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Comprehensive Gait Examination and Evaluation in Persons with Neurological Disorders

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Physicaltherapy.com

Learner Outcomes

§ Identify key components of a comprehensive pathological gait analysis for patients with neurological disorders, including outcome measures

§ Identify the common gait deviations/gait patterns present in pathological gait for each of the common neurological injuries or diseases

§ Hypothesize probable causative factors for specifically identified gait deviations in pathological gait

§ Formulate a hypothesis-driven gait analysis of patients (video cases) with neurological disorders
Goals of Normal Gait

- Movement along desired path
- Maintaining weight bearing stability
- Conserving energy
- Absorbing shock

Norms

- Cadence: steps per minute (113-116)
- Velocity: 82 m/min or 1.37 m/sec
- BOS: 2-4”
- Toe out: 7°
- Stance phase: 62% of gait cycle
- Swing phase: 38% of gait cycle
- Single limb support: 80% of time
- Double limb support: 20% of time
Weight Acceptance

- Forward progression
- Stability
- Shock absorption

- Initial Contact and Loading Response

Single Limb Support

- Stability
- Forward progression

- Mid stance and terminal stance
Swing Limb Advancement

- Foot clearance
- Limb advancement

- PSw, ISw, MSw, TSw

What is the common factor???

Forward Progression
Stance versus Swing

Examine Both Sub Phases

- SINGLE LIMB INSTABILITY IN STANCE
- IMPAIRED LIMB CLEARANCE IN SWING
Pathological Gait Analysis

- Compare patient to normal
- Segmental
- Start distal, work proximal
- ID major problems that prevent accomplishment of 3 functional tasks (what were these?)
- Major versus minor deviations

Various conditions of gait

- Environment
- Multi tasking
- Varying load
- Speed demands
Hypothesis Drive Examination and Evaluation

- Distinguishing major from minor deviations
- Prioritizing problems
- Hypothesize the causative factors for each major gait deviation
- Test those hypothesis
- Re-assess post intervention and repeat process as necessary
Observational analysis

- Advantages
- Disadvantages
  - Moderate reliability at best
  - How do we maximize accuracy?

Gait Analysis:
GAIT ANALYSIS: FULL BODY EXAMPLE

RANCHO LOS AMIGOS NATIONAL REHABILITATION CENTER PHYSICAL THERAPY DEPARTMENT

Reference Limb:

<table>
<thead>
<tr>
<th>Major Deviation</th>
<th>Minor Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trunk</td>
<td></td>
</tr>
<tr>
<td>Pelvis</td>
<td></td>
</tr>
<tr>
<td>Hip</td>
<td></td>
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<tr>
<td>Knee</td>
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<tr>
<td>Ankle</td>
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<tr>
<td>Toes</td>
<td></td>
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</tbody>
</table>

Major Problems:

- (WJ) Weight Acceptance
- (SLA) Single Limb Support

(SLA)

- Weight Acceptance
- Single Limb Support

Excessive UE Weight Bearing

Gait Analysis Form

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An example....

- Billy Bob has left hemiplegia and has impaired swing limb clearance.
- His MD says he has “drop foot”
- You prescribe an AFO that limits plantarflexion to neutral (ie substitutes for the dorsiflexors)
- Unfortunately, Billy Bob walks essentially the same, with or without the AFO
- What’s the problem?
Temporal and Spatial Measures

- Gait Speed
  - 10 m walk
- Cadence
- Endurance Measures
  - 2, 6, 12 minute walk
  - 6MWT has strongest correlation with step activity
    - Mudge S, Stott NS, Arch Phys Med Rehabil, 2009
- Gait Symmetry
- Combination Measures
  - TUG
  - Berg Balance Test
  - DGI or FGA
  - Tinetti Gait and Balance Scale

Other Instrument Measures

- GAITRite
- Shoe Inserts
- Step activity monitor/pedometer
- Motion Analysis
- Forceplate Analysis
- EMG Analysis
What about Measures of Participation?

- QOL improves with increases in gait speed
- Relationships between QOL and gait parameters
- Determinants of Community Ambulator
- Link to cost and caregiver burden

Pathological Mechanisms

- 5 Functional Categories
  - Deformity
  - Muscle weakness
  - Sensory Loss
  - Pain
  - Impaired Muscle Control
Deformity

- Lack of sufficient passive mobility
- Can’t achieve normal postures and ROM necessary for walking
- Contracture most common cause
- Structure change in connective tissue component of muscles
  - Elastic
  - Rigid

Deformity in Stance

- PF contracture
- Knee flexion contracture
- Hip flexor contracture
- Adductor contracture
Deformity in Swing

- PF contracture
- Knee flexion contracture
- Adductor contracture

Sensory Loss

- Primarily problems with proprioception
  - Inconsistent gait pattern
  - Intact motor – substitutions for lost sensation
  - Impaired motor + sensory loss = inability to substitute
- Perceptual deficits
- Balance disorders can be consequence of both motor control and/or sensory dysfunction
Pain

- Reactions to pain can cause deformity and muscle weakness
- Deformity: resting postures
- Muscle weakness: reduced activity, protective reflex

Muscle Weakness

- Weakness and/or insufficient recruitment or activation
- Origin of weakness:
  - Upper motor neuron lesion
  - Lower motor neuron lesion
  - Muscle pathology
- More than MMT grade
  - Muscle endurance
  - Lever length
Muscle Weakness in Stance

- Quadriceps weakness – hyperextension early in stance (IC or LR); inability to accomplish LR
- Plantarflexor weakness – extensor thrust in MSt to TSt OR excessive ankle DF throughout
- Hip extensor weakness – excessive hip flexion at IC and LR
- Hip abductor weakness - contralateral pelvic drop MSt
- Anterior tibialis – foot slap at LR
PF Weakness in Stance
Muscle Weakness in Swing

- Anterior tibialis weakness – flat foot or forefoot IC; decreased foot clearance throughout swing
- Knee flexor weakness – decreased knee flexion in MSw to TSw
- Knee extensor weakness – doesn’t achieve full extension at TSw
- Hip flexor weakness – difficulty initiating PSw and ISw (lack of balance between flexors)
- Bottom line: Poor limb clearance

Impaired Motor Control

- In those with upper motor lesion
- Combination of:
  - Muscle weakness
  - Impaired selective control
  - Emergence of primitive locomotor patterns
  - Spasticity
Dynamic Systems Theory

- Movement emerging out of constraints on the system
  - Individual
  - Task
  - Environment

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Upper versus Lower Motor Neuron Gait

- Upper motor neuron lesion
  - Increased tone
  - Little to no muscle wasting
  - Muscle weakness
  - Hyperreflexia

- Lower motor neuron lesion
  - Flaccid (or low tone)
  - Significant, rapid muscle wasting
  - Decreased or absent reflexes

- Possible to have mixed
CVA and TBI
Clinical Presentation

- Knee instability
- Impaired balance, impaired or absent sensation
- Decreased walking speed
- Increased energy expenditure
- Spasticity
- Decreased selective motor control

Gait Disturbance in Stroke

- “mixture of deviations and compensatory motion dictated by residual functions”
  - Balaban B, Tok F, PM R, 2014
- Spatio-temporal parameters and sagittal kinematic waveforms change over several trials of gait analysis
  - Increased gait speed
  - Decrease in gait variability
Typical Foot/Ankle Abnormalities

- **Swing phase**
  - Poor swing limb clearance
  - Equinovarus posture
  - Poor prepositioning for initial contact

- **Stance phase**
  - Foot flat or forefoot contact
  - Medial/lateral instability
  - Varus ankle
  - Lack of pronation
  - Lack of dorsiflexion
  - Absent first rocker
  - Absent or impaired second, third, and forth rocker

Typical Knee Abnormalities

- **Instability**
  - Poor tibial control and/or quadriceps weakness
    - Knee buckling

- **Compensations for knee instability**
  - Forward trunk lean
  - Knee hyperextension
    - Hyperextension could be from weak quadriceps but in patients with CVA/TBI, more likely cause is weak plantarflexors

**Can you understand why weak plantarflexors would lead to knee hyperextension?**
Typical Hip and Pelvis Abnormalities

- Hip weakness
  - Forward trunk lean to help stabilize knee
    - Increases energy costs and shortens step length
- Pelvic retraction
  - Decreases momentum that can be generated
  - Makes hip flexion activation more difficult
  - Again causes decrease in step length

Fish et al, 1999

Head, Arm, Trunk Abnormalities

- Lateral trunk lean
  - Over-reliance on sound side
  - Lean away from weaker side to assist with swing
- Forward trunk lean
  - Often due to knee instability
- Decreased arm swing
  - Often due to decreased gait speed, but lack of trunk and pelvic rotation contribute to this

Fish et al, 1999
Spinal Cord Injury

- Depends on: level of injury, degree of motor and sensory sparing
- Often bilateral presentation of symptoms, but potentially not symmetrical
- Alterations in muscle tone... often more flexor hypertonicity in the LEs
- Compensatory versus restorative
Multiple Sclerosis

- Ataxia
- Sensory loss
- Fatigue
- Hypertonicity
- Weakness
- Unilateral or bilateral deviations and impairments
  https://www.youtube.com/watch?v=b3tv5OUmigc
  https://www.youtube.com/watch?v=1_4Lv2EXW4s

Multiple Sclerosis

- Slower preferred speed
- Longer double limb support
- Decreased swing times
- Wider BOS
- Able to capture these changes even in persons with mild MS
Abnormal Dynamics in Walking Patterns - MS

- Linear decline in walking speed in 12MWT
- Robust correlation with subjective fatigue
- Even those with mild disability differed significantly from controls in walking speed
- Degree of U-shape attenuated in persons with MS
  - Burschka JM et al, BMC Neurol, 2012

Evaluating walking in MS

- Timed 25’ walk
- Patient self-report 12-Item MS Walking Scale
- Dynamic Gait Index
- TUG
- 2- or 6-minute walk test
  - Quantify fatigue
  - Bethoux F, Bennett S, Int J MS Care, 2011
Parkinson’s Disease

- Very narrow BOS
- Poor weight shift
- Decreased step length
- Decreased gait speed
- Increased number of steps per distance
- Festinating or retropulsive gait
- Difficulty with transitions

FALLS

PD – Relationship between Gait and Postural Stability

- Both gait analysis and computerized dynamic posturography are important to assess
  - Postural stability seen in early and late PD
  - May help ID PD earlier
- Visual feedback-based balance training improves gait AND postural instability in early PD
Gait characteristics and falls

- Systematic review of literature on walking biomechanics and falls in persons with PD
- Higher risk for falls in those with:
  - Slower walking speed
  - Lower cadence
  - Shorter strides
  - More mediolateral head and pelvis motion
  - Creaby MW, Cole MH, Parkisonism Relat Disord, 2018
Diabetic Peripheral Neuropathy

- Gait deviations consistent with sensory loss (what are they)
- Impaired swing limb clearance
- Potential instability in stance
- Pain with gait
- Neuropathy may not be only cause of gait deviations in persons with DM

Motor Neuron Disease

- Examples
- What do you need to know?
- Then what?
Cerebral Palsy

- Diminished heel contact
- Flexion at knees and hips
- Hyperextension of trunk
- Plantarflexed ankles
- Scissoring

How do we improve our gait assessment?
Video Case 1

- ID major gait deviations
- Hypothesize causative factors
- Examine potential causative factors
- Identify potential outcome measures
Video Case 2

- ID major gait deviations
- Hypothesize causative factors
- Examine potential causative factors
- Identify potential outcome measures
Video Case 3

- ID major gait deviations
- Hypothesize causative factors
- Examine potential causative factors
- Identify potential outcome measures
Questions?

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