Idiopathic Toe Walking: Current Concepts in Evidence-Based Practice

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Survey Question

Course Objectives

By the end of this course the student should be able to:

1. Define and discuss toe walking from a historical perspective to current accepted concepts.
2. Compare and contrast toe walking associated with disease and toe walking in the absence of a medical condition.
3. Identify and discuss a comprehensive evaluation for a patient referral due to toe walking.
4. Analyze and synthesize current research and clinical criteria in the diagnosis of idiopathic toe walking.
5. Describe and apply current research findings on gait kinematics and kinetics in idiopathic toe walking.
6. Analyze and synthesize current research into suggested relationships with other body systems.
7. Discuss and analyze the proposed long-term consequences of idiopathic toe walking for the purpose of supporting an appropriate treatment plan of care.
8. Identify and discuss current evidence-based management options in the treatment of idiopathic toe walking.
9. Identify the indications, contraindications, risks, and benefits of the different management options available for the treatment of idiopathic toe walking.
10. Discuss the role of the physical therapist as a part of an inter-professional team member in the management of idiopathic toe walking.
11. Discuss and analyze current evidence-based physical therapy intervention protocols in the management of idiopathic toe walking.
12. Discuss and analyze an evidence-based physical therapy clinical practice algorithm in the management of idiopathic toe walking from referral to discharge.
Definition

- Toe walking is the absence or limitation of heel strike in the gait cycle
- Toe walking: symptom of disease processes, trauma, neurological dysfunction
- Idiopathic Toe walking: in the absence of medical diagnosis
- First described by Hall et. al. in 1967: “congenital short tendo calcaneus”
- Video Clip: 3 year old toe walker
  http://www.youtube.com/watch?v=IQRkSrmcH5E

Etiology

**Unknown**

Speculations:

- Sensory processing deficits caused by lack of barefoot walking in developed countries
- Myopathy: different proportions of Type 1 muscle fibers in gastrocsoleus found on biopsy
- Genetics/Family history (autosomal dominant)

General Points

- Toe walking is a natural part of gait development:
  - Wide BOS, hips ER, knees flexed, ankles PF
- Considered normal up to the age of 2 years
- Considered “idiopathic” if it persists beyond age 2 years in the absence of other medical diagnosis.
- Treatment for ITW is complex due to its unknown etiology.
- Research available on expensive approaches while lacking in conservative management options.
Evaluation

Requires thorough evaluation

1. History
   - Birth history
   - Past medical history
   - Developmental milestones (particularly related to gait)
   - Family history

2. Physical Examination
   - Thorough neuromuscular exam (sensation, tone, strength, ROM, deep tendon reflexes)
   - Integumentary (skin inspection)
   - Pain assessment
   - Gait analysis
   - Speech/language and Sensory processing screen

3. Diagnostic Tests (if warranted)
   - EMG activity, muscle biopsy (myopathy), blood test (creatine phosphokinase levels), Toe Walking Tool

Polling Question #1

Diagnosis

- Persisting beyond age 2
- Heel accelerometry data: being tested with heel sensors in boot.
- Medical conditions associated with toe walking must be ruled out: neurological or orthopaedic conditions, physical injuries

- Classic presentation:
  - Neurologically normal
  - Normal muscle strength and selective muscle control
  - Prefer to walk on balls of feet
  - Varies in form and frequency:
    - Bouncing to tip toe
    - 100% time to intermittent
  - Normal or tight ROM heel cords
  - Must can self-correct (use a heel-toe pattern) when prompted
  - Self Corrected Toe Walking Gait Video
Polling Question #2

Kinematic Profiles: Cerebral Palsy versus ITW

**CP**
- Ankle:
  - Sagittal plane: lack of 1st rocker
- Knee:
  - Sagittal plane: flexion during stance phase
  - Frontal plane: significant disruptions

*additional impairments: deficits in strength, balance, selective motor control.

**ITW**
- Ankle:
  - Sagittal plane:
    - significant increase of plantarflexion during stance and swing phase of gait
    - initial swing dorsiflexion followed by sudden plantarflexion midway through swing phase
  - Frontal plane: Normal
- Knee:
  - Sagittal plane: mild knee hyperextension during stance phase
  - Frontal plane: Normal

Kinetic Profiles-ITW

1st Rocker (heel strike, eccentric contraction of anterior tibialis):
- Absence of ankle DF moment
- Loading response power absorption phase

2nd Rocker (midstance, eccentric contraction of gastrosoleus):
- Elevated PF moment
- Power generation phase

Swing Phase (concentric contraction of anterior tibialis):
- Increased PF

3rd Rocker (terminal stance "push off", concentric contraction of gastrosoleus):
- Diminished PF moment
- Diminished ankle power generation phase
Prevalence

- Small studies report up to 7% rate in general population
- Problem: cultural bias and small sample sizes make it difficult to generalize to entire population (prevalence unknown).
- Genetic basis exists (family history)
- No sex differences (1:1 ratio)

Polling Question #3
Relationship to Motor Development

Characteristics of Typical Early Ambulation:
- Limited ankle strength → push-off absent
- Compensation → co-contraction of opposing muscle groups
- Initial heel strike appears at approximately age 18-24 months
  - Forward inclination of body to erect trunk
  - Co-contraction to reciprocal activation
- Heel strike with active dorsiflexion: after age 2 yrs
- Push off with active plantarflexion: refined up to age 4-5 years
- Reaching mature level: age 7-8 years

Relationship to Other Systems

- Handedness: a left hand dominance association has been described (Williams et. al., 2011)
- Sensory Processing:
  - the neurological process that organizes sensation from the body and environment in order to effectively respond to such stimuli.
  - Sensory processing dysfunction: a failure in this process.
  - Tactile defensiveness and deficits in proprioception are speculated to contribute most to ITW

ITW and Neuropsychiatric Symptoms

Engstrom et. al., 2012
Long-Term Consequences

- The natural history of ITW is mixed
- Habitual toe walking
- Shortened Achilles tendon/contracture development
- External tibial rotation
- Improper balance/increased risk of falling: center of mass shifted anteriorly
- Slower running speeds/shorter strides to compensate for balance deficits
- Increased weight bearing on metatarsal heads/forefoot and decreased weight bearing on heel; early on this reduces heel bone development leading to risk of pain when child is forced to bear weight onto heels later in life.

Polling Question #4

Treatment Options

- Nonsurgical Management:
  - Physical Therapy
  - Footwear
  - Orthotics
  - Whole body vibration?? (Williams et. al, 2013)
  - Casting/Serial casting*
  - Botulinum toxin A*

- Surgical Management:
  - Surgical lengthening of triceps surae muscle-tendon complex*

*have best evidence for improved outcomes
Footwear/Orthotics

- Most support based on clinical opinion
- Suspected mechanisms of action
  - Provides tactile input that may change neurological input and influence gait pattern
  - Provides a mechanical advantage that alters motion and influences gait pattern
- Full length carbon fiber foot orthosis
- Plantar-flexion stop/Dorsiflexion assist
- Night time bracing

Whole Body Vibration

- No research exists in children with ITW
- Current available evidence: improvements in muscle length and strength after short bursts of whole body vibration.
- Current research question (Williams et. al., 2013): Will whole body vibration have an immediate mechanical and/or neuro-modulation effect on gait pattern and heel strike?

Serial Casting

- Most evidence exists (with or without Botulinum Toxin A)
- Postulated mechanism of action: Elongation of non-contractile elements and increase in number of sarcomeres.
- Complications:
  - Skin irritation
  - Pressure wounds
  - Permanent tissue damage

(Less likely in ITW population due to normal skin sensation in these children)
Botulinum Toxin A

At recommended doses, complications are rare:
- Localized: muscle weakness and pain at injection site (temporary, few weeks)
- Systemic: Flu like symptoms 2-3 days

At higher doses:
- Bladder dysfunction: injections to LE muscles
- Dysphagia (difficulty swallowing): injections to UE and neck

Small cases of death in children with CP GMFCS V during administration of large doses under general anesthesia

Contraindication: Fixed contractures

Botulinum Toxin A + Casting
(Engstrom et. al., 2013)

Randomized controlled trial
- 26: Casting only (to neutral, 1x for 4wks)
- 21: Casting + Botulinum Toxin A (4 injections distal/proximal calf)

Baseline Pre-, 3-month Post-, 12 months Post-treatment testing

Results:
- No difference between groups
- Both groups showed improvement in ankle ROM, frequency of toe walking, and several gait parameters.
- 38/47 children still toe walked to some extent (only nine ceased toe walking)
- Neuropsychiatric problems had no influence of treatment effects

Limitations: small sample size, no control group (without intervention), some children revealed group allocation to PT evaluator, parent questionnaire regarding toe walking frequency is used not a validated tool

Surgical Management

- Indications:
  - fixed contractures
  - unresolved cases following non-surgical management.

- Complications:
  - Post operative infection
  - Tendon necrosis
  - Deep vein thrombosis
  - Sensory Loss
  - Over-correction or over-lengthening
Over-lengthening and Crouch Gait

Surgical Lengthening Considerations
• Must first determine the location of the posterior tightness.
  ▪ Gastrocnemius, Soleus, or Both
  ▪ Silfverskiöld test: examine the patient supine with knee extended, than flexed.
    - Dorsiflexion limited with knee extension only: Gastroc
    - Dorsiflexion limited with knee flexion only: Soleus
    - Dorsiflexion limited with knee flexion and extension: Both

Surgical Lengthening Procedures
Gastrocnemius tightness ➔ Gastrocnemius Lengthening
Soleus tightness ➔ Muscle lengthening more distal approaching the muscle-tendon junction
Both ➔ percutaneous Achilles tendon lengthening
(Oetgen & Peden, 2012)

[Watch video clip of post-op case]
### Physical Therapy Management

#### Motor Performance

| 1. ↑ Dorsiflexion ROM  | 1. Passive, active, and positional stretching of gastrocnemius and soleus |
|------------------------|------------------------------------------------|---|
| Goal: 10+ degrees of DF | 2. Stretching of trunk and other LE muscles |
|                        | 3. Strengthening of trunk and LE muscles: |
|                        | - NMES, taping, resistive ex, gait training |
|                        | 4. Manual therapy  |
|                        | - massage, joint mob |
|                        | 5. Home program |
|                        | 6. EDUCATION |

#### Treatment

- ↑ Dorsiflexion Strength

1. Passive, active, and positional stretching of gastrocnemius and soleus
2. Stretching of trunk and other LE muscles
3. Strengthening of trunk and LE muscles:
   - NMES, taping, resistive ex, gait training
4. Manual therapy
   - massage, joint mob
5. Home program
6. EDUCATION

### Dorsiflexion ROM and Strength

- Manual stretching
- Positional stretching gastro: orthotic prescription
- Self stretching (standing at wall, off step, or long sitting with belt)
- Standing on incline/wedge
- Kicking a ball
- Stair climbing or step ups
- Walking up an incline (i.e. ramp or inclined treadmill)
- Squatting or stooping (picking up objects from floor, heel down)
- Walking backwards on treadmill or pulling a toy
- Heel or "duck walking" (HPP: pick a hallway)
- Walking with swim flippers
- Cycling
- Theraband: active dorsiflexion
- Toe raises (seated or standing)
- Kinesiotaping: facilitation technique, anterior tibialis
- NMES: neuromuscular E-stim or FES (anterior tibialis)

### Gastroc Strengthening

- Heel raises off step
- Plyometrics: vertical and broad jumps (initiated with heel contact)
- Theraband exercises: plantar flexion
- Heel toe pattern gait training
  - Treadmill/ground
  - Up an incline
- Kinesiotaping: facilitation of gastroc during full length training.
- NMES or FES (gastrosoleus)
Stretching/Strengthening of Trunk and Other LE muscles

- Prone extension or “superman”
- All 4’s alternate extension
- Wall or knee push ups
- Theraband: back rows, scap retraction, chest press
- Sit ups/crunches/plank
- Lunges
- Chair squats/wall sits
- Bridges (single and double leg)
- Therapy ball activities to strengthen core and pelvis
- Single leg stance training (stable to unstable surfaces)
- Beam walking
- Ball toss (weighted balls)

Polling Question #5

Motor Control-Based Intervention

(Clarke et al., 2010):
1. Stair stepping strategy (3 min)
2. Standing balance (DL/SL) X 60 seconds
3. Stooping activity (50 reps/hour)
4. Controlled stepping and heel toe practice
5. Sensory and intrinsic foot activities
6. Age appropriate motivation
7. Information for parents
8. Home activities

http://links.lww.com/PPT/A19
PT Management Algorithm

(LeCras et al., 2011)

PT Treatment Algorithm

(LeCras et al., 2011)
Discharge from PT

1. If child/family are noncompliant with therapy and HEP.

2. If child has met established goals:
   - Ankle PROM DF at least 10 degrees
   - Heel-toe pattern frequency > 75% time
   - Independence with HEP
   - Age-appropriate gross motor skills

QUESTIONS????

Thank you for your interest! If you have further questions, I can be reached at: bamceff@gmail.com

References


Dietz F. Khunwara S. (2012). Idiopathic toe walking: to treat or not to treat, that is the question. Iowa Orthopaedics Journal, 35: 184-188.


References


