Toe Walking: How to Know Who to Worry About
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Introduction and Course Goals
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The Utility of Motion Analysis in Diagnosis and Decision-Making

The goals of this course are to help participants:
- Improve observation skills for detecting gait deviations associated with toe walking while realizing the limitations of assessing toe walking by observation alone;
- Become familiar with some diagnoses commonly associated with toe walking;
- Become familiar with the components of computerized gait analysis;

The goals of this course are to help participants:
- Understand foot position and motion (the 3 rockers) throughout the gait cycle in typically developing children;
- Understand the clinical utility of gait analysis as it applies to differentiating idiopathic toe walking from other diagnoses; and
- Recognize “red flags” or additional gait features of toe walkers that warrant additional evaluation or work-up.

Background
- Toe walking is a commonly encountered gait problem and often results in referral of patients to medical professionals.
- Various neurologic, traumatic, and developmental diagnoses have been associated with toe walking as well as habitual or idiopathic type
- All can cause great concern for patients, parents, and providers.

Background
- Watch the following videos
  – Note similarities as well as differences
  – Do you know the diagnosis at first glance?
Background

- We all agree that these patients lack a normal heel contact and weight bear through the forefoot; hence, they are all toe walkers.
- What is the underlying diagnosis?
- Is there a need to treat?
- What is the appropriate treatment?

Review of Common Diagnoses Associated with Toe Walking

- Prior to age 2, toe walking is very common
- Cases lacking definitive etiology are called “idiopathic” (or we just haven’t figured it out yet)
- Search for neurologic, developmental, pathologic conditions
- May be dynamic or due to structural contracture/deformity

Causes of Toe Walking

- Cerebral palsy
- Congenital muscular dystrophy
- Tethered Cord Syndrome
- Diastematomyelia
- Spina bifida
- Autism
- Schizophrenia
- Global Developmental Delay

- Charcot-Marie-Tooth Disease
- Transient dystonic rxn
- Venous malformation or tumor (posterior calf)
- Ankylosing spondylitis
- Congenital or aquired LLD
- ????

Where to begin?

- History
  - Birth (premie?; breech?)
  - Trauma
  - Pain
  - Family
- Physical Exam
  - ROM/Contracture
  - Motor strength/isolation
- Imaging
  - Xray (DDH/LLD)
  - MRI (Neural axis; limb)

- Gait analysis
  - Visual inspection/Video
  - “Doctor Walk”
  - Kinematic/Kinetic data
  - EMG

Introduction to 3D Motion Analysis

- Motion analysis components
  - Clinical exam
  - Static vs. dynamic
  - Kinematics – anatomy of a plot
  - Kinetics – anatomy of a plot
  - EMG ?
- Gait terminology
  - rockers
- Introduction to motion data

Motion Analysis

- Definition:
  - Systematic and Objective Documentation of Human Locomotion
- Why?
  - Improve understanding of pathomechanics at the individual joint and segment level
  - Determine causes of gait abnormalities
  - Define treatment – based on objective data
  - Evaluate treatment – based on objective data
Is visual observation of gait enough?

What is the role of motion analysis in understanding and treating toe walking?

- Let’s look at some examples to understand why not…

What is the cause of toe walking?

- Excessive equinus?
- Excessive knee flexion in stance?
- Both?

How should we evaluate toe walking?

- Segment orientation vs. relative angle?
- Foot orientation vs. ankle angle?

How should we evaluate toe walking?

- Cannot assume:
  - toe contact = excessive equinus
  - drop foot = excessive equinus
- Must consider impact of ankle and knee joint angles

Sagittal plane kinematic plots of ankle and knee motion.

Toe Walking vs. Equinus

Ankle shows “typical” peak dorsiflexion in stance. Timing of peak dorsiflexion is incorrect.

- Definition of Toe Walking
  - Heel is higher than the forefoot
- Appropriate treatment will depend on determining the cause(s) of toe walking
**Methods:**

- History
- Clinical examination
- Video-taping
- Motion analysis - kinematics
- Force analysis – kinetics
- Dynamic Electromyography – muscle activity during motion

**1) Video-taping**

- Ambulation
- Standing
- Sitting

**2) Clinical Examination**

- Purpose: to determine causes of gait abnormalities
  - joint contractures
  - muscle strength
  - atypical bony torsions
  - muscle tone
  - voluntary control

**3) Motion Analysis**

- 3-D Joint angular changes during walking
  - Upper body
  - Pelvis
  - Bilateral hips, knees and ankles
- Barefoot and braces
- VICON 512
  - Plug-in-gait
- VICON
  - 12 camera

**4) Force Analysis**

- 3 embedded force plates
- Joint moments (torques)
- Joint powers

**5) EMG – electromyography**

- Purpose: determine muscle contraction patterns
- Muscle activity during movement, tone assessment and strength assessments
- Surface and indwelling electrodes
- Lower extremities
- Upper extremities
**Gait Data Review**

- History
- Video
- Clinical exam
- 3-D kinematics
- 3-D kinetics
- EMG
- Foot pressure
- Radiograph
- Barefoot vs. brace
- Versus age matched typical data
- Multi-disciplinary team approach

**Calculating Joint Kinematics**

Reflective joint/segment markers → (joint angle plot)

**Ankle Sagittal Plane Motion**

- **Angle Definition**
  - the relative angle between the long axis of the shank and the plantar aspect of the foot
  - as viewed by looking along an axis perpendicular to the shank-foot plane
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Ankle Sagittal Plane Motion

Ankle Sagittal Plane Motion

Ankle Sagittal Plane Motion

Ankle Sagittal Plane Motion

Ankle Sagittal Plane Motion
Knee Sagittal Plane Motion

Knee Flexion-Extension

% Gait Cycle

Calculating Joint Kinetics

Reflective joint/segment markers

Joint Kinetic Data

Joint Moments and Powers During Motion

Typical and Pathological Joint Kinematic and Kinetic Patterns

• Ankle kinematics
  – Is there a heel strike?
  – Is foot ever plantigrade?
  – Is there foot drop in swing?
  – Is the timing off?
• Ankle kinetics
  – Can the ankle generate power?

Typical and Pathological Joint Kinematic and Kinetic Patterns

• Knee kinematics
  – Knee position at initial contact affects foot position at initial contact
  – A flexed knee predisposes patient to contact the floor with the toes
  – Ankle may be in typical or excessive dorsiflexion and result in toe walking