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Using Gait Analysis to Drive Interventions for Gait Recovery in Patients with Neurological Disorder

Jill Seale, PT, PhD, NCS
Physicaltherapy.com
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Objectives

- Use observational gait analysis and subjective gait measures to target impairments and activities for intervention.
- Integrate the concept of task specificity into therapeutic exercises to target gait deviations
- Appraise current best research evidence and apply to current practice
- Evaluate how the use of orthotic devices and assistive devices impact our 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!

Stance Limb

Deviation	Impairment
• Absent or diminished heel strike	• Tight or spastic PFs; weak DF; sensory dyfucntion (not likely)
• Excessive DF in stance	• Weak PF; hamstring contracture
• Excessive PF in stance	• Tight, spastic, or weak PF; weak quads (if early); hip flexor contracture; quadriceps spasticity (not likely)

Stance Limb

Deviation	Impairment
• Knee hyperextension (thrust) during stance	• Tight, spastic, or weak PF; quad weakness (if early); hip flexor contracture
• Knee wobble during stance	• Weak PF; weak quads (less likely); sensory dysfunction
• Excessive knee flexion during stance	• 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)

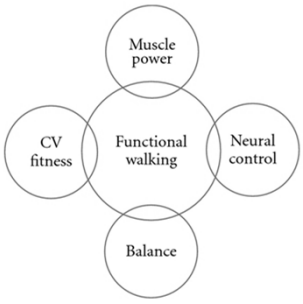
Swing Phase

Deviation	Impairment
• Excessive lateral lean	• Compensation for weak swing
• Excessive posterior lean	• Hip flexor tightness; weak hip/trunk extensors
• Excessive hip and trunk flexion	• Tight ERs; weak IRs or psoas
• Excessive hip external rotation	
• Hip-hiking	• Compensation for weak swing
• Circumduction	

Swing Limb

Deviations	Impairment
• Scissoring	• Tight/spastic abductors; sensory dysfunction
• Absent or diminished heel strike	• 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
  - Winstein 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?

Number of Repetitions

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

Category	Sessions Observed, n	Sessions Observed, Percent*	Repetitions, Mean n	95% Confidence Interval of the Mean	SD	Range
Upper extremity						
Active exercise	118	73	54	41–68	75	1–541
Passive exercise	67	41	33	22–44	45	1–246
Sensory	29	18	13	8–19	15	1–71
Functional	83	51	32	20–44	56	1–420
Lower extremity						
Active exercise	160	70	75	58–93	113	1–802
Passive exercise	63	27	12	9–16	14	1–88
Sensory	10	4	10	4–15	8	1–25
Functional	20	7	6	2–10	10	1–34
Gait						
Episodes	193	84	6	5–6	5	1–39
Steps	193	84	357	296–418	432	3–2614
Stair climbing						
Episodes	50	22	3	2–4	2	1–12
Steps	50	22	38	31–45	26	2–122
Transfers	219	70	11	9–13	12	1–78
Balance	147	47	27	19–35	48	1–432

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?

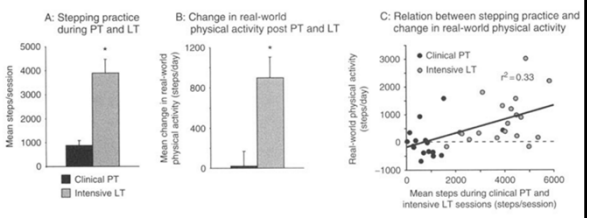
DOSE
vs.
RESPONSE?

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



Moore et al, *Stroke*, 2010

What about the P word?

- What is the best time frame for retraining function?
- Is recovery possible in chronic stages?
  - Teasell R et al, *Top Stroke Rehabil*, 2012
- 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
    - Page SJ, Gater DR, Bach-y-Rita P, *Arch Phys Med Rehabil*, 2004.

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
    - Page SJ, Gater DR, Bach-y-Rita P, *Arch Phys Med Rehabil*, 2004.

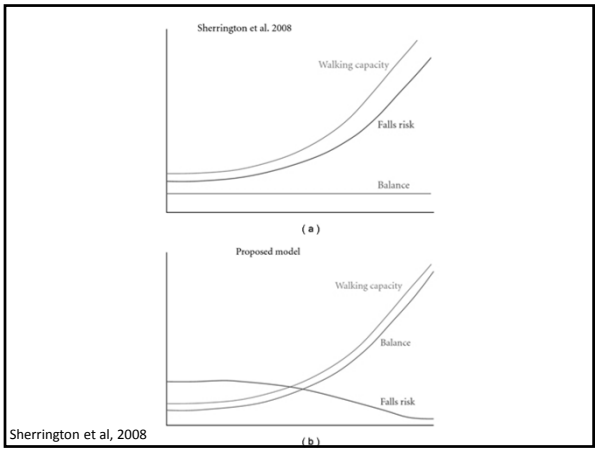
Task Oriented Circuit Training

- 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

Target Endurance

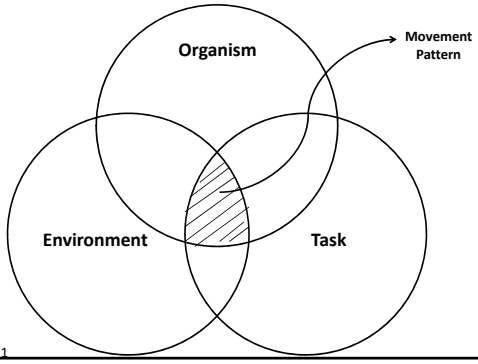
- In sample of stroke survivors 1 year post stroke, only 50% could complete 6 minute walk
- Those who completed the walk did so at only 40% of predicted distance
- Strong relationship between endurance as measured by 6 minute walk and community integration
- Increasing endurance could reduce handicap

Balance



Sherrington et al, 2008

Becoming a Master Manipulator



Newell, 1991

Video Case 1

Video Case 1

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

Video Case 2

Video Case 2

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

Video Case 3

Video Case 3

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

Questions?

jiseale@utmb.edu