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Translation of Gait Analysis to Interventions for Gait Recovery in Persons with Neurological Disorder

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Physicaltherapy.com

Learning Outcomes

- Synthesize gait examination and evaluation to target impairments and activities for intervention.
- Integrate the concept of task specificity into gait retraining to target gait deviations
- Apply current best research evidence to current practice in gait retraining to achieve holistic gait recovery
- Evaluate how the use of orthotic devices and assistive devices impact gait retraining interventions
- Utilizing video patient cases, create appropriate plans of care for targeting gait recovery
Critical Ingredients in Gait Analysis

- Outcome measures across ICF
- Outcome measures that match goals
- Outcome measures that are as objective as possible
- Accurate observational analysis
- Hypothesis driven examination of impairments
- Attention to detail at all levels!

Gait Analysis SHOULD Impact Treatment and POC

- GA significantly influences the therapeutic planning and reinforces decision-making in persons in chronic post stroke phase
- Clinical examination plus 3-D gait analysis
- Treatment implications for surgery, BTx, orthotic management, and physiotherapy
Stance Limb

**Deviation**
- Absent or diminished heel strike
- Excessive DF in stance
- Excessive PF in stance

**Impairment**
- Tight or spastic PFs; weak DF; sensory dysfunction (not likely)
- Weak PF; hamstring contracture
- Tight, spastic, or weak PF; weak quads (if early); hip flexor contracture; quadriceps spasticity (not likely)
### Stance Limb

#### Deviation
- Knee hyperextension (thrust) during stance
- Knee wobble during stance
- Excessive knee flexion during stance

#### Impairment
- Tight, spastic, or weak PF; quad weakness (if early); hip flexor contracture
- Weak PF; weak quads (less likely); sensory dysfunction
- Weak PF; tight or spastic PF (less likely); hamstring contracture

### Stance Limb

#### Deviation
- Trendelenberg
- Excessive hip external rotation
- Excessive lateral lean
- Excessive posterior lean
- Excessive hip and trunk flexion

#### Impairment
- Weak hip abductors
- Tight ERs; compensation for tight PFs
- Weak contralateral swing
- Weak contralateral swing
- Tight hip flexors; weak hip extensors
Stance Phase

**Deviation**
- Weightbearing on lateral border of the foot
- Weightbearing on medial border of the foot
- Vaulting

**Impairment**
- Foot/ankle instability; contralateral swing dysfunction
- Foot/ankle instability (less likely); compensation for tight PFs
- Contralateral swing dysfunction

Swing Phase

**Deviation**
- Decreased clearance during swing (tripping or dragging)
  - Decreased dorsiflexion during swing
  - Decreased knee flexion during swing
  - Decreased hip flexion

**Impairment**
- NOT JUST FOOT DROP
- Tight or spastic PF; weak DF
- TSt dysfunction; tight or spastic quads; weak hamstrings (least likely)
- Weak hip flexors (or just slow); tight/spastic extensors (less likely)
Swing Phase

**Deviation**
- Excessive lateral lean
- Excessive posterior lean
- Excessive hip and trunk flexion
- Excessive hip external rotation
- Hip-hiking
- Circumduction
- Vaulting

**Impairment**
- Compensation for weak swing
- Hip flexor tightness; weak hip/trunk extensors
- Tight ERs; weak IRs or psoas
- Compensation for weak swing

Swing Limb

**Deviations**
- Scissoring
- Absent or diminished heel strike

**Impairment**
- Tight/spastic abductors; sensory dysfunction
- Weak DF; lack of full knee ext at terminal swing
Rehabilitate all the Components

Bowden, Embry, Gregory, 2011
Strength Training

- Moderate evidence to support improvement in gait efficiency
- Questionable transference of strength gains to function
- Training needs to be specific
- Fair to strong evidence supporting increased strength, gait speed, improved functional outcomes, and improved quality of life (without increase in spasticity)

Task Specificity

- Task-specific training can be defined as the **systematic** and **repetitive practice** of **functional tasks** that can be performed **within the stroke survivor’s level of available voluntary motion**
  - Weinstein et al, 2004

- But how do we apply task specificity to therapeutic exercise?
- Do we even need to?
- Is that possible?
Task Specificity in Therapeutic Exercise… How to begin

- Analyze task and find deficits
- Hypothesize causative impairments for identified deficits
- Test out hypotheses to ID causative impairments
- What is the norm, in terms of motor activity, ROM, sensation, etc…?

Example:
Plantarflexors weakness in gait

- What is norm?
  - Peak firing from loading response through terminal stance
  - Type of contraction: Eccentric primarily
  - Position of limb is closed chain
  - Range of motion: from position of 5° plantarflexion to 10° dorsiflexion
  - Degree of difficulty: HIGH (long lever high, torque demand, controlling body weight)
So what would task specific ther-ex look like?

- Ther ex would match the key characteristics of the task:
  - Type of contraction
  - Range of motion
  - Training to fit demand: load, repetition, lever arm

How do we usually strengthen plantarflexors?
Plantarflexor Strengthening for Improving Gait

Example:
Stretching Plantarflexors
Example:
Dorsiflexor weakness in gait

- What is norm?
  - Firing from mid PSw through LR
  - Type of contraction: Concentric in swing, eccentric in LR
  - Position of limb is open chain in swing, closed chain in LR
  - Range of motion: from 15° plantarflexion to 0° dorsiflexion to 5° plantarflexion
  - Degree of difficulty: Moderate (short lever, mostly open chain, on for long period of time)

Does this work for us?
What else is necessary in addition to task specificity?

Table 4: Frequency and Numbers of Repetitions in Categories and Subcategories, Pooled Across All Seven Sites

<table>
<thead>
<tr>
<th>Category</th>
<th>Sessions Observed, n</th>
<th>Sessions Observed, Percent</th>
<th>Repetitions Mean, n</th>
<th>95% Confidence Interval of the Mean</th>
<th>SD</th>
<th>Range</th>
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<tbody>
<tr>
<td>Upper extremity</td>
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<td>41–68</td>
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<td>19–35</td>
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<td>1–432</td>
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</table>

All values rounded to the nearest whole number.  
*Total number of observed sessions=312. Denominators used to calculate percentage of observed sessions were as follows: upper extremity subcategories, n=162; lower extremity subcategories, gait and stairs, n=230; transfers and balance, n=312; see Methods section for explanation.

Lang et al 2009
Intensity…
How do we manipulate it?

– Repetition
– Time in therapy
– Frequency of therapy
– Cardiovascular response
– RPE
– Functional
– Challenging
– Load
– Speed

But…how much is enough?

Does the dosage change the overall response?

**DOSE**  
**vs.**  
**RESPONSE**
Change intensity, change response!

Results:

• Conventional PT:
  – Average # of steps during session: 886 steps
  – Average of 3,822 steps/day before conventional PT; no change after intervention

• Locomotor Training:
  – Average # of steps during session: 3,896 steps
  – Average of 5,560 daily steps after discharge from LT
  – Significant improvement in gait speed & gait efficiency

Moore et al, 2010
What about the P word?

- What is the best time frame for retraining function?
- Is recovery possible in chronic stages?
- What is a plateau?
  - Common in all areas of neuromuscular performance
  - Achieving an adaptive state
  - Stable training stimulus = stabilization of max performance
  - Not indication of diminished capacity for motor improvement

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Breaking through the Plateau

- What can we do when patient plateaus?
  - Expect recovery
  - Periodization
    - Adjust exercise delivery so that positive adaptations continue
    - Modify intensity, session duration, changing routine, etc…
    - Task specific, repeated practice protocols
    - CHALLENGING exercise regimens
Task Oriented Circuit Training

- Group setting training
- Beneficial for improving mobility
- Contradictory results:
  - More effective for improving walking distance, time, and speed compared to other exercise
  - Improvements in gait endurance, no changes in walking amount or rate; gains lost in 3 months
  - English and Hillier, 2010
  - Mudge, 2009

Task Oriented Circuit Training

- Meta-analysis
- Large and significant effects for lower extremity strengthening, gait velocity, gait endurance, balance
- Acute/subacute as well as chronic stages
- Connecting strength improvements to functional improvements
- Even with minimal dose
  - Knox et al, *Clin Rehabil*, 2018
In sample of stroke survivors 1 year post stroke, only 50% could complete 6 minute walk

Those who completed the walk did so at only 40% of predicted distance

Strong relationship between endurance as measured by 6 minute walk and community integration

Increasing endurance could reduce handicap
Balance

Sherrington et al., 2008

Sherrington et al., 2008

Proposed model

Walking capacity

Balance

Falls risk

( a )

( b )
Aerobic Training

- Aerobic exercise-induced increase in BDNF
- Increased BDNF may facilitate motor learning and neuroplasticity
- Also a benefit to cognitive function
- Improves efficiency and reserve
- Priming for Neuroplasticity

MS Recommendations

- Deficits should be addressed to improve energy efficiency and reduce falls
- Compensation using appropriate assistive devices, bracing and wheelchairs may be necessary
- Rehab can make positive impact on quality of life and independence

Mang et al, Phys Ther, 2013
### Parkinson’s Specific Considerations

- Aerobic and strength training exercises improve aerobic capacity, walking, strength, posture and balance
- Questions that remain: exercise intensity and medication on/off timing  
- Exercise improves both motor (gait, balance, strength) and nonmotor (depression, apathy, fatigue, constipation)  
  - Van der Kolk NM, King, *Mov Disord*, 2013
Historical Orthotic Management of Persons with Stroke

- 22% of patients receiving stroke rehabilitation were discharged with an ankle foot orthosis (AFO)
- Patients who were most impaired in motor, walking, and balance functions typically received an AFO.
- Controversial
- Orthotic use discouraged due to perception that their use prevents or delays recovery
- Pre-fabricated PLS often provided in acute care

Current Trends – PTs

- Reluctance to provide solid ankle device; don’t recognize the need to substitute for weak plantarflexors
- Philosophy on orthotics: wait to prescribe, try to do without
- Misconception that orthotics diminish muscle activity and somehow inhibits recovery
  - “Do as little as possible because you know everything you limit in brace is actually taking away something that’s normal”
  - “I try to stay away from them as much as possible to maximize recovery”
- Seale J, Utsey C, unpublished data
Orthotic Impact on Gait

- Improve quality of gait, improve gait speed, and reduce energy expenditure during ambulation.
- Immediate improvements in functional ambulation categories
- Immediate improvements in gait speed, quality, and endurance
- Increased step or stride length

Orthotic Impact on Balance and Other Function

- Immediate improvements in balance
- Decreased fall risk
- Not detrimental to stair climbing and sit<>stand
- Less postural sway, improved weight distribution symmetry
- No data on impact on quality of life or participation
Effect of AFOs on Muscle Activation

- **Literature Review**
  - 11 studies in individuals with neurological disorders
  - Diagnoses included: CVA, SCI, peripheral “foot drop”, & children with CP
  - Electromyography (EMG) of LE muscles while walking with & w/out AFOs
  - Multiple types of AFOs investigated (solid, hinged, oil-damper, PLS, etc)

- **Weaknesses of the Literature**
  - Variability in muscles tested
  - Variability in braces tested
  - Only 1 long-term outcome
  - Some used surface electrodes, some used intramuscular electrodes
  - Variability in data collected and analyzed

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Effect of AFOs on Muscle Activation

**Summary of the Evidence**

- Of the 11 studies:
  - 6 showed equal or more normalized EMG in AFO
  - 4 showed less normalized EMG in AFO
  - 1 showed equal, more normalized, and less normalized EMG in AFO depending on the muscle tested
  - No notable trend toward the rigidity of the brace resulting in more or less normalized EMG

- **No clear evidence that:**
  - AFOs decrease muscle activation in individuals with neurological disorders
  - More rigid braces exaggerate any possible negative side effects of bracing
  - There is a long-term detriment to muscle activation, function, or impairments
Assistive Devices

- Goal is least supportive device that promotes continuous walking with most normal pattern

Becoming a Master Manipulator

Newell, 1991
Video Case 1

- Major gait deviations
- Likely causes
- How do we treat?
  - Strength
  - ROM
  - Endurance
  - Balance
  - Task specific function
Video Case 2

- Major gait deviations
- Likely causes
- How do we treat?
  - Strength
  - ROM
  - Endurance
  - Balance
  - Task specific function
Video Case 3

- Major gait deviations
- Likely causes
- How do we treat?
  - Strength
  - ROM
  - Endurance
  - Balance
  - Task specific function
Questions?

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