Idiopathic Toe Walking

- Persistent toe walking after 2 years of age
- No identified underlying diagnosis
- May or may not have equinus contractures
- Knee not affected – full knee extension at initial contact

*Eastwood et al., JPOB, 1997; Hicks et al., JPO, 1988; Williams et al., J Child Neurol, 2013*

Idiopathic Toe Walking - Kinematics

- Increased ankle plantar flexion throughout stance and swing
- Full knee extension at initial contact
- Full knee flexion in swing
- Compensatory increased hip flexion

Idiopathic Toe Walking - Kinetics

- Typical peak power generation in terminal stance
- Consistent with typical ankle plantar flexor strength

EMG – Idiopathic Toe Walking

- Premature onset gastrocnemius activity in terminal swing
- Early termination tibialis activity in terminal swing and activity in mid stance
- Very similar findings for same muscles in CP toe walking
- No EMG response to passive stretch
Idiopathic Toe Walking

- May be able to normalize some kinematic and kinetic variables on demand
- “Doctor walk” may look better but still have subtle differences

Pendharkar et al., Gait Posture, 2012

Idiopathic Toe Walking Treatment

- Treatment depends on severity
  - Reassurance
  - Stretching/PT
  - Casting
  - Bracing/night splinting
  - Surgery (level depends on Silfverskiöld test)
  - No role for BOTOX due to lack of spasticity


Pre – Post Sx for Toe Walking

- Kinematic changes in stance and swing
- Heel initial contact and plantar grade foot
- Power generation at push off maintained

Unilateral Idiopathic Toe Walking

- Red flag
  - If diagnosis of hemiplegia is negative
  - Examine for other possibilities
    - Spinal
    - Tumor
    - Etc.

Cerebral Palsy

- Lack of selective inhibition can result in unrestricted muscle firing/spasticity +/- plantar flexor contracture
- Gastrocnemius more involved than soleus
- Knee may or may not be involved
- Can’t voluntarily correct

Rose et al., JPO, 1999

Cerebral Palsy

- Equinus alone
- Equinus plus limited knee extension
- Limited knee extension without equinus
**Cerebral Palsy**

- Equinus alone
- Equinus plus limited knee extension (dashed)
- Limited knee extension without equinus (solid)

**Knee Flexion-Extension**

- 80 ° Flex
- Ext

**Plantar-Dorsiflexion**

- Dorsiflexion in swing
- Typical dorsiflexion at initial contact
- Typical knee modulation

**Cerebral Palsy – Vault vs. Involved Side**

- Compensatory toe walking
  - Vaulting
- Hemiplegia
- Clinical exam differences
  - Passive ROM
  - Ability to isolate voluntary contraction
  - Typical strength

**EMG – Cerebral Palsy**

- Continuous activity for 100% gait cycle for gastrocnemius common
- Increased of anterior tibialis activity at toe off with minimal lower level activity through remainder of gait cycle
- EMG response to passive stretch

**Vault vs. Involved Side**

- Kinematic differences
- Vaulting side:
  - Dorsiflexion in swing
  - Typical dorsiflexion at initial contact
  - Typical knee modulation

**Cerebral Palsy Treatment**

- Stretching/PT
- Casting
- Bracing/night splinting
- Surgery (level depends on Silfverskiöld test)
- Botox can decrease spasticity but will not address contracture

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**Vault vs. Involved Side**

- Kinetic differences
- Vault
  - Dorsiflexor moment loading response (not shown)
  - Reduced power generation terminal stance

**Hemiplegic side = dashed line**
**Vault side = solid line**

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**Vault vs. Involved Side**

- Knee Flexion-Extension

- Plantar-Dorsiflexion

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**Vault vs. Involved Side**

- Ankle Moment
- Ankle Power

- Gen Abs W/kg

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**IC #33  Toe Walking – Case Examples**

Part 2 - 3
Pre vs. Post Involved Side

- **Ankle Kinematics**
  - Improved dorsiflexion in stance and swing (gastrocnemius lengthening)
  - Possible due to positive confusion test
- **Knee Kinematics**
  - Changes a result of multi-level surgery (hamstrings and rectus procedures included)

Pre vs. Post Involved Side

- **Ankle Kinetics**
  - Improved peak plantar flexor moment and power generation terminal stance
  - Improved ankle moment and power modulation (shape of curve)

Pre vs. Post Non-involved Side

- **Ankle Kinematics**
  - Improved dorsiflexion in stance and swing
- **Knee Kinematics**
  - Increased peak knee flexion in swing to clear limb (not needed prior to treatment due to contralateral toe walking)

Pre vs. Post Non-involved Side

- **Ankle Kinetics**
  - Heel initial contact unchanged
  - Improved peak power generation terminal stance
  - Ankle functioning more optimally with elimination of the vault

Charcot-Marie-Tooth Disease

- **Hereditary Motor and Sensory Neuropathies**
  - > 40 genes associated with different forms of disease (CMT 1A, CMT 1B, CMT 2, CMT 3, CMT 4, CMT X, etc, etc)
  - Abnormalities in myelin sheath or axon
  - Peripheral nerves affected – motor and/or sensory
CMT – toe walking
• Least common presentation

Ankle Function
• Equinus throughout the gait cycle
• Toe contact pattern
• Plantar flexor contracture (add values)
• Reduced power generation in terminal stance
• Strength profile variable plantar flexor weakness

Knee Function
• Typical extension at initial contact
• Typical peak and timing to peak flexion in swing

Hip Dysplasia
• Toddler w/ unilateral toe walking (if unilateral hip dislocation)
• Limited hip abduction
• Supple ankle/knee
• May be associated with h/o other “packaging problems” (torticollis, metatarsus adductus)

Hip Dysplasia
• Toe walking is a compensation for the leg length difference due to dislocated hip
• Apparent leg length difference since hip is high riding
• Treat the hip not the limp

Leg Length Difference
• Similar to DDH, but there is an actual LLD rather than just “apparent”
• Scoliosis may also give “apparent” LLD if associated w/ pelvic obliquity
• Too many reasons to cover here (list included for reference)
• Careful history (congenital vs acquired)
### Congenital

- Hypoplasia syndrome
- Proximal femoral focal deficiency
- Tibial deficiencies
- Fibular deficiencies
- Hemiatrophy
- Hemihypertrophy
- Idiopathic
- Klippel-Trenaunay-Weber syndrome

### Aquired

- Trauma
- Acute bone loss
- Physcial injury
- Fracture healing
- Burns
- Irradiation
- Iatrogenic
- Infection
- Osteomyelitis
- Septic arthritis
- Popura fulminans
- Inflammation
- Juvenile rheumatoid arthritis

### Leg Length Difference

- Which is the abnormal limb? (shortening vs overgrowth)
- Toe walking is one compensation
- Patients may also compensate w/ asymmetric knee/hip/pelvis ROM

Song et al., JBJS, 1997

### Tumor

- Tumor can put pressure on calf muscle itself or a nerve
- Vascular malformation may result in gastrocnemius spasm/contracture
- Unilateral; may be associated w/ tenderness


### Hereditary Spastic Paraparesis (Familial Spastic Paraplegia)

- Progressive lower extremity weakness and increased tone/spasticity
- Selective voluntary control including ankle
- MRI brain/spine usually normal
- Positive family history
- > 50 types


### Disease Progression

- Bilateral crouch maintained
- Bilateral increasing toe walking due to increasing equinus
- Bilateral increasing plantar flexor contracture: 5° to -20° (R) and -10° (L)

2007 2010

right (solid) / left (dashed) knee and ankle sagittal plane kinematics
Other Etiologies - Syrinx

- MRI documented
- Syrinx from T1 – T4
- Age 4+11 years
- Plantar flexor contracture right side only: -5° with knee flexed and -15° with knee extended
- Difficulties isolating right ankle motion

Syrinx – con’t

- Right excessive plantar flexion knee extension couple with equinus and knee extension in stance (right = solid line)
- Left typical function (left = dashed line)

Other Etiologies - Myopathies

- Diseases of skeletal muscle that can be progressive
- Inherited, inflammatory, or caused by endocrine or metabolic problems
- Result in skeletal muscles weakness and atrophy

Ullrich Congenital Myopathy

- Progressive increase in toe walking over time
- Progressive increase in ankle plantar flexor contracture over time

Other Etiologies - Tumors

- Concern: unilateral toe walking
- Increasing tightness in his left ankle
- Pain/discomfort with left rapid passive dorsiflexion and palpation around the musculo-tendon junction of the left gastrocnemius
Tumors con’t

- Equinus of left ankle in stance and swing
  - -15 deg (knee 0 & 90)
- Toe initial contact with absence of dorsiflexor moment at loading response
- Reduce ankle power generation
  - Unable to test plantar flexor strength due to limited ROM

Diagnosis of Toe Walking

- What you need to know to make treatment decisions:
  - Medical and birth history
  - Family history of similar problems
  - Ankle passive ROM
  - Ability to isolate function at the ankle
  - Assessment of spasticity
  - Ankle function during gait (kinematics and kinetics)
  - Knee function during gait (kinematics)
  - EMG during gait and in response to passive stretch
  - Imaging when appropriate

References


