Using Movement Systems Diagnosis & Functional Interventions to Address Mobility

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APTA Combined Sections Meeting

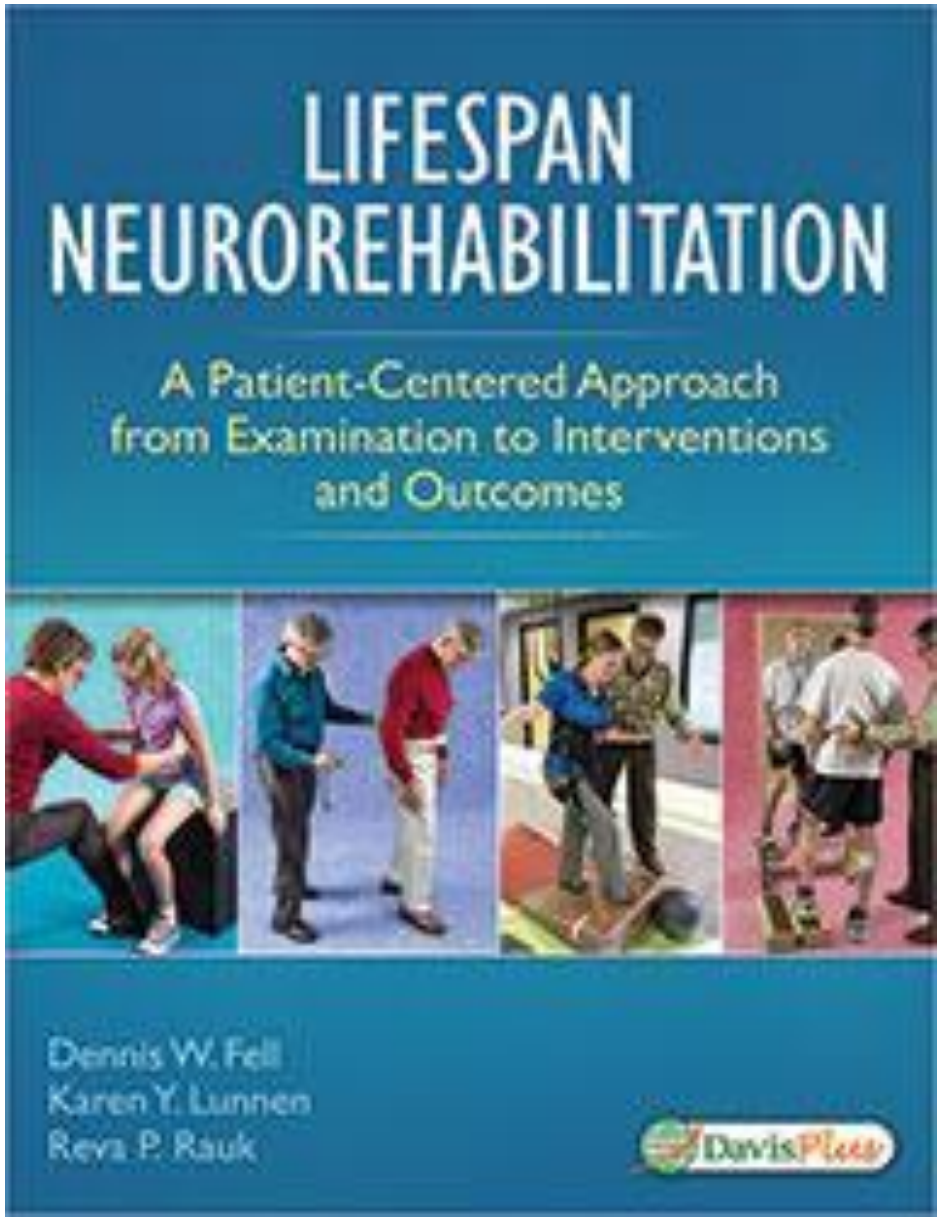
January 25, 2019, Washington, DC

Disclosure:

Potential Conflict of Interest

Related to the content of this course...

- Dr. Fell is Chief Editor and author of the, (2018) Lifespan Neurorehabilitation: A Patient-Centered Approach from Examination to Interventions and Outcomes.New York: Davis Hall. ISBN-13: 978-0-8036-4609-4
- Dr. Simpkins and Dr. Pinto Zipp are co-authors of Chapter 2 “Making Clinical Decisions” and Chapter 37 “Intervention for Upright Mobility”.



Course Objectives:

After participating in this presentation, the learner should be able to:

1. Explore the tenets of the movement system and movement system diagnoses
2. Describe upright mobility from the perspective of the learner, task and environment.
3. Explain why task analysis is a key element of an examination.
4. Apply a framework that uses movement systems diagnosis (MSD) in the clinical management of patients with disorders of upright mobility.
5. Design and modify an intervention using functional mobility activities to address a patient's specific MSD.

I. The movement system and the complexity and organization of upright mobility

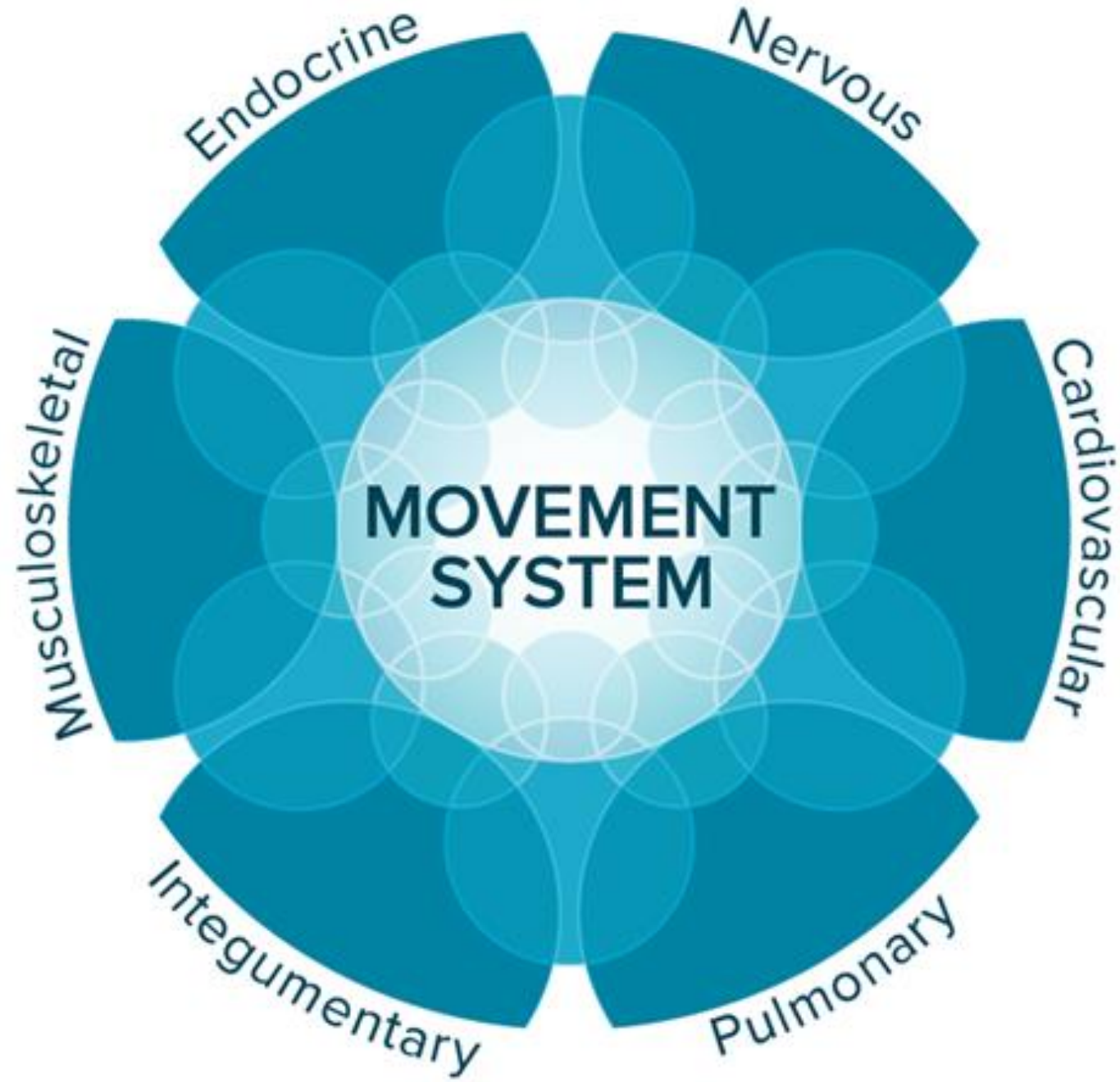
Dennis Fell, PT, MD

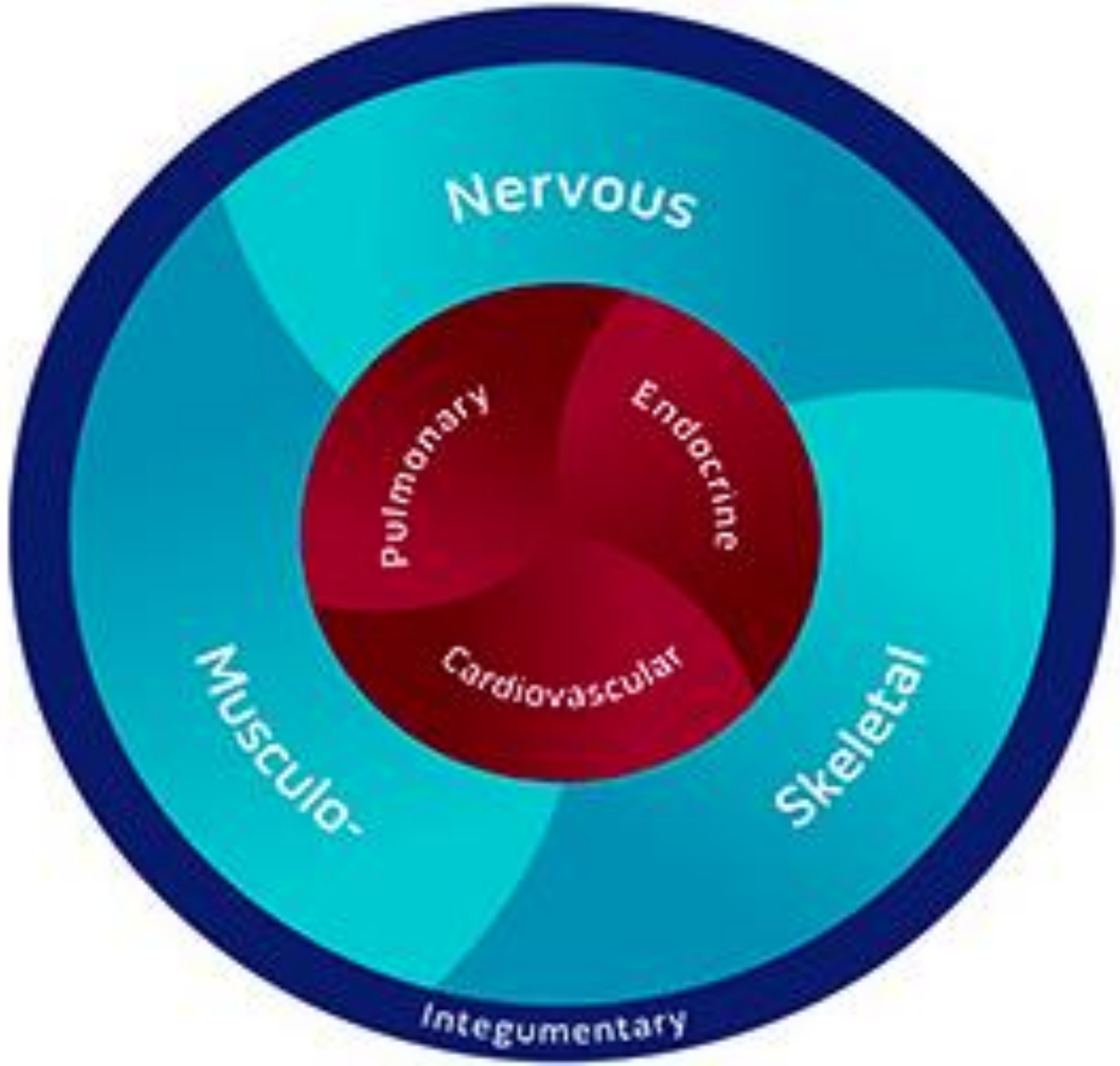
The Movement System – in context of PT Practice

- Vision: “transforming society by **optimizing movement** to improve the human experience.” (APTA HOD, 2013)
- “The **human movement system** comprises the anatomic structures and physiologic functions that interact to move the body or its component parts.” (APTA, 2014)
- “The **movement system** is the term used to represent the collection of systems (cardiovascular, pulmonary, endocrine, integumentary, nervous, and musculoskeletal) that interact to move the body or its component parts.” (APTA White Paper, 2015)

Human Movement

- A complex behavior within a specific context (today = upright mobility; locomotion
- In Physical Therapist Practice (from APTA White Paper, 2015):
  - Unique perspective on purposeful, precise, and efficient movement across the lifespan
  - Examine and evaluate movement system -> customized plan
  - Maximize individual's ability to engage with and respond to environment


Endocrine
Nervous
Musculoskeletal
Cardiovascular
MOVEMENT SYSTEM
Integumentary
Pulmonary



www.physiospot.com

Systems within the movement system – relationship to upright mobility

- tactile sense (light touch, pressure from foot)
- proprioceptive sense
- pain
- motor (muscle tone, force production, motor control for stability and movement including initiation/cessation/continuous, coordination)
- musculoskeletal,
- vestibular
- balance/equilibrium
- cardiovascular, pulmonary,
- integumentary
- cognitive (memory, attention/dual task)

Upright mobility tasks: essential requirements (Shumway-Cook, Chapter 12, Patla)

- Progression
- Postural Control / Stability
- Adaptation

And amazingly, all of this is processed without conscious control

- so we need to train patients for this as well

Other requirements for bipedal locomotion (Hedman et al, 2014)

Full consensus on 5 locomotor requirements

- Initiation
- Termination
- Anticipatory Dynamic Balance
- Multi-Task Capacity
- Walking Confidence

and partial consensus for 7 other requirements (Hedman, 2014)

Movement system diagnoses/possible effects on gait

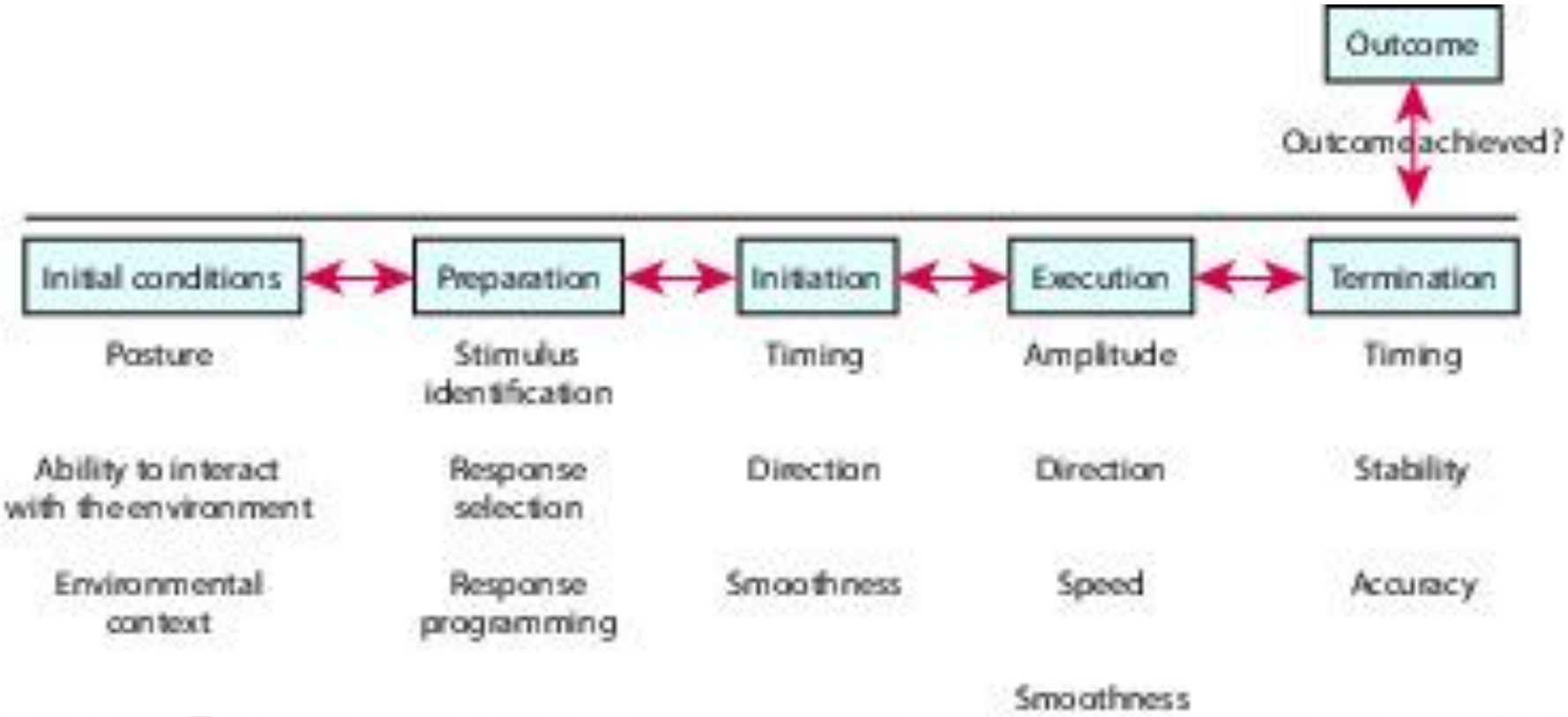
Table 37-5 From Fell, 2018, p.1146

TABLE 37-5 Movement System Diagnoses

MOVEMENT SYSTEM DIAGNOSIS	POSSIBLE EFFECTS ON GAIT
Movement pattern coordination deficit	Variable foot placement; slow, small steps; may need assistance
Force production deficit	May need assistive device or assistance; may have severe gait deviations such as crouched gait, or knee buckling in mid-stance; may not be able to ambulate
Sensory detection deficit	Variable foot placement; may require assistance; gait may improve with vision
Sensory selection and weighting deficit	Deviation from straight path; difficulty with changes in sensory environment
Perceptual deficit	Variable gait impairment; asymmetrical posture
Fractioned movement deficit	Slow, stiff movement; marked gait deviations; may need ankle foot orthosis or assistive device
Hypermetria	Variable foot placement; may need assistance
Hypokinesia	Difficulty initiating gait; variable step length; may need assistance
Cognitive deficit	Unable to modify movement based on instructions; poor memory for movement-related instruction

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Process for Assessing Movement (Hedman, 1996)



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II. Upright mobility in context: Learner, Task, Environment

Susan Simpkins, PT, EdD

Making A Movement Systems Diagnosis

What information contributes to the clinical reasoning needed to make a MSD?



Movement Systems Diagnosis

Medical Diagnosis ⟷ **Movement Systems Diagnosis**

- Based on the patient's signs and symptoms, and results of a standardized set of tests and measures
- Guides medical management of these patient's problems
- Does not specifically consider the patient's movement problems

- Based on the patient's primary movement system signs and symptoms, the results of a standardized set of tests and measures, and movement analysis
- Guides the plan of care for the management of the patient's movement problems
- Enable research on treatment efficacy based on a MSD rather than medical diagnosis
- Improves outcomes by reducing variation in practice

Upright Mobility is Highly Valued

The ability to walk is highly valued by patients and caregivers.

- Household mobility, makes a significant contribution to quality of life (Myers 2003).
  - Increases the patient's independence and reduces caregiver assistance
  - Takes more than walking; household mobility also requires sit- to-stand/stand-to-sit, standing



Upright Mobility Tasks

- Community mobility includes an even greater range of tasks, such as negotiating curbs, stairs, ramps, & uneven surfaces
  - Walking can reduce the development of secondary impairments and health conditions related to sedentary lifestyle (CDC 1995)

Walking and other mobility task are the focus of PT *when there is a reasonable likelihood* that upright mobility is a possibility.

Question: What is the best approach to optimize a patient's potential to relearn or develop upright mobility?



APTA.org



Clinical practice guideline to improve locomotor function following chronic stroke, incomplete spinal cord injury and brain injury

T. George Hornby1,2 Darcy S. Reisman3, Irene G. Ward4,5, Patricia L. Scheets6, Allison Miller3,4, David Haddad4 and the Locomotor CPG Appraisal Team Collaborators: Emily J. Fox7, Nora E. Fritz8, Kelly Hawkins7, Christopher E. Henderson1, Kathryn L. Hendron9, Carey L. Holleran10, James E. Lynskey11, Amber Walter12

Diagnoses: Stroke, motor incomplete SCI, Traumatic Brain Injury

Population: Persons in the chronic stage (> 6 months) of an acute onset CNS injury

Specific Training Protocols: Increase speed; increase distance that included FITT

Recommendations: Strong, moderate, weak evidence, potential harm, and cost

CPGs & Movement Systems Diagnosis

Questions:

Are there similar impairments and motor control problems across the three diagnoses?

Might theses common impairments and MC problems respond best to a specific approach to intervention?

Currently, studies examine intervention for specific diagnoses. However, participants in these studies may have different movement system problems (diagnoses) which contributes to variable outcomes.

Movement Systems Diagnoses Are About Improving Outcomes to Optimize Function -Today Upright Mobility

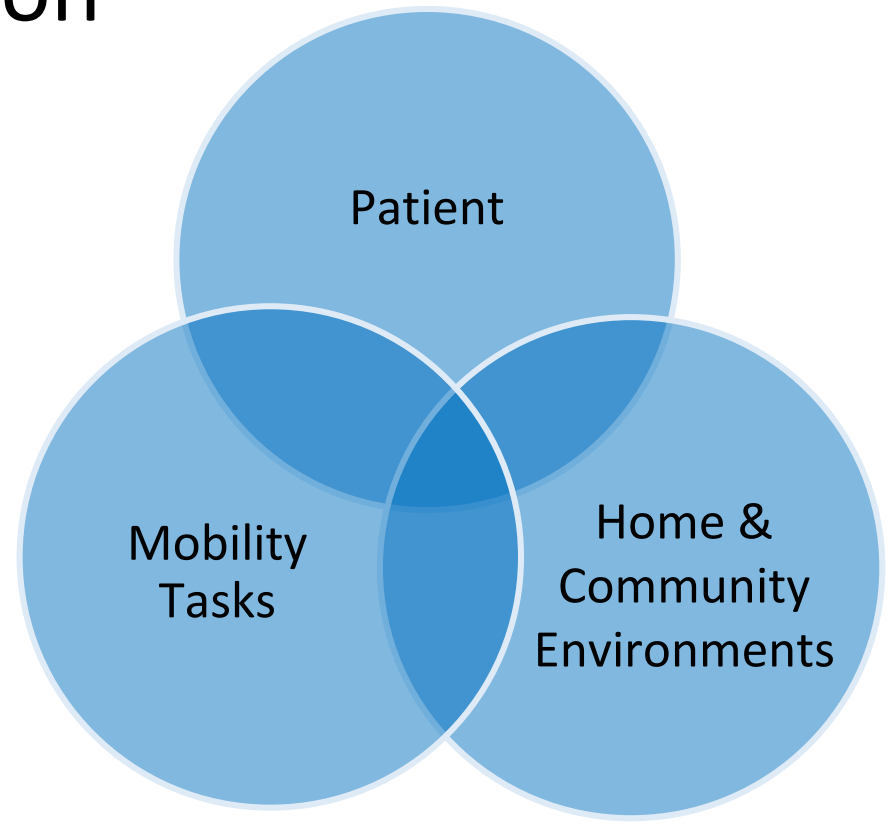
- Patients will be diagnosed by the cluster of problems demonstrated in an examination
  - Treatment will then be directed towards treating the problems associated with movement systems diagnosis, independent of medical diagnosis
  - Research will help identify which interventions result in the best outcomes.
- Establish best practices, standard of care, clinical practice guidelines
- Better prognosis –Better ability to predict outcomes

PHYSICAL
MOVEMENT
SPECIALISTS
THERAPY

Movement Systems Diagnosis

Gather information through examination

- History
  - The patient
- Systems review
- Outcome measures
- Movement analysis of tasks



Making a Movement Systems Diagnosis: Examination -What do we need to know?



Who is our patient?

- Diagnosis, age, age at onset, course, severity level, integrity of movement subsystems, patient reported problems, patient's goals

- **Which mobility tasks are important to the patient?**
  - Sit to stand, stand to sit, standing, walking, complex walking

- **Which environments are important in the patient's life?**
  - Home, work, school, community

ICF to Organize the Examination
Contextual Factors

Personal Factors

- Age, gender, medical diagnosis
- Comorbidities
- Patients values and goals
- Understanding of health condition
- Support system-family, friends
- Financial resources
- Prior outcomes in therapy
- Health behaviors

Environmental Factors

- Home and community accessibility
- Access to health care
- Assistive technology
- Transportation
- Educational/vocational resources
- Social and leisure interests

Examination: Tests & Measures

- Select standardized outcome measures to gather information needed to establish a movement systems diagnosis
  - EDGE Task Force Recommendations* - Diagnosis specific
  - ANPT Clinical Practice Guideline (Moore 2018)
    - Suggests a core set outcome measures for adults with neurologic conditions
- Core set includes 5 times sit to stand, Berg Balance Scale, Functional Gait Assessment, 6-minute walk test, 10 meter walk test, Activities Specific Balance Confidence Scale
  - Pediatrics - Standardized tests of motor development, participation measures
- Core set of tasks for observational analysis (Hedman 2018)
  - Sit to stand/stand to sit, sitting, walking, step up, reach, grasp, manipulation

*www.neuropt.org/professional-resources/anpt-clinical-practice-guidelines/core-outcome-measures-cpg

Health Condition- Neurologic Condition

Body Structure & Function Impairments*

- Weakness
- Abnormal tone
- Incoordination
- Involuntary movements
- Abnormal synergies
- Pathologic reflexes
- Poor balance
- Sensory deficits
- Perceptual deficits
- Cognitive deficits

Activity Limitations

- Sitting
- Standing
- Sit-to-stand/stand-to-sit/floor-to-stand
- Walking
- Step-up/down
- Reach, grasp, manipulation
- Stairs
- Inclines
- Uneven surfaces

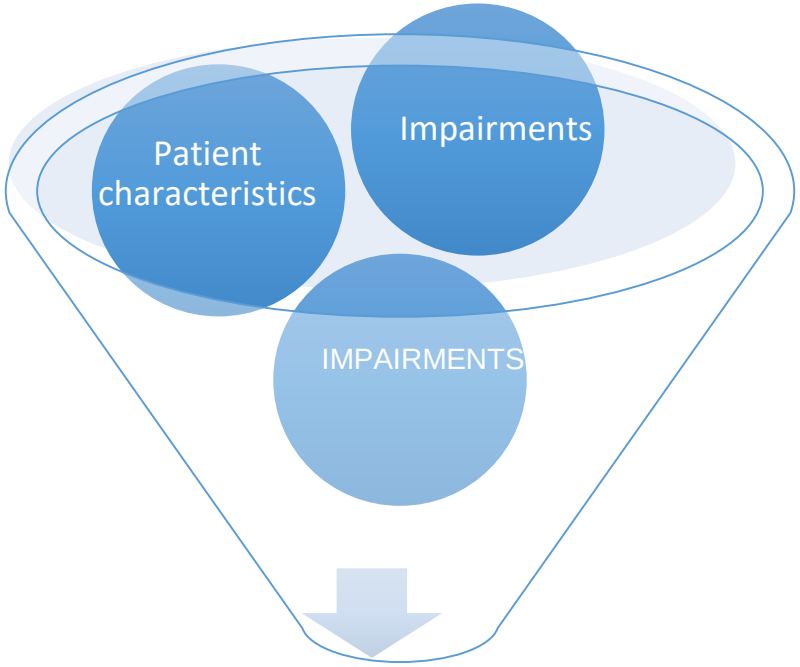
Participation Restrictions

- Mobility: Home, school, work, community
- Self-care abilities
- Household management
- Vocational skills
- Recreational interests

*Shumway-Cook A, & Woollacott M. Motor Control Translating Research into Clinical Practice

PRIMARY MOVEMENT SYSTEM IMPAIRMENTS & ACTIVITY LIMITATIONS

Weakness
Abnormal tone
Coordination deficits
Involuntary movements
Abnormal synergies
Poor balance
Pathologic reflexes
Sensory deficits
Perceptual deficits
Cognitive deficits



MOVEMENT SYSTEM PROBLEMS AFFECTING TASK PERFORMANCE

Sitting
Standing
Sit-to-stand/stand-to-sit
Walking
Step-up/down
Reach, grasp, manipulation
Stairs
Inclines
Uneven surfaces

Shumway-Cook & Woollacott (20)

Hedman et al 2018

Examination: Observational analysis of movement

Core set of tasks suggested for movement analysis with the addition of tasks relevant to children*

- Sitting
- Standing
- Sit-to-stand; stand –to-sit; floor-to-stand; stand-to-floor
- Walking, floor mobility
- Step up/down
- Reach, grasp, manipulation

Movement Analysis - Offers the best opportunity to assess how impairments and the interaction of primary impairments interferes with mobility

*Hedman et al (2018)

Video

Identifying Problems with Task Performance

Dilemmas

- We have a set of core tasks, but not standardized approach to movement analysis or a common language to describe what we observe.
- What are we looking for in a movement analysis

  - Quantitative measures
  - Qualitative measures

  - Is there a set of performance criteria that will used as a basis for comparison?
  - Safety, effectiveness, efficiency , and timeliness. If so, how will these characteristics be operational define?

Movement Continuum (Hedman et al)

- Defining the components of the continuum to improve utility of the framework movement analysis
  - What are the parameters of each component of the sequence?
  - What abilities are needed to satisfy the requirements of each component of the sequence?
  - What are the consequences to movement following neurologic injury?

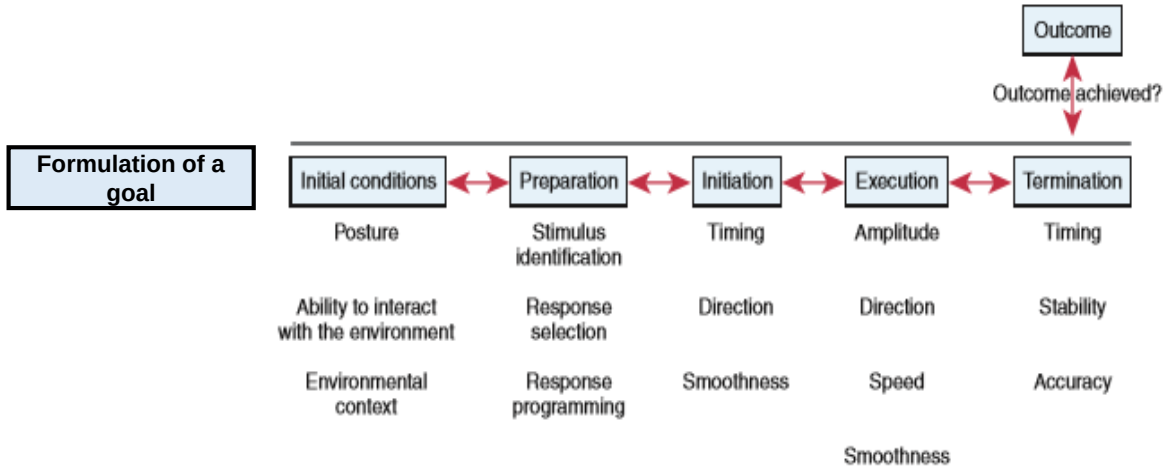


FIGURE 2-12 Illustration of the sequence of the five stages of the Hedman et al temporal model for task analysis, including initial conditions, preparation, initiation, execution, and termination. Key features for each stage are listed *(From Hedman, Rogers, and Hanke, Neurologic professional education: Lining the foundation science of motor control with physical therapy intervention for movement dysfunction. Journal of Neurologic Physical Therapy, 1996, 20:9-13.).*

Initial Conditions Assessment of self and environment	**Healthy Movement System**	**Effects of neurologic impairments on initial conditions**	**Consequences of neurologic impairments on movement**
Posture/position	◦ Body orientation (sitting, standing, lying) ◦ Verticality ◦ Midline orientation ◦ Biomechanically correct postural alignment	◦ Atypical postural alignment ◦ Unable to maintain midline posture ◦ Asymmetrical weight bearing	◦ Movement is inefficient ◦ Stress on joints ◦ Poor match between the individual's movement, and task and environment
Ability to interact with the environment based on prior experience and current state of the movement system	◦ Sensation, Perception and Cognition ◦ Attention ◦ Memory (ST & LT experience) ◦ Problem solving	◦ Sensory Deficits ◦ Visual field deficits ◦ Somatosensory deficits - sensory input from body conflicts with previous internal representations ◦ Perceptual problems ◦ Unilateral neglect ◦ Figure ground ◦ Depth perception ◦ Cognitive Problems ◦ Attention ◦ Memory	◦ Movement is unsafe (poor postural support) ◦ Goal is not attained
Environmental context ◦ **Stationary (Closed)** ◦ **Moving (Open)** ◦ **Social, cultural context**		◦ Problem solving ◦ Predictive ability	

Preparation (prior experience and current state of the movement system)	**Healthy Movement Systems**	**Potential Problems with neurologic impairment that may interfere with preparation**	**Consequences for motor control**
Stimulus Identification (regulatory vs nonregulatory features)	◦ Arousal ◦ Attention ◦ Visual search ◦ To detect task-specific information through sensory systems ignoring irrelevant information	◦ High/low arousal ◦ Visual deficits ◦ Attention problem: ◦ Poor selective attention: ◦ Ineffective visual search strategies ◦ Cognitive problems: ◦ Unable to distinguish between relevant and irrelevant sensory information ◦ Memory impairment:unable to benefit from prior experience or from practice during therapy sessions	◦ Does not pick up relevant task-specific information ◦ Slow information processing ◦ Increased latency between instructions and action ◦ Even a longer latency for complex movements and those with a high accuracy requirement
Response Identification	◦ Mover considers options, strategies available	Unable to identify an effective movement strategy	Selects ineffective/ inefficient/unsafe movement strategy Goal may not be attained
Response Selection	◦ Determine movements that will most efficiently effectively and safely achieve goal	Unable to select an effective movement strategy	Same
Response Programming	◦ Postural and task components organized ◦ Direction of limb movements ◦ Movement speed ◦ Force control	Unable to organize effective movement	Same

Initiation	Healthy Movement System	Potential Problems Following Neurologic Impairments	Consequences
Timing	Anticipatory postural muscle activity precedes movement onset to account for internally generated forces – and external forces Turning on the postural and task muscles needed for a specific task… • At the optimal time • In the optimal sequence • To the right extent (amplitude)	APAs not timed to movement onset Movement initiated slowly	Increased fall risk Unable to maintain stable posture/position Unable to capitalize on momentum
Direction	Onset of movement of body segments, joints moves limbs/body in desired direction	• Disruption of postural synergies • Weakness	Movement not sequenced properly Reduced movement accuracy
Smoothness	◦ Modulation of agonist/ antagonist ◦ Reciprocal inhibition ◦	Weakness and abnormal tone • Inability to overcome inertia	

xecution-Coordination of body segments hat contribute to the desired movement attern	Healthy Movement Systems	Problems seen following neurologic injury	Consequences
mplitude	Force generation	Hypertonicity and paresis: Unable to produce appropriate force	Force not well tuned to task requirements
irection	Selection an sequencing of body segments and muscle activity Process intrinsic feedback	Functional synergies (coupling) are often disrupted Diminished/absent sensory information limits error detection and correction to ongoing movement	Accuracy is impaired- overshooting and undershooting
peed	Timing of muscle onset and ability to sustain need level of muscle activity	Increased onset latency in activation of postural and task muscles Difficulty sustaining muscle activity to support movement	Movement performed slowly- takes longer to complete (MT increases)
moothness	Agonist/antagonist relationship	Co-contraction for stability Abnormal reciprocal inhibition Movement looks stiff, jerky	Reduced accuracy
ming			

Termination – movement cessation	Healthy Movement System	Problems seen following neurologic injury	Consequences
Timing	Postural and task muscles off… At the right time	Balance system must be prepared for cessation of movement Termination not “built in” during the planning process	Postural instability Unable to stop movement when needed
Stability	In the right order (sequence)		Increased risk for falls
Smoothness	To the right extent (amplitude)		Decreased accuracy

Outcomes - ability to processes intrinsic feedback	Healthy movement systems	Problems seen following neurologic injury	Consequences
Goal attained	Sensory systems detect intrinsic feedback No error signal – no change to movement plan	Due to lack of sensory information or inability to process sensory information the mover does not “understand” why goal was not attained	Unable to modify next attempt to improve outcome
Goal not attained	Error signal – movement did not occur as planned- plan modified to improve outcome of next attempt		

Moving in the real world: Gentile's Taxonomy of Task

Tasks

- Mobility
- Stability

} With or without object manipulation (single; dual; multi-tasking)

- Degree of variability

Environment

- Closed
- Open
- Degree of variability

Challenges patient:

- Attention
- Predictive ability
- Adaptation

Core tasks in real-life situations

Videos

What did you observe? Why is the patient having difficulty?

- Where in the movement continuum is the patient having the most difficulty?
- Why is the patient having this difficulty?

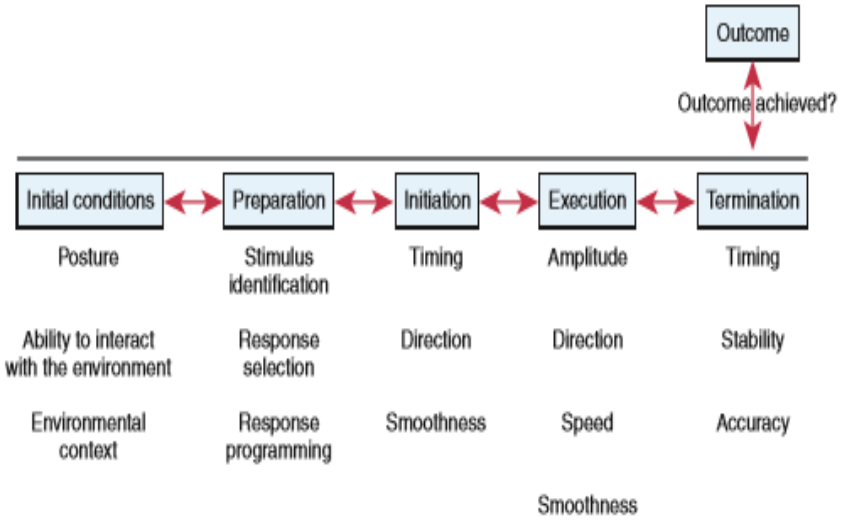


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Movement Systems Diagnoses

TABLE 37-5 Movement System Diagnoses

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Perceptual deficit	Variable gait impairment; asymmetrical posture
Fractioned movement deficit	Slow, stiff movement; marked gait deviations; may need ankle foot orthosis or assistive device
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III. Exploring the tenets associated with MSDxs in both pediatric and adult patients with neurologic problems

Genevieve Pinto Zipp, PT, EdD

Exploring Movement System diagnoses across the lifespan

Where do we begin?

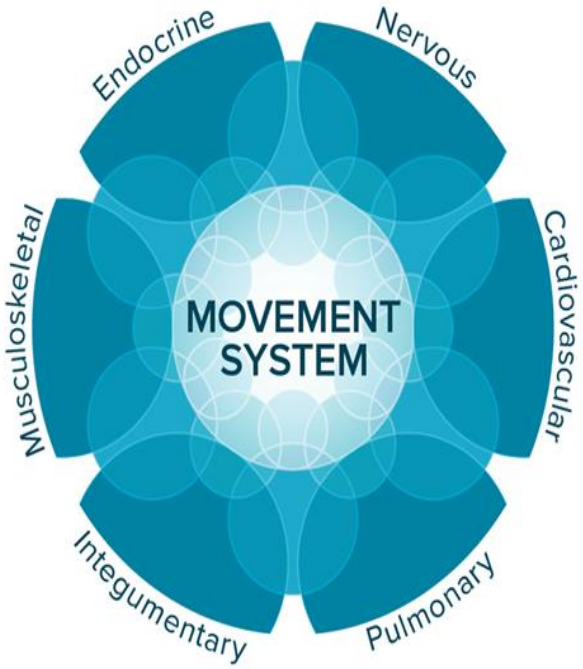


Movement System

"is the term used to represent the **collection** of systems (cardiovascular, pulmonary, endocrine, integumentary, nervous, and musculoskeletal) that **interact** to move the body or its component parts."

(from APTA White Paper, 2015)





APTA's Guiding Principles- *Identity*

"physical therapy profession will define and promote the movement system as the **foundation** for optimizing movement to improve the health of society.

Recognition and validation of the *movement system* is **essential** to understand the structure, function, and potential of the human body.

The physical therapist will be responsible for evaluating and managing an individual's movement system **across the lifespan** to promote optimal development; diagnose impairments, activity limitations, and participation restrictions; and provide interventions targeted at preventing or ameliorating activity limitations and participation restrictions.

The movement system is the **core of** physical therapist practice, education, and research." (from APTA White Paper, 2015)

Intent of the Movement System



To unify the profession, regardless of:

- practice setting
- patient population
- body part or function

To identify the profession based on our body of knowledge

Why Are Physical Therapists Movement System Practitioners?

- provide a **unique** perspective on purposeful, precise, and efficient movement across the **lifespan** based upon the **synthesis** of their distinctive knowledge of the **movement system** and expertise in **mobility** and **locomotion**.

- **examine** and **evaluate** the movement system (including diagnosis and prognosis) to provide a **customized** and **integrated** plan of care to achieve the individual's goal-directed outcomes.

- maximize an individual's ability to engage with and respond to his or her **environment** using movement-related interventions to optimize **functional capacity** and **performance**

Physical Therapist Practice and The Movement System
August 2015, APTA WHITE PAPER- The Movement System
(updated 11/16)

- Strive for movement system diagnoses that **span** all populations, health conditions, and lifespan
- Use **similar recognized** movement-related terms to describe similar movements, regardless of pathology or other characteristics of patient/client



4 C's

- ❑ **Clarity**
- ❑ **Communication**
- ❑ **Collaboration**
- ❑ **Continuity**

Common Language



Common Identity

Movement System Diagnoses

- Dysmetria
- Force Production Deficit
- Fractionated Movement Deficit
- Hypokinesia
- Movement Pattern Coordination Deficit
- Postural Vertical Deficit
- Sensory Detection Deficit
- Sensory Selection and Weighting Deficit
- Cognitive Deficit

A place to start
Taking a deeper dive

(Scheets et al., 2015)
(Scheets P, Sahrmann S, Norton B, 1999; 2007)

Movement Pattern Coordination Deficit
Sensory Detection Deficit

DYSMETRIA

inability to **grade forces** appropriately for the **distance and speed** aspects of a task.

- Undershooting or overshooting
- Wide base of support & repeated stepping
- Abnormal rhythm and incoordination during rapidly alternating movements
- No change with practice
- Sit to Stand-wide base of support; may see excessive sway at trunk; uses UE to stabilize
- Difficulty grasping small objects

(Sheets et al., 2015)

FORCE PRODUCTION DEFICIT

Movement Pattern Coordination Deficit
Hypokinesia

primary movement fault is **weakness**.

- Prone on elbows, pull to sit, floor to stand, sit to stand, gait, reach and grasp
- Unable to stand unsupported or loss of support moment at hip and knee during single limb support
- Limited improvement in performance with practice; may worsen with repeated trials
- In more severe forms may be unable to sit unsupported

(Sheets et al., 2015)

FRACTIONATED MOVEMENT DEFICIT

inability to fractionate movement associated with moderate or greater **hyper-excitability**. Always associated with **central neurological deficit**.

- Slow; unable to make rapid reversals in movement
- Unable to generate force rapidly
- Moderate or greater hyperexcitability
- Grade 3 or 4 on the modified Ashworth
- May exhibit +ATNR, +STNR
- Consistent nonfractionated Movement Pattern Across Multiple tasks

(Sheets et al., 2015)

Force Production Deficit
Cognitive Deficit

HYPOKINESIA

slowness in **initiating** and **executing** movement. May be associated with stopping of ongoing movement.

Sit to Stand or Floor to Stand, Slow or lack of preparatory movement

- Assistance with initiation
- Loss of balance on termination
- Unable to shift center of mass forward

Gait

- Difficulty initiating ambulation
- Arrests in ongoing movement during functional tasks (Sheets et al., 2015)

Force Production Deficit
Sensory Selection & Weighting Deficit
Sensory Detection Deficit
Dysmetria

MOVEMENT PATTERN COORDINATION DEFICIT

inability to **coordinate** an intersegmental task because of a **deficit in timing and sequencing** of one segment in relationship to another. Performance typically **improves** with practice and instruction.

Sit to stand, gait, reach and grasp, jump, skip

- Increased latency in postural movement patterns
- Inappropriate amplitude of postural adjustments or responses
- Increased posterior sway during stance activities

(Sheets et al., 2015)

POSTURAL VERTICAL DEFICIT

Sensory Selection & Weighting Deficit
Sensory Detection Deficit
Fractionated Movement Deficit
Force Production Deficit

inaccurate perception of vertical orientation resulting in postural control deficits and the tendency to **resist correction of center of mass alignment.**

- Shifts center of mass beyond limits of stability to side or backward without **weight acceptance**
- **Resists correction or becomes fearful/agitated** when center of mass alignment is corrected
- Deficits may present in sitting, standing, or with walking depending on severity
- **Sensation of "falling"** when shifted toward correct vertical alignment
- May have **disregard or neglect** of involved extremities (Sheets et al., 2015)

SENSORY DETECTION DEFICIT

Movement Pattern Coordination Deficit
Postural Vertical Deficit
Sensory Selection & Weighting Deficit
Force Production Deficit

inability to execute intersegmental movement due to **lack of joint position sense or multi -sensory failure** affecting joint position sense, vision, and/or the vestibular system.

- ❑ Moderate to severe impairment of joint position sense or protective sensation of one or both LEs
- ❑ Mild or greater loss of joint position sense **and** touch sensation of one or both UEs
- ❑ New **visual field deficit** greater than 50%
- ❑ Sit to Stand, Gait, Reach and grasp
    - Foot slapping
    - Slow and dyscoordinated
    - Some improvement with **visual guidance**

(Sheets et al., 2015)

SENSORY SELECTION AND WEIGHTING DEFICIT

inability to initiate or maintain postural orientation or motor performance as a result of decreased ability to **screen for and attend** to appropriate sensory inputs. Patients may demonstrate **sensory seeking or sensory avoidance** behaviors

- ❑ Deviation in line of progression to one or both sides
- ❑ Instability with **head turning**
- ❑ Turning Around: **Loss of balance** or increased ankle or hip sway at termination, Worse with faster movement, **Dizzy**
- ❑ Able to stand unsupported but may require practice
- ❑ **Increased sway** or instability with eyes closed or other change in sensory conditions
- ❑ May demonstrate hip strategy during static standing tasks
- ❑ Postural responses may be **delayed or exaggerated**
- ❑ **May improve with modification of sensory** needs and practice, instruction and
- ❑ **Sensory sensitive**

(Sheets et al., 2015)

COGNITIVE DEFICIT

Fractionated Movement Deficit
Movement Pattern Coordination Deficit
Force Production Deficit

impaired motor control related to **lack of** arousal, attention, or ability to apply **meaning** to situation that is appropriate for age.

- Lack of arousal
- Lack of response to stimuli
- Absent attention to examiner and situation
- Absent ability to apply meaning to situation

(Sheets et al., 2015)

So why use Movement System Diagnoses

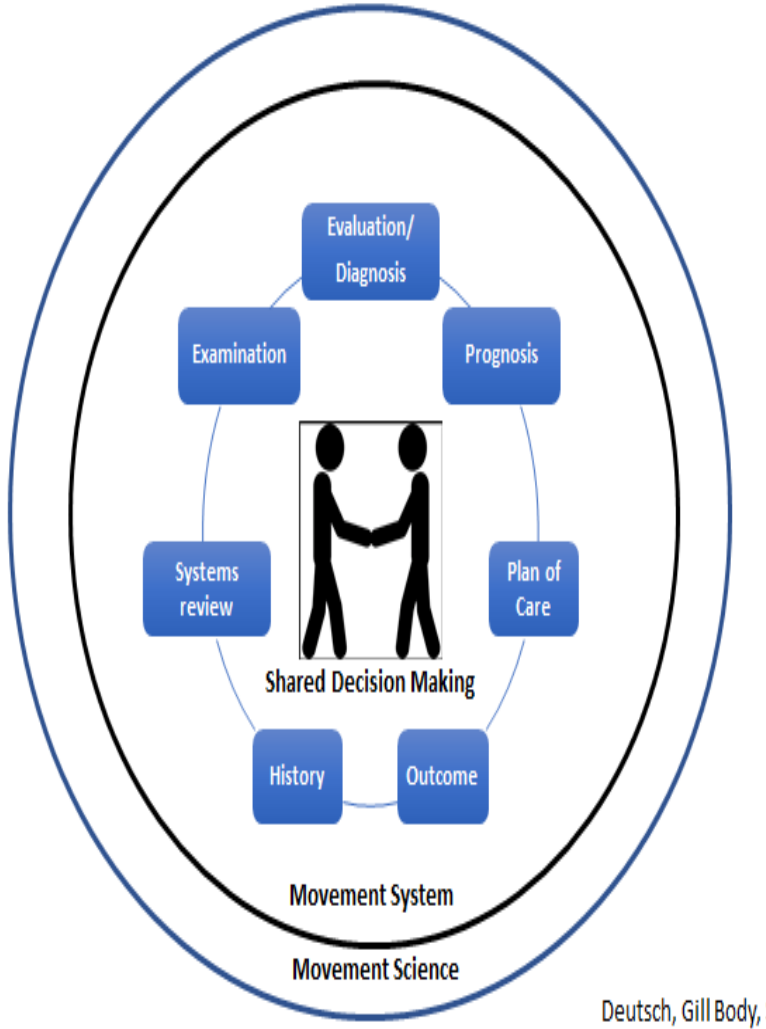
Offers a consistent method and language for establishing **pattern recognition** of movement system issues across all setting and populations

Affords a more **systematic study** of intervention outcomes based upon MSDxs

Person-centered care

May enable the **characterization** of responders and non-responders when evaluating movement-related interventions effectiveness either in the clinic or in the research environment and can aide in the development of clinical (intervention) **prediction rules** (CPRs) and ultimately **guide clinical decision-making**.

Promote clarity specific to what is being observed, communicated and collaborated with the healthcare team, and lead to the **promotion of continuity of care**.



Deutsch, Gill Body, Schenkman 2018



Insight generation

What led you to your **insights** about the areas impacting the individual's function?

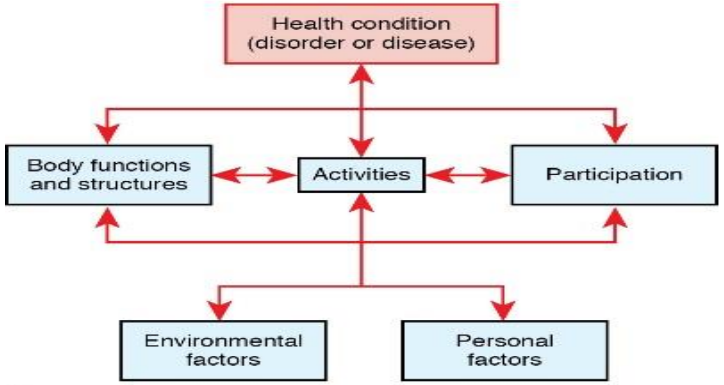
How confident are you about your decision making process used?

How would you **define and defend** your insights to another health professional?

Apples OR Oranges?





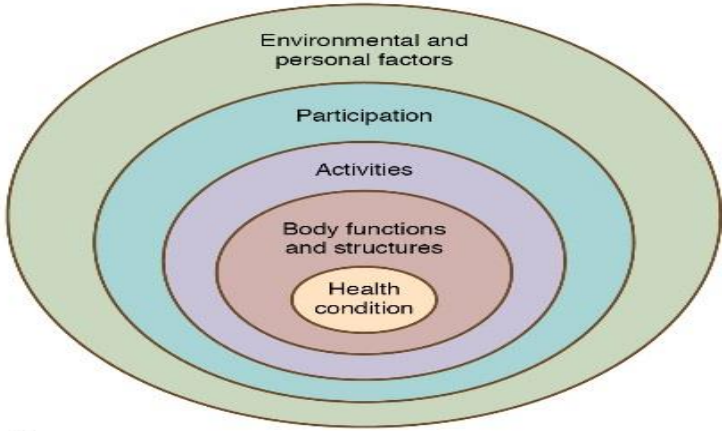


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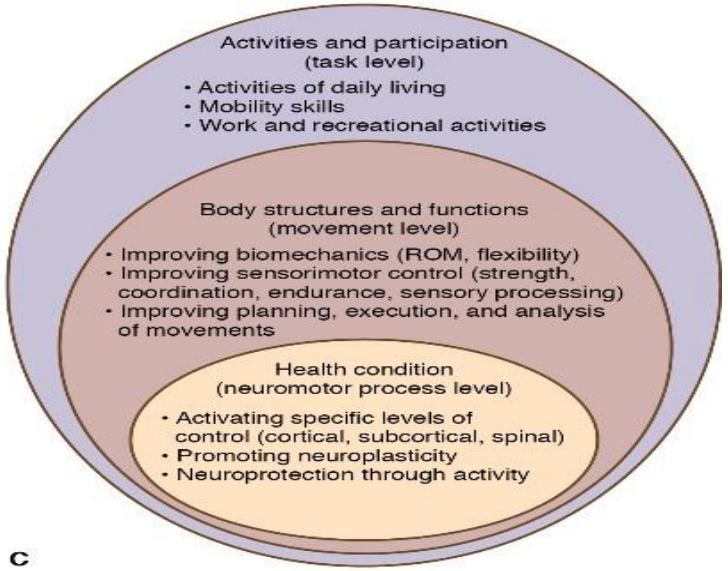
Many to One







B



C

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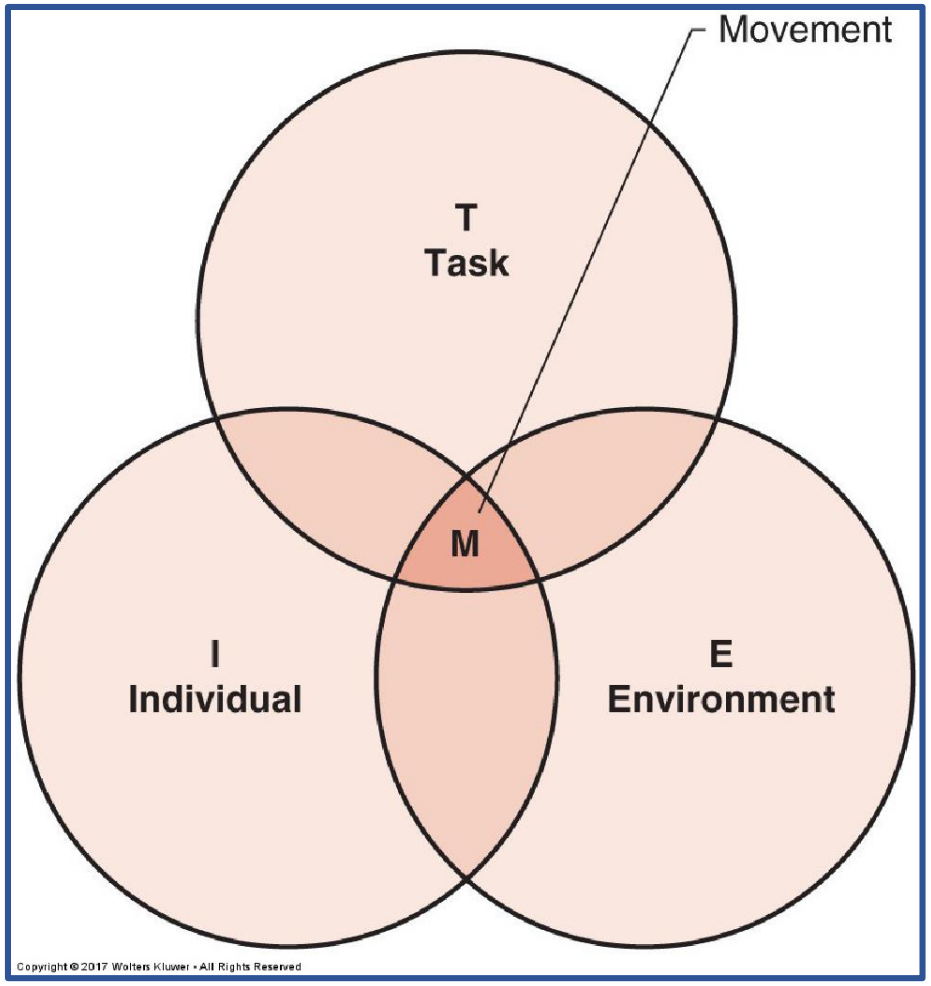
Key Principles of Dynamic Systems Theory (DST)

Movement occurs through

- **dynamic interaction of many systems,**
- that are **constrained** by the characteristics of the individual, the task being performed and the environment in which the movement occurs.

Major component of attaining functional competence is learning

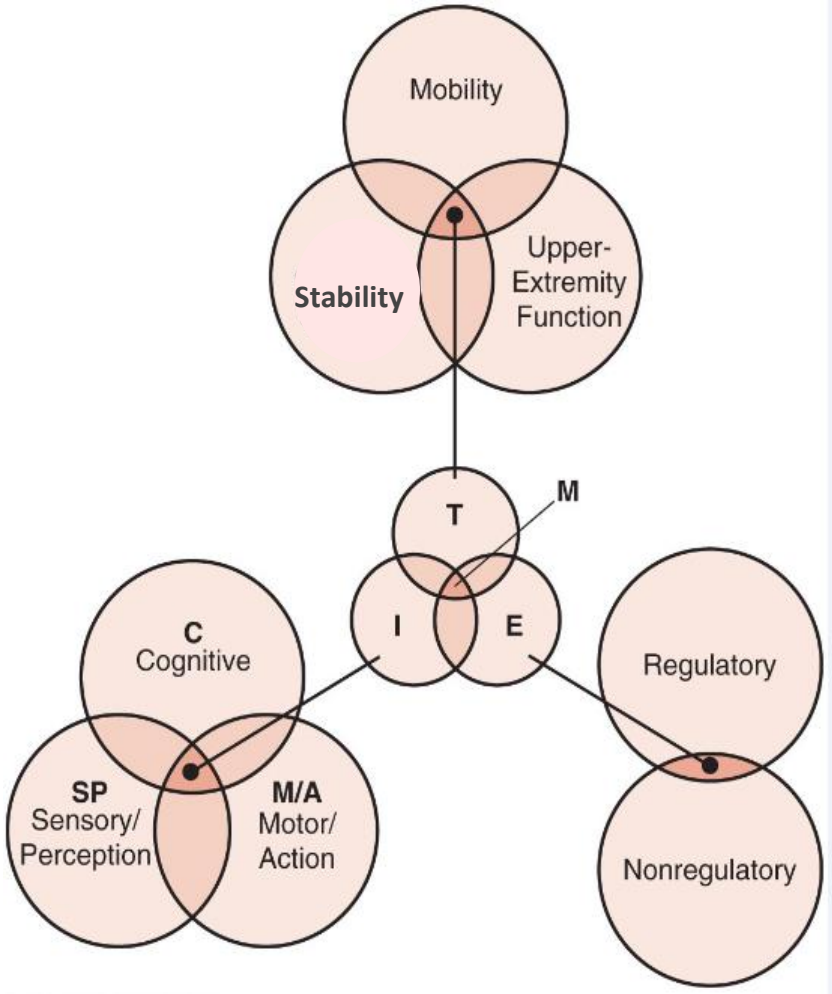
- nature of one's self-organizing movement system
- current intrinsic constraints

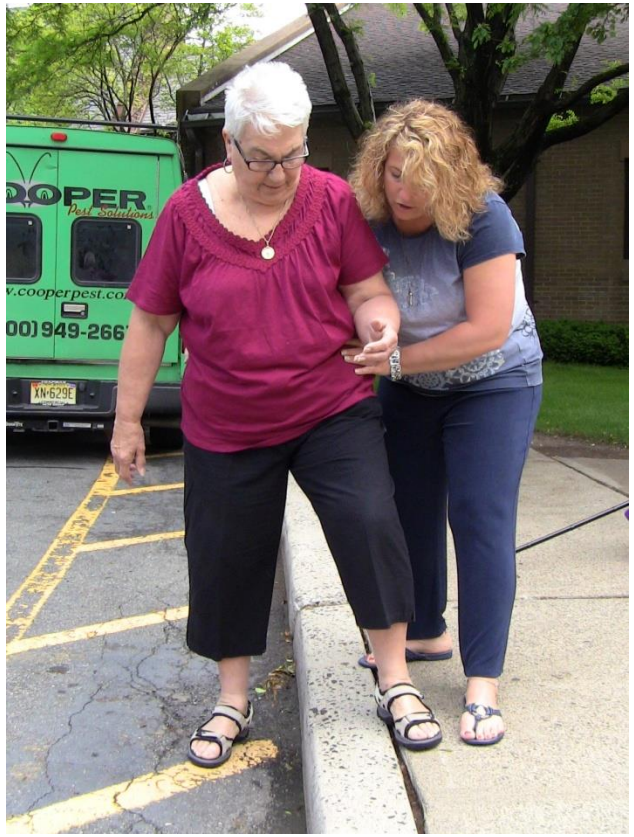


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we must consider all variables that contribute to motor control







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Integration

Movement System Diagnoses

- Movement pattern coordination deficit
- Force production deficit
- Sensory detection deficit
- Sensory selection and weighting deficit
- Postural vertical deficit
- Fractioned Movement deficit
- Dysmetria
- Hypokinesia
- Cognitive Deficit

Task

- Rolling
- Lying to sit to lying
- Sit to stand to sit
- Squatting/Bending

- Crawling/Walking/
- Running/Wheelchair
- Step up and step down

- Reaching
- Grasping
- Manipulating
- Lifting

Temporal Criteria

- Initial condition
- Preparation
- Initiation
- Execution
- Termination

for insight generation

TASK		Temporal Criteria	Movement pattern coordination deficit	Force production deficit	Sensory detection deficit	Sensory selection and weighting deficit	Postural Vertical deficit	Fractioned Movement deficit	Hypermetria	Hypokinesia	Cognitive Deficit	INTERVENTION	OUTCOME
	Action Function · Body stability · *Body transport* · No object manipulation · *Object manipulation* Environmental Context · Regulatory conditions stationary · *RC In motion* · No inter-trial variability · *Inter-trial variability*	Initial condition Preparation Initiation Execution Termination											

Gathering Insights
Using Task-Driven Approach
to Movement Analysis

Task Goal: “Walk unassisted outdoors and in crowded areas.”

Component Activities and Relevant Movements:

- ❑ Walk in different directions, turn in different directions, stop/start
- ❑ Walk on various terrain and navigate surface changes and obstacles
- ❑ Scan environment (move eyes & head) and adjust direction & speed of walking under different environmental conditions (lighting, stationary vs. moving, space)
- ❑ Walk and talk, walk and carry objects (dual task)
- ❑ Open and close doors

Movement Analysis:

Ambulation, Stair ascent & descent, Sit to stand, walking, floor to stand, bending, reach/grasp/turn/push

Generate Hypothesis

Can we use this framework to *gather insights and generate hypothesis* for the pediatric client?

TASK		Temporal Criteria	Movement pattern coordination deficit	Force production deficit	Sensory detection deficit	Sensory selection and weighting deficit	Postural Vertical deficit	Fractioned Movement deficit	Hypermetria	Hypokinesia	Cognitive Deficit	INTERVENTION	OUTCOME
	Action Function · Body stability · *Body transport* · No object manipulation · *Object manipulation* Environmental Context · Regulatory conditions stationary · *RC In motion* · No inter-trial variability · *Inter-trial variability*	Initial condition Preparation Initiation Execution Termination											

So what?

- ❑ **Clarity**
- ❑ **Communication**
- ❑ **Collaboration**
- ❑ **Continuity**

- ❑ **IDENTITY**



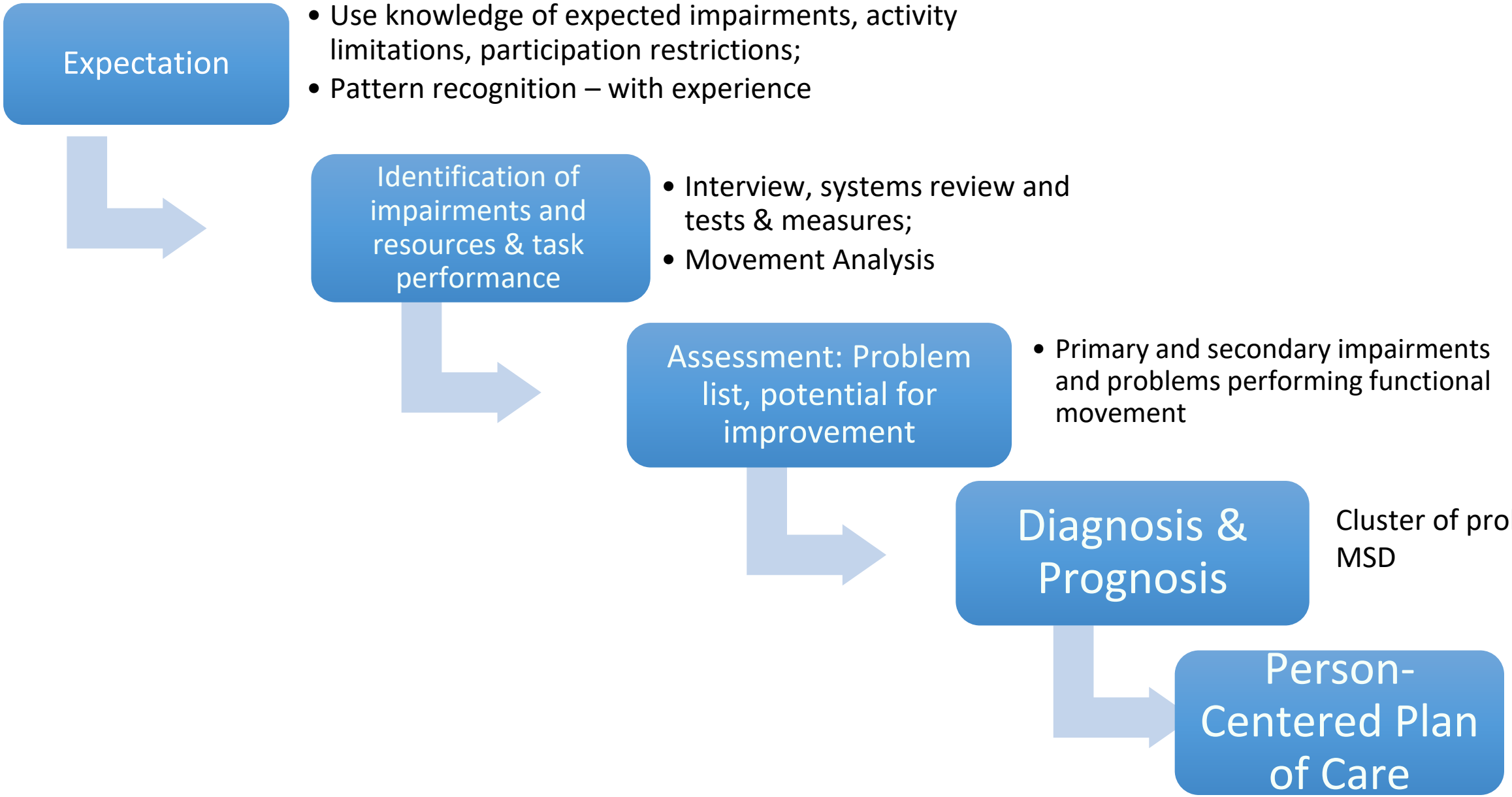




IV. Framework to guide therapists in integrating MSDxs and Functional Upright Mobility Activities

Exploring and Exploiting




Expectation
• Use knowledge of expected impairments, activity limitations, participation restrictions;
• Pattern recognition – with experience
Identification of impairments and resources & task performance
• Interview, systems review and tests & measures;
• Movement Analysis
Assessment: Problem list, potential for improvement
• Primary and secondary impairments and problems performing functional movement
Diagnosis & Prognosis
Cluster of problems MSD
Person-Centered Plan of Care

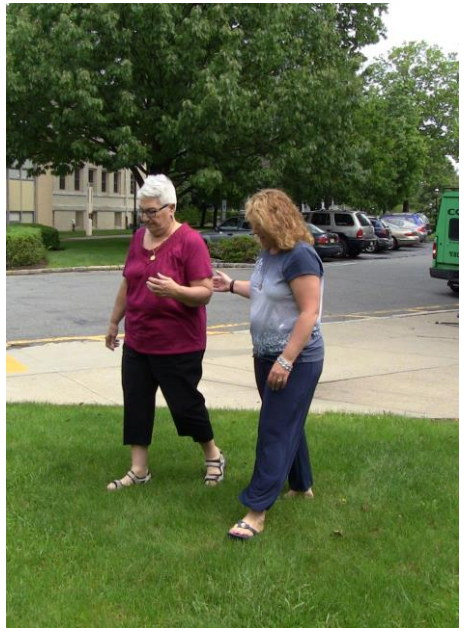
Retraining upright mobility includes three broad areas of rehabilitation

1. Therapeutic exercise/Direct Interventions to **address** identifying underlying impairments,
2. Functional training that is task specific and personally **meaningful**,
3. The use of devices and equipment to augment or support func**tional ability**
   - Especially in context of permanent deficits

Eclectic approach- maximize functional independence

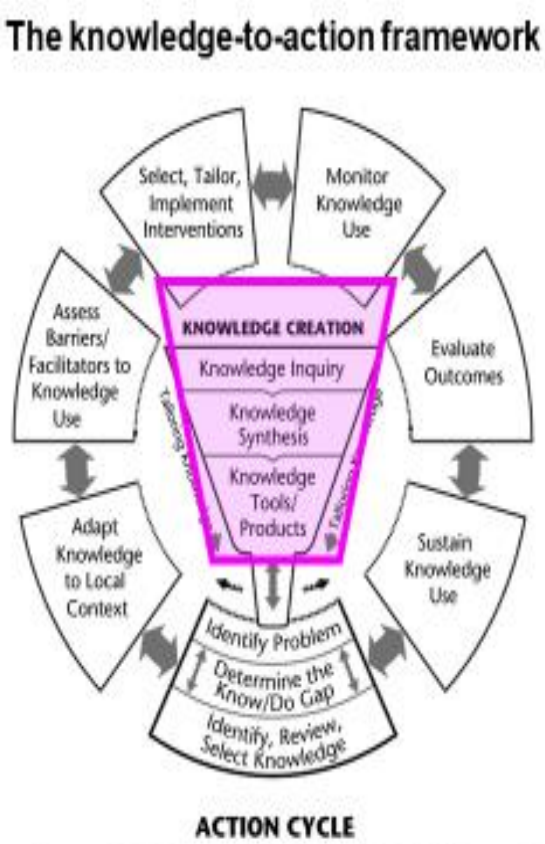
- Balancing Remediation & Compensation Models
- Exploiting Neural Plasticity
- Promoting Motor Control via Principles of Motor Learning







Embracing Knowledge Translation Practices



Straus SE, Tetroe J, Graham ID, 2nd Edition. 2013.
Knowledge Translation in Health Care: Moving From Evidence to Practice

Aids us in our questioning:

- **What** type of exercise- with what degree of intensity, for how long, and in what specific position- is best?
- **How** should I intentionally progress these exercises and activities to place optimal demand on the system for optimal improvement?

Clinical practice guideline to improve locomotor function following chronic stroke, incomplete spinal cord injury and brain injury

T. George Hornby, Darcy S. Reisman, Irene G. Ward, Patricia L. Scheets, Allison Miller, David Haddad and the Locomotor CPG Appraisal Team.

Collaborators: Emily J. Fox7, Nora E. Fritz8, Kelly Hawkins7, Christopher E. Henderson1, Kathryn L. Hendron9, Carey L. Holleran10, James E. Lynskey11, Amber Walter12

"Results: Strong evidence indicates that clinicians should offer walking training at moderate to high intensities or virtual reality (VR)-based training to individuals with stroke, iSCI, and TBI to improve walking speed or distance. In contrast, weak evidence suggests that strength training, circuit (i.e., combined) training or cycling training at moderate to high intensities, and VR-based balance training may improve walking speed and distance. Finally, strong evidence suggests body-weight supported treadmill training, robotic-assisted training, or sitting/standing balance training without VR should not be performed to improve walking speed or distance."

Underlying Concepts Directing Approaches

- Experience-dependent neuroplasticity

- Motor-learning principles
  - Repetitions (without repetition)
  - Practice environment (functional/meaningful)
  - Feedback (purposeful)

10 principles to encourage experience-dependent plasticity (Kleim, 2010)

TABLE 14-2. Principles of Experience-Dependent Plasticity	
PRINCIPLE	**DESCRIPTION**
1. Use It or Lose It	Failure to drive specific brain function can lead to functional degradation.
2. Use It and Improve It	Training that drives a specific brain function can lead to an enhancement of that function.
3. Specificity	The nature of the training experience dictates the nature of the plasticity.
4. Repetition Matters	Induction of plasticity requires sufficient repetition.
5. Intensity Matters	Induction of plasticity requires sufficient training intensity.
6. Time Matters	Different forms of plasticity occur at different times during training.
7. Salience Matters	The training experience must be sufficiently salient to induce plasticity.
8. Age Matters	Training-induced plasticity occurs more readily in younger brains.
9. Transference	Plasticity in response to one training experience can enhance the acquisition of similar behaviors.
10. Interference	Plasticity in response to one experience can interfere with the acquisition of other behaviors.

Principles of Locomotor Training from IV-STEP

- Activity-based therapy (Behrman, JNPT 2017)
- Locomotor Training Principles (Harkema, “Locomotor Training” text 2011)

  i. Maximize weight bearing on the legs (Principle 1)
  ii. Optimize sensory cues (Principle 2)
  iii. Optimize the kinematics (i.e. trunk, pelvis, and lower extremities) for each motor task (Principle 3)
  iv. Maximize recovery strategies, minimize compensation strategies (Principle 4)
- Task-specific training

Principles of Locomotor Training from IV-STEP

- Areas of Progression
  a. Endurance
  b. Speed
  c. Weight-Bearing (Load)
  d. Independence

Exploring Therapeutic Activities to Improve Upright Mobility

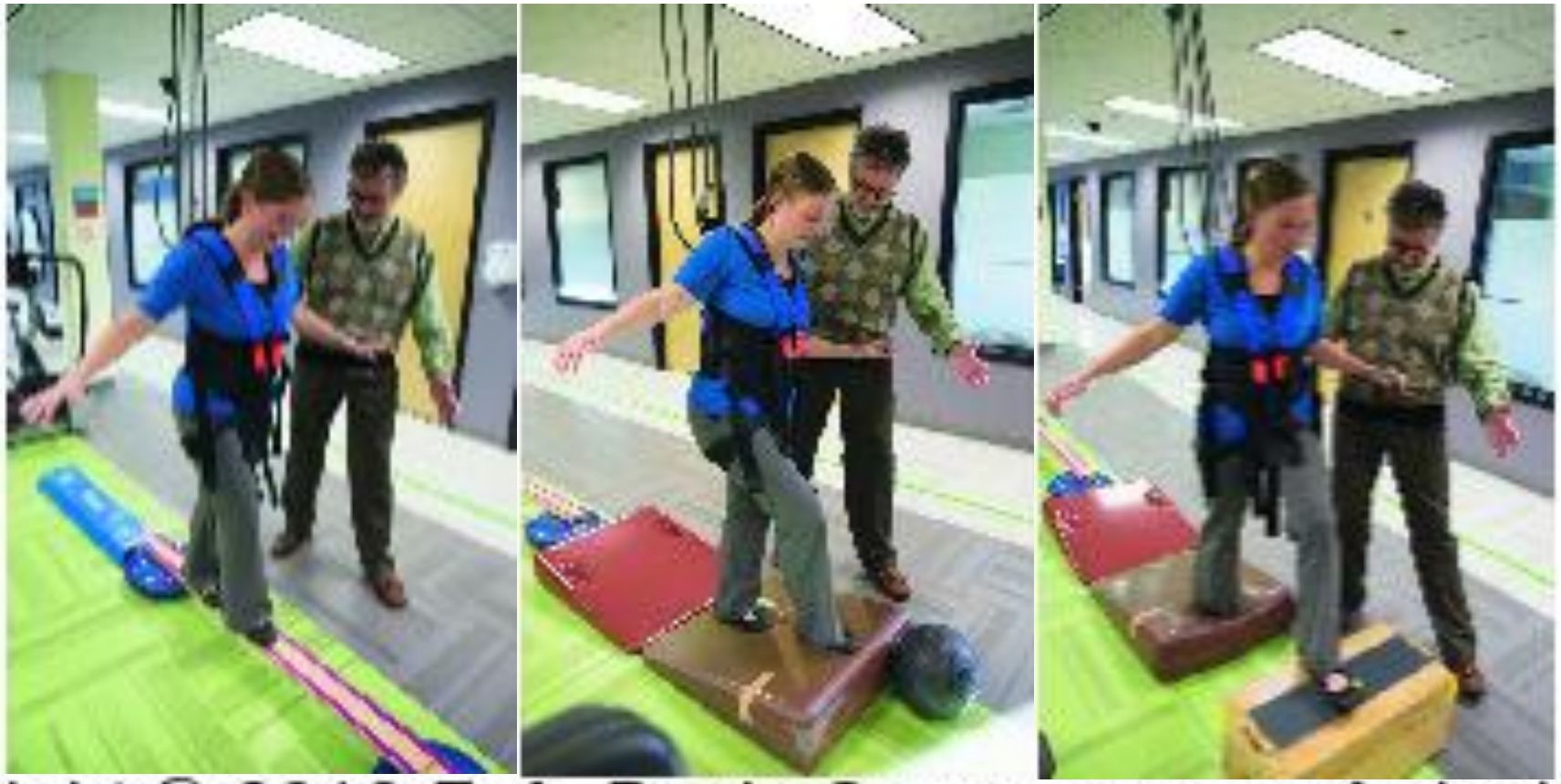
- BWS, BWSTT
- Exoskeleton-Assisted
- Virtual Reality/Gaming
- Complex Walking Activities
- Attention and Dual Task Control

Body-weight support



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Body-weight support: overhead ceiling harness (Fell, Figure 37-8)



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Exoskeleton-assisted gait training



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Virtual Reality / Gaming

- Can result in robust clinical improvement of function (esp UE)
- Questions of availability and access for clinical practice
- May complement other rehab interventions

Complex Walking Activities

- Adapt movement strategies to more challenging, unpredictable conditions
- Explore internally & externally driven task demands

TABLE 37-6 Locomotor Adaptation Under Eight Environmental Dimensions Associated With Community Mobility

DIMENSIONS	
Distance Temporal characteristics Ambient features Terrain Physical load Postural transitions Attentional demands Avoidance awareness	*Systematically vary the complexity of a walking activity by modifying these 8 dimensions individually and concurrently*

Adapted from Patla A, Shumway-Cook A. Dimensions of mobility: Defining the complexity and difficulty associated with community mobility. *J Aging Phys Act.* 1999b;7:7–19.

Simpkins, S., Pinto Zipp, G. & Fells, D. (2018). Functional Activities in Upright Mobility. In: D.W. Fell (Ed.), *Concepts & Principles of Neurologic Therapy.* New York: Davis Hall. ISBN-13: 978-0-8036-4609-4

Simpkins, S., Pinto Zipp, G. & Fells, D. (2018). Functional Activities in Upright Mobility. In: D.W. Fell (Ed.), *Concepts & Principles of Neurologic Therapy*. New York: Davis Hall. ISBN-13: 978-0-8036-4609-4

TABLE 37-7 Functional Task-Oriented Activities for Training Upright Mobility

TASK	MODIFICATION/PROGRESSION TO VARY TASK COMPLEXITY	EXAMPLE OF LOW COMPLEXITY → HIGH COMPLEXITY
Pointing with foot: • Position foot (dorsiflexion [DF] or plantar flexion [PF]), specified hip, and knee to make contact with **an object**	• Incorporate variability in object size, shape, and distance from individual, stationary, or moving object, with or without upper extremity (UE) support unilaterally or bilaterally • Incorporate modifications to speed, vision, and attentional demands; degree of intertrial variability; externally or internally paced, continuous, or noncontinuous performance	**A stationary object → a moving object**
Sliding the foot: • Position of the foot (DF or PF), specified hip, and knee for **directional sliding**	• Incorporate variability in direction, required distance traveled of the sliding foot from the stationary foot, with or without UE support unilaterally or bilaterally • Incorporate modifications to speed, vision, and attentional demands; degree of intertrial variability; externally or internally paced, continuous, or noncontinuous performance	**One-directional sliding → bidirectional sliding**
Standing reach with point/grasp: Pointing to or grasping **an object**	• Incorporate variability in object size, shape, and distance from individual; stationary or moving object; position of feet (tandem, narrow, or wide base of support); specified hip and knee position; unidirectional, bidirectional, unilateral, or bilateral reaching; required distance traveled of the reaching arm, with or without UE support unilaterally or bilaterally • Incorporate modifications to speed, surface firmness, vision, and attentional demands; degree of intertrial variability; externally or internally paced, continuous, or noncontinuous performance	**Stationary object → moving object**

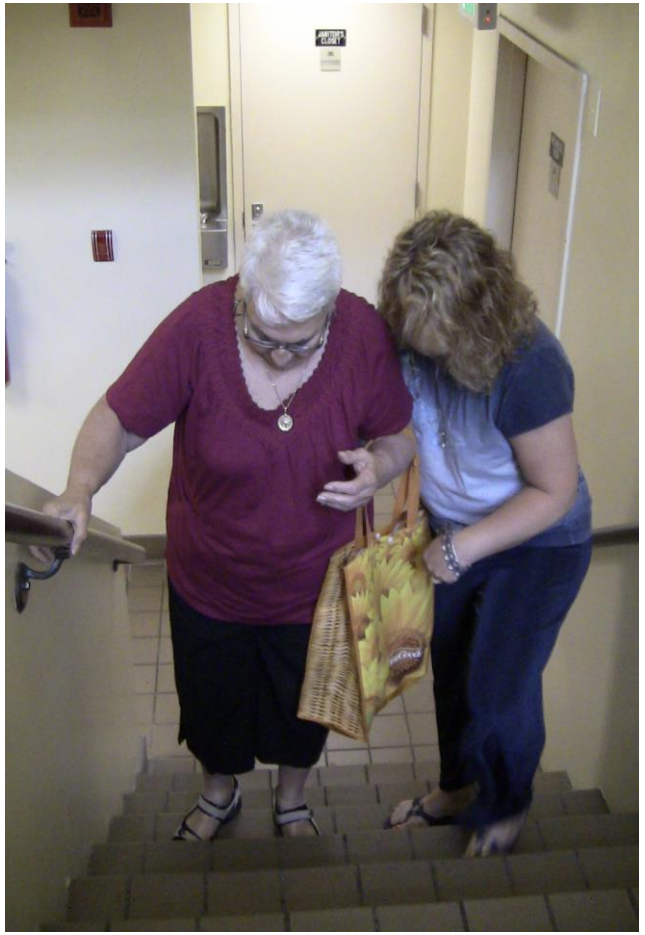
Simpkins, S., Pinto Zipp, G. & Fells, D. (2018). Functional Activities in Upright Mobility. In: D.W. Fell (Ed.), *Concepts & Principles of Neurologic Therapy*. New York: Davis Hall. ISBN-13: 978-0-8036-4609-4

Lifting: Lifting **an object**	• Incorporate variability in object size, shape, weight, and distance from individual; stationary or moving object; position of feet (tandem, narrow or wide base of support); specified hip and knee position; unidirectional, bidirectional, unilateral or bilateral lifting; required distance traveled of the reaching arm, with or without UE support unilaterally or bilaterally • Incorporate modifications to speed, vision, and attentional demands; degree of intertrial variability; externally or internally paced, continuous, or noncontinuous performance	**Stationary object → moving object**
Pushing: Pushing **an object**	• Incorporate variability in object size, weight, shape and distance from individual; stationary or moving object; position of feet (tandem, narrow, or wide base of support); specified hip and knee position; unidirectional or bidirectional stepping; unilateral or bilateral lifting; required distance traveled pushing, with or without UE support unilaterally or bilaterally • Incorporate modifications to speed, vision, and attentional demands; degree of intertrial variability; externally or internally paced, continuous, or noncontinuous performance	**Stationary object → moving object**
Pulling: Pulling **an object**	• Incorporate variability in object size, weight, shape and distance from individual; stationary or moving object; position of feet (tandem, narrow or wide base of support); specified hip and knee position; unidirectional or bidirectional stepping; unilateral or bilateral lifting; required distance traveled pulling, with or without UE support, unilaterally or bilaterally • Incorporate modifications to speed, vision, and attentional demands; degree of intertrial variability; externally or internally paced, continuous, or noncontinuous performance	**Stationary object → moving object**

Dual tasking
“subtle changes impacting MS and function”







Simpkins, S., Pinto Zipp, G. & Fells, D. (2018). Functional Activities in Upright Mobility. In: D.W. Fell (Ed.), *Concepts & Principles of Neurologic Therapy.* New York: Davis Hall. ISBN-13: 978-0-8036-4609-4

TABLE 37-8 Dual Task Motor Skill Categorization Using Gentile's Taxonomy of Motor Skills (With Upright-Mobility Examples)

ACTION FUNCTION	BODY STABILITY		BODY TRANSPORT	
	No Object Manipulation	*Object Manipulation*	*No Object Manipulation*	*Object Manipulation*
Environmental Context				
Stationary regulatory conditions No intertrial variability	Standing and reading a sign	Standing in front of a TV pressing the "Enter" button on a TV remote	Walking and reading a sign	Walking and pressing the "Enter" button on a TV remote
Stationary regulatory conditions / Intertrial variability	Standing on a variety of surfaces reading a sign	Sitting in front of a TV on a stool playing an interactive video game with a handheld remote control	Walking on a variety of surfaces and reading a sign	Walking on a variety of surfaces and texting on a cell phone
In-motion regulatory conditions No intertrial variability	Walking on an inclined treadmill with consistent speed while talking on a hands-free cell phone	Walking on an inclined treadmill with constant speed while talking on a handheld cell phone	Walking in a shopping mall with a friend while carrying on a conversation	Walking in a shopping mall with a friend while carrying on a conversation and carrying shopping bags
In-motion regulatory conditions Intertrial variability	Walking on an inclined treadmill with speed varied by a trainer while talking on a hands-free cell phone	Walking on an inclined treadmill with speed varied by a trainer while talking on a handheld cell phone	Walking in a crowded shopping mall with a group of friends while carrying on a conversation	Walking in a crowded shopping mall with a group of friends while carrying on a conversation and carrying shopping bags

Simpkins, S., Pinto Zipp, G. & Fells, D. (2018). Functional Activities in Upright Mobility. In: D.W. Fell (Ed.), *Concepts & Principles of Neurologic Therapy.* New York: Davis Hall. ISBN-13: 978-0-8036-4609-4

TABLE 37-9 Secondary Tasks That Can Be Part of a Dual Task Intervention

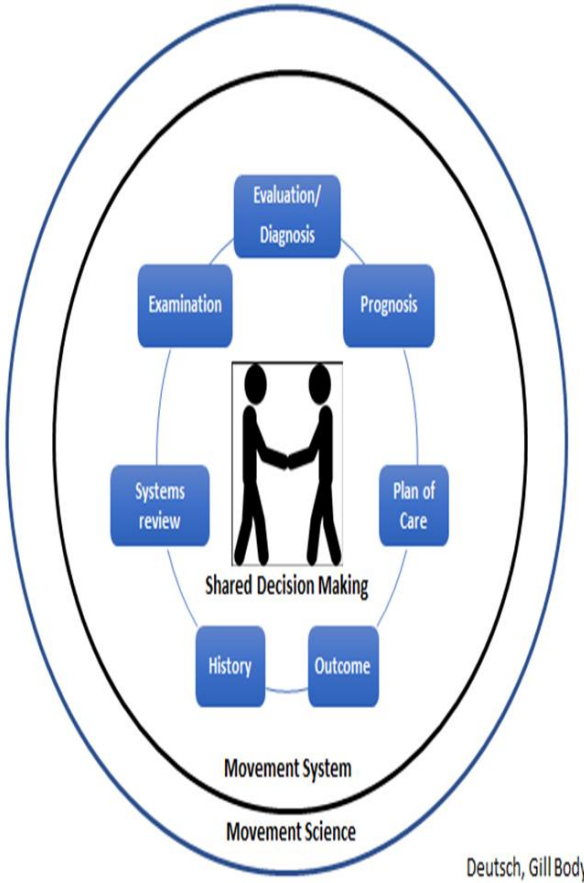
SECONDARY COGNITIVE TASKS	SECONDARY PHYSICAL/MOTOR TASKS
• Continuously repeat a simple phrase: "Where is the child?" (Morris, 1996) • Repeat the word "Apple apple, apple…" with one syllable per step while walking (which the patient can match to the cadence) • Repeat the word "Banana banana banana…" with one syllable per step while walking (which does not match a right-left cadence as easily) • Identify shapes or common objects (dog, comb, cat…) from photo cue cards (Huang, 2003) • Identify environmental sounds (cow, whistle, bird, doorbell) from a sound effects CD (Huang 2003)	• Coin transference: use the hand to transfer coins from one pocket across the midline to the opposite pocket (O'Shea, 2002)
• Ask the patient to talk (answer questions or carry on a conversation) while walking • Progress to asking more complex questions • Listing tasks (80s movies, fruits, etc.)	• Read a sign on the wall while walking
• Counting forward 1–10 • Progress to counting backward from 100 • Progress to counting backward from 100 by sevens (100, 93, 86, 79…) or counting backward by threes starting at a random number between 20 and 100 (e.g., 46, 43, 40, 37, 34, 31…) (Shumway-Cook, 2000a)	• Carry a glass in the hand (start with an empty glass) • Progress to carrying the glass half-full of water • Progress ultimately to carrying the glass full of water (Lundin-Olsson, 1998, Shumway-Cook, 2000a)

Simpkins, S., Pinto Zipp, G. & Fells, D. (2018). Functional Activities in Upright Mobility. In: D.W. Fell (Ed.), *Concepts & Principles of Neurologic Therapy.* New York: Davis Hall. ISBN-13: 978-0-8036-4609-4

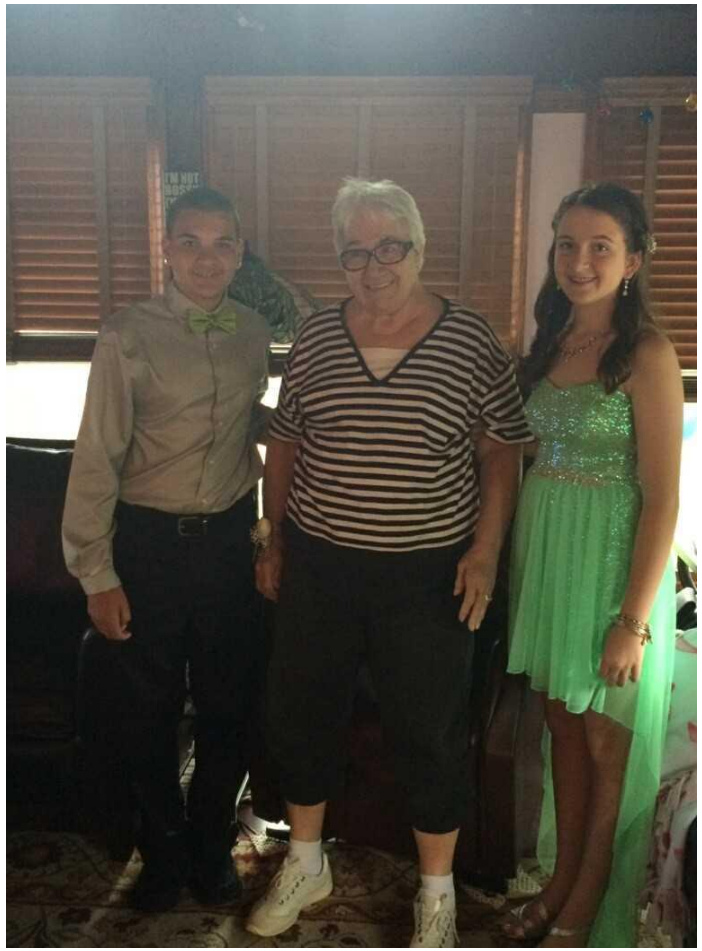
TABLE 37-9 Secondary Tasks That Can Be Part of a Dual Task Intervention—cont'd

SECONDARY COGNITIVE TASKS	SECONDARY PHYSICAL/MOTOR TASKS
• Digit recall/digit span: repeat a sequence of random single-digit numbers forward • Start with two digits and progress up to eight • Progress to backward digit recall, asking the patient to repeat the digits but in reverse order • Repeat the days of the week in reverse order beginning with Sunday (Morris, 1996)	• Carry a tray • Progress to carrying a tray with items on it, including ultimately unstable items that roll around or a glass full of water • Carry an empty backpack and then increase the weight while carrying the backpack over bilateral shoulders or one shoulder (Bond, 2000; Canning 2005)
• Traffic light color verbal response (when shown a color, verbally state what you are expected to do at that color when crossing the street while maintaining your posture) (Pinto Zipp, 2006)	• Use a cell phone while walking (combines the motor task of holding the phone to the ear and the cognitive task of problem-solving about the call and conversation)
• Modified Stroop test: present subjects with printed color names (the words), but printed in a variety of colors of ink (i.e., ink color is always inconsistent with the color name; for example, the word "blue" may be printed in red ink). The patient is asked to verbally state the color of the ink, ignoring the word (i.e., the color name) (Jensen, 1966; Stroop, 1935).	• Video game manipulation (Pinto Zipp, 2011)

Take Home Message



Deutsch, Gill Body, Schenkman 2018



Movement Specialists
Key is to Promote

- knowledge translation for person-centered care
- practice of functional tasks throughout the day using optimal patterns of movement

4 C's

Clarity, Communication, Collaboration, Continuity


QUESTIONS

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