROM during the above functional activities

Interventions to Improve PROM into DF

• Serial Castings
  – Serial casting improved PROM into DF in up to 100% of children with ITW (Brouwer 2000, Engstrom 2013)
  – The more ankle DF gained, less toe walking perform (Fox 2006)

Interventions to Improve PROM into DF

• Traditional stretching/physical therapy: Pediatric literature
  – No articles, specific to stretching plantar flexors in children
    • Few articles do report improvements in hamstring length in children who performed a stretching program (Coledam 2012; Santonja Medina 2007; Reid 2004)
    • Motor control intervention in ITW: 1 hour, 2x/week for 9 weeks
      – Ankle motion improved (only one to >15 degrees) but toe walking did not decrease (Clark 2010)
Interventions to Improve PROM into DF

- Night splinting:
  - No studies found on this topic

Interventions to Improve Gait

- Serial Castings
  - Complete resolution of toe walking after casting ranges from 0%-100% of subjects
  - Improvement in toe walking after casting ranges from 46.1%-100% of subjects
  - Improvements in gait parameters remained 3 and 12 months after casting (Engstrom 2013)

Interventions to Improve Gait

- Traditional stretching/Physical Therapy
  - A few immediate gait changes were noted in ITWs after passive stretching (Hirsch 2004)
  - Motor control intervention: 1 hour 2x/week for 9 weeks
    - Ankle motion improved (only one to >15º) but toe walking did not decrease (Clark 2010)

Interventions to Improve Gait

- Night Splinting:
  - 1 article discusses the use of night splinting with idiopathic toe walkers
    - Botox and a night splint allowed 7/10 to stop toe walking
      - 2 required additional injection
      - 1 required heel cord lengthening

Conclusion of Interventions to Improve PROM into DF and Gait

- Serial casting appears to be the most effective conservative interventions to improve DF ROM and/or gait
  - If limited PROM into DF in a weight bearing or non-weight bearing position, recommend serial casting as initial treatment

Interventions to Improve PROM into DF

- Some families decline serial casting
  - Offer PT 1x/week x 4 weeks with HEP
    - PT treatment in the clinic will focus on static stretching with use of a warm-up or superficial heat, PNF, heel raises, sensory integration, and motor control strategies (Clark 2010, Young 2013, Radford 2006)
  - Offer referral to PM & R or another specialist
### Traditional Stretching/PT to Improve ROM

- Limited evidence to support the use of traditional stretching/PT to address ROM loss into DF and gait in children with ITW
- Recommended only as an alternative if a family initially declines casting (Clark 2010; Hirsch 2004)
  - Make an attempt to see if any progress can be made
    - Limit the duration of time because of limited evidence
    - Build a rapport with the family and avoid loss of child to follow up
    - Recommend serial casting again

- 4 weeks was chosen as the duration:
  - Greater than 3 weeks of stretching may provide more improvement in ROM than < 3 weeks (Harvey 2002)
  - Avoid using too many services on an intervention that may not be effective in improving PROM into DF or gait

### Interventions to Improve ROM

- Serial casting was declined originally, child underwent 4 weeks of traditional PT, continued reduced ankle DF ROM
  - Recommend serial casting again to family
  - Most effective conservative intervention
  - May get a different response because treatment was tried without success and you have a better rapport with the family
    - If family declines serial casting again
      - Recommend night splint (Jack 2004)

### Night Splinting

- 1 article discusses the use of a night splinting with idiopathic toe walkers
  - Botox and a night splint allowed 7/10 to stop toe walking (Jack 2004)
    - 2 required additional injection
    - 1 required heel cord lengthening
  - Longer duration stretching at a medium intensity provides more improvements in ROM than shorter duration stretching at a higher intensity

- After obtainment of a night splint
  - Return to PT immediately to ensure proper fit
  - Return to PT 1x/month for 4 months to:
    - Assess progress
    - Increase stretch if gaining ROM in night splint
    - Reassess ROM and toe walking status after 4 months of treatment
      - Continued limited ROM into DF, recommend serial casting one final time
        - If family declines, refer back to PM & R or another specialist
ITW Algorithm General Concepts

- **Concept #3: ROM is WFL’s in WB and NWB positions**
  - This could be at
    - Initial evaluation
    - After casting
    - After traditional stretching/PT
    - After night splinting
  - Recommend PT for 6-8 weeks and use of orthoses

Note on Treatment after Serial Casting

- No toe walking 1 week after casting, they will still complete 6-8 weeks of PT
- Provides the best chance at reducing reoccurrence of toe walking
  - Casting causes weakness and significant improvements in ROM over a short duration of time
  - Child has not walked with a heel to toe gait pattern prior to casting and could benefit from gait training to reinforce this pattern
  - Child has not had the sensory input into his/her heel due to toe walking and would benefit from sensory strategies to improve tolerance to this new input

ROM is WFL’s and ITW Present

- PT 1 time per week for 6-8 weeks focusing on strengthening exercises, motor control, gait re-training, and sensory strategies
  - Most will not outgrow ITW without negative consequences (Eastwood 2000 and Sala 1999)
  - Literature on traditional PT’s impact on reducing toe walking is limited and at times shows minimal impact
  - Article that best investigates the use of PT differs from our recommendations (Clark 2010)
    - The children had to have at least 0º DF which is less than our cut off criteria
    - Did not combine it with use of orthoses
    - Did not apply vibration to children with hypersensitivity

- **ROM is WFL’s and ITW Present**
  - Recommend use of orthoses for all children with ankle ROM WFL’s with one exception
    - Children who undergo serial casting will be reassessed 1 week after casting.
      - Orthoses are not recommended if they are no longer toe walking
  - Goal of the orthoses
    - Block toe extension and/or ankle plantar flexion to reduce toe walking in children who toe walk despite having adequate ankle dorsiflexion ROM
    - 2 studies presented at national conferences found orthotics significantly reduce toe walking (Herrin 2012 and Geil 2012)
    - Resolution of ITW in 71% of children treated variably with casts and/or AFOs (Dietz 2012)

Toe Walking in Orthotics

- Assess effectiveness of orthoses in reducing or eliminating toe walking with wear 2-4 weeks after obtainment
  - Toe walking in orthotics, recommend either a change in style or referral to PM & R or another specialist
  - If after a change in style, toe walking continues, recommend referral to PM & R or another specialist
    - Follow-up with PT as needed

Discharge from PT

- **Concept #4: When to discharge from PT:**
  - Ankle DF PROM WFL’s and toe walking < 20% at 3 month follow up without use of orthotics
  - Consider discharge if child is referred to PM & R due to
    - Inability to gain functional ROM into DF with PT interventions
    - Family declining serial casting and/or night splinting and child is not making ROM gains with traditional PT
    - Inability to reduce or eliminate toe walking with use of orthotic and traditional PT
    - Toe walking is reduced or eliminated with orthotics and tradition PT but returns when interventions are discontinued
Rehabilitative Treatment in Idiopathic Toe-Walking

Elizabeth Maus, PT, DPT, PCS

Rehabilitative Treatment in ITW

- Serial casting
- Orthoses
- Night splinting
- Stretching
- Motor Control
- Sensory/proprioception
- Shoe wear
- Auditory feedback
- Kinesiotape

Objectives

- Compare rehabilitative treatment options to create an individualized treatment plan for a case child with idiopathic toe walking
- Discuss treatment options for children with idiopathic toe-walking that necessitate referral to medical specialist

Casting: Our Practice

- Recommended for children with ankle DF < 10° NWB/ < 25° WB.
- Changes number and/or length of sarcomeres
- Stretch peri-articular tissue
- Casted 1x/ week until
  - ROM goal is met
  - 2 consecutive visits with no change in ROM
  - Skin breakdown prevents cast application

ROM Goals with Serial Casting

- When to stop casting?
  - NWB Goal: PROM into ankle dorsiflexion with knee extension in a non-weight bearing prone position is stratified based on age:
    - 2-3 years of age: up to 20-30 degrees
    - 4-6 years of age: up to 20-25 degrees
    - 7-10 years of age: up to 15-20 degrees
    - 11-adult: up to 11-15 degrees
  - WB Goal: lunge test: 35-40 degrees

- WB Goal Stratified by Age Rationale:
  - Mean DF with knee extension in a NWB position is 22.8-28 degrees with a SD of 6.6-7.4 degrees (Soucie 2011, Alanen 2001)
    - Range with SD: 16.2-35.4 degrees
  - As children age, ROM values decrease (Soucie 2011)
  - Considered mean measurements of available studies to stratify the ROM measure by age.
  - Also considered recommendations from Cusick 2007 in our decision
**ROM Goals with Serial Casting**

- **WB Goal:**
  - Mean on the lunge test for healthy children 7-15 years of age was 43.7 degrees (+/-5) (Evans 2012)
  - We wanted to cast to close to the mean resulting in weight bearing cutoff criteria of 35-40 degrees

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**Style of Orthoses**

- Available evidence on the ideal style of orthotic is conflicting:
  - 2 small studies presented at AAOP conference in 2012
  - Geil 2012: AFO vs. foot orthoses with carbon fiber bottom
    - AFO’s produced more heel strikes with orthotics donned
    - FO were more effective in maintaining heel contact once child was no longer wearing orthoses

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**Wearing Schedule**

- Duration per day:
  - No evidence to guide this decision
  - Expert opinion of the group:
    - Wear them the majority of the day (i.e.: at school) due to the goal of breaking the habit of toe walking
    - Periods of time at home before and after school out of them to allow for practice of walking without then donned and variations in sensory input

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**Style of Orthoses**

- Herrin 2012: AFO vs. foot orthoses with carbon fiber bottom
  - Measured parent satisfaction and parent report of toe walking
  - Significantly less toe walking (p<.05) in AFO group reported compared to FO.
  - Higher satisfaction in AFO group vs. FO group after treatment
  - FO could be used more long term with less invasiveness (less visible, less joints restricted)

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**Wearing Schedule**

- Duration of wear (weeks/months)
  - No evidence to guide this decision
  - Expert opinion of the group:
    - Until outgrown with rechecks every 3-6 months
    - Once outgrown, 3 month trial without orthoses
    - PT follow up at the end of 3 month trial
      - If toe walking continues after 3 months without orthoses use: refer to PM and R; consider re-issuing orthoses and F/U with PT as needed.
      - If toe walking is not present, then discharge
**Night Splinting**

- Utilized to maintain or improve ankle range of motion
- Custom or off-the-shelf
- Adjustable angle or fixed

**Stretching**

- Literature is lacking on effectiveness of stretching in children with ITW
- Stretching dose is developed based on TD children

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**Stretching Dose**

- **Duration per stretch**: 30-60 second holds
- **Repetitions**: 4 times per day
- **Frequency**: 4-5 times per week
- **Stretching period**: 4 weeks
- **Total dose**: 30 minutes
- Warm up or superficial heat prior to stretch

**Stretching**

- Why at least 4 times* per week?
  - Four times per week improved ROM more effectively than two times per week (Santonja Medina 2007).
- Why 60 second* holds?
  - 30 s and 60 s of stretch were more effective than zero or 15 s, and no significant difference in ROM was found between subjects who stretched for 30 s or 60 s. Thus, recommend using 30 seconds of stretching. (Bandy 1994, Bandy 1997)

*We decided to increase the number of times per week from 4 to 5 and increase the hold time from 30 to 60 because we felt that parents compliance with HEP can be inconsistent and thus by increasing it a little they are more likely to meet the above recommendations.

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**Stretching**

- Why 4 weeks?
  - Expert opinion: that we want to treat them for 4 weeks to establish rapport
  - Also Stretching episode of >3 weeks "marginally" more effective than <3 weeks. Also "marginally" more effective in patients with more restricted ROM at onset of intervention. (Harvey 2002)

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**Stretching**

- Why 30 minutes total dose?
  - Trend towards 30 minutes of total stretch time (as counted by adding all the stretching times together) being more beneficial than 15 of less stretching minutes. No greater benefit with total dose> 30 minutes with pooled improvement of 2.49 degrees (Radford 2006)
- Why 4 times per day?
  - 30 minutes of stretching= 1800 seconds of stretching
  - 1800 secs/30 secs holds = 60 reps over the 4 weeks
  - 60 reps/4 weeks= 15 reps per week
  - Thus 15 reps/4 times per week= 4 stretches per day.
**Type of Stretching**
- Static stretching is recommended
  - Static stretching is more effective in improving ROM than no stretching, AROM, or dynamic stretching (Bandy 1998, Davis 2005, O’Sullivan 2009)
- Achieving end range of motion with the stretch has also been found to be important in achieving ROM gains in stiff joints (Flowers 1994)

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**Shoe Choice**
- Two studies comment on the effect of shoes on gait in children
  - Flip flops/thong sandals (Chard 2013):
    - In typically developing children, use of flip flops with thongs, increased ankle dorsiflexion during contact and reduced hallux dorsiflexion during walking 10% prior to heel strike at heel strike and 10% post toe-off as compared to barefoot

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**Shoe Choice**
- With shoes, children walk faster by taking longer steps with greater ankle and knee motion and increased anterior tibialis activity
- Shoes reduce motion and increase the support phases of the gait cycle
- During running, shoes reduce swing phase leg speed, attenuate some shock, and encourage rearfoot strike pattern

Wegener 2011

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**Kinesiotape**
- Kinesiotaping – no conclusive evidence
  - Targeted hamstring flexibility and saw no change in hip flexion ROM (Merino-Marban 2011)
  - Functional improvements noted in children with cerebral palsy but no change in ankle equinus (Iosa 2010)
  - Theory (only) that a kinesiotape dorsiflex assist pattern could be applied in an attempt to enhance a heel strike. (Martin 2003)

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**Motor Control**
- Motor control intervention
  - 1 hour, 2x/week for 9 weeks.
  - Ankle motion improved (only one to >15 degrees)
- Improve selective motor control
  - Train muscles not used during toe-toe gait pattern/needed for heel-toe gait pattern
  - Foot flat without knee hyperextension

Clark 2010

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**Motor Control**
- Variable results for each subject
  - 3/5 had at least 5 degree improvement in DF ROM
  - 4/5 had improved heel-toe gait during intervention period
    - 1/5 maintained heel toe gait at 30 day follow up
  - Some had changes in ankle DF
  - PDMS scores improved (not significant)
  - Spontaneous heel-toe walking did not improve
External Feedback

• Auditory feedback – no conclusive evidence
  – Auditory biofeedback can be used to modify behavior and provide feedback at heel strike
  – Study used augmented auditory feedback was used with a foot switch in the shoe that produced a burring sound with pressure, but only on 1 side.

Sensory Needs in Children with ITW

• ITW display abnormal vibration perception and hypersensitivity to tactile stimulus (Williams 2012, Williams 2013)

• Healthy subjects who are more sensitive to vibration, have higher pressures under the great toe with walking/running (Nurse 1999)

Application of Vibration to Address Hypersensitivity

• In healthy subjects, vibration applied to the feet either blocked or reduced tactile messages (Ribot-Cisear 1989)
  – Application of 10 minutes of vibration, significantly changed the mean tactile threshold for at least 10 minutes (Hochreiter 1983)

• Protocol is published for ITW
  – Plan to apply whole body vibration to determine if it impacts toe walking (Williams 2013)

Application of Vibration to Address Hypersensitivity

• At NCH, applying vibration x 10 minutes to the soles of the feet at the beginning of a treatment session
• Encourage the family to purchase a vibration device to utilize at home 3-5 times per day spread over the day

Vibration Equipment

• Vibrating pillows
• Vibrating slippers
• Vibrating massagers
Textures as Treatment for Hypersensitivity

- Apply a variety of textures to the plantar surface of his/her feet prior to working on walking
  - Initially start with heavy and smooth surfaces and move towards more light weight and fuzzy stimulus (i.e. feathers)
  - Use caution against pushing through sensitivities

  Curry 1988, Danella 1973

Vestibular Treatment Strategies (for Hypersensitivity)

- Slow linear vestibular stimulation has been found to decrease arousal and inhibit defensive responses
  - Swinging on a linear glider
  - Could put the glider on an incline to get a stretch at the same time
  - After these techniques have been used it has been suggested that the patient needs to practice task specific activities

  Ayres 1972, Farber 1982, Fisher 1983

Proprioception Treatment Strategies

- Standing (stance phase) on a therapy swing while therapist cues for hip and knee flexion. Perform with patients eyes open and closed.
  - Swing displacement from all directions
- Lots of ambulation through and over uneven surfaces
- Walking on moon shoes
- Up and down ramp
- Jumping in the foam pit
- Lifting heavy objects
- Standing on uneven surfaces that challenge balance
- Pushing heavy objects (i.e.: PT on a stool)

Case Study

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Objective

- Practice clinical decision making using an evidence based algorithm

Case Study

- 3 year old female referred to PT with diagnosis of ITW
- Subjective:
  - Mom reports child toe walks 50% of the time
  - Toe walking increases with excitement or when shoes are doffed
  - Child mouths toys or cold objects
  - History of 6 months of speech therapy but no other delays or diagnoses
  - Born at 38 weeks gestation weighing 7 lbs. 3 ounces and is a twin, No NICU stay
  - No pain
  - No family history of toe walking
  - Walked (I) at 14 months of age
Case Study

- Objective:
  - PROM into DF with knee extension in NWB
    - R 15°, L 14°
  - DF on WB lunge test
    - R 30°, L 28°
  - SPM
    - No definite dysfunction on any category
    - Some problems noted on body awareness and touch categories
    - 50% of time on toes bilaterally

Case Study

- Objective:
  - Able to stand with foot flat posture and walk with heel to toe gait pattern when cued
  - Reflexes are within normal limits
  - Eye contact and social interactions are appropriate
  - No developmental delay noted
  - No clonus noted

Poll the Audience

- Does this child pass or fail the TWT?
- Using the algorithm, please determine the appropriate interventions for this child
- List 3 specific sensorimotor treatment techniques that could be used with this child during physical therapy
- List 2 appropriate choices of orthoses

Treatment Provided

- PT 1 time per week x 8 weeks using a sensorimotor approach and shoe inserts with carbon fiber plates

Treatment Provided

- Proprioception/Balance
  - Dyna disc balancing, SLS, bosu balance
- Vibration to soles of feet x 5-10 minutes per foot
  - Family also purchased for home

Treatment Provided

- Trunk/hip strength
  - Sit ups, prone scooter board, superman’s, wheel barrel walks, side lying hip abduction, lower abdominal toy pick up with feet, bridging
- Heavy work
  - Pushing PT on a scooter down the hallway, weighted ball activities
- Active DF
  - Duck walking (walking on heels), popping bubbles with toes, seated scooter board
Immediate Outcome

• On week 3, mom reported she did not have to remind child to walk with her feet flat that week
  – This was maintained for the duration for the 8 weeks of PT
  – No toe walking noted at last PT session
  – Mom reports on last day of treatment that child is only on her toes once in a while when excited

Long-Term Follow-Up

• Reassessment 1 month after last treatment session
  – Mom reports < 20% of the time on toes
  – 10% of time on toes as observed by PT
  – PROM in to DF in NWB: 20º bilaterally

Case Study 2

• A 4 year old boy presents for PT evaluation due to toe walking. History and examination reveal the following:
  • No complications with birth or delivery
  • Started walking independently at 13 months
  • Broke left femur at age 23 months, set in long leg cast for 6 weeks, toe walking started after cast was removed.
  • Walks on toes at least 75% of the time
  • Toe-Walking Tool is Normal
  • Sensory Processing Measure is abnormal
  • Ankle dorsiflexion PROM measures at +1 on right, -4 on left in NWB
  • What do you recommend?

Case Study 2

• After first treatment:
  – Ankle dorsiflexion PROM measures to 20 degrees
  – Toe walking present 50% of the time
  • What do you recommend next?

Case Study 2

• At the conclusion of PT treatment:
  – Toe walking <10% of the time
  – No complaints of pain
  – Maintained ankle dorsiflexion
  • What do you recommend?

Case Study 2

• 6 months later, parent calls reporting increase in frequency of toe-walking to nearly 100% when barefoot.
  • Reports patient had OT evaluation but did not pursue treatment
  • At PT re-check, you note toe walking 75-100% of the time
  • Ankle dorsiflexion measures 15 degrees bilaterally
  • What do you recommend?
Case Study 2

• 12 months after orthoses and night splints added to treatment plan, parent calls reporting increase in frequency of toe-walking to near 100% and leg pain
• At PT re-check, you note toe walking 75-100% of the time
• Standing with foot flat, knee hyperextension
• Ankle dorsiflexion measures 0 degrees on left, 5 degrees on right
• Complains of pain in legs 3-4 days of the week
• 1-2 beats of clonus with quick ankle dorsiflexion
• What do you recommend?

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