

# **MOVEMENT SYSTEM DIAGNOSES NEUROMUSCULAR CONDITIONS**

## **Examination**

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Updated from Scheets PL, Sahrman SA, Norton BJ, Stith JS, Crouner BE. What is backward disequilibrium and how do I treat it? A complex patient case study. J Neurol Phys Ther. 2015 Apr;39(2):119-26 (Appendix).

## **Introduction**

The following examination items are those that are needed to make a movement system diagnosis for neuromuscular patients. The examination is a combinatorial examination (all tests must be considered together) and is focused on movement system deficits that impact upper and lower extremity functions. There is a combination of analysis of performance of key tasks and traditional tests for impairments. There are screening tests for musculoskeletal (mechanical) pain problems and cardiopulmonary problems, however, these tests are insufficient for making movement system diagnoses in these areas. Positive results on these screening tests should prompt the therapist to examine the cardiopulmonary and musculoskeletal areas more closely.

The examination focuses on movement system aspects of the patient's presentation only. The examination does not include tests that measure prior function, care giver burden, or personal and environment factors that are considered when managing an entire case. Likewise, the examination does not include all tasks or activities that may be of interest to the patient. This examination only consists of tests that are believed to be diagnostic in determining a movement system diagnosis.

The examination consists of observational task analysis of tasks which we believe to be diagnostic for our purposes and tests for impairments. Most of the impairment tests we use in this examination are standard parts of physical therapy practice. Consequently, we have not described how to perform these tests in detail. We have provided interpretive comments that relate the test result to the diagnostic process. We have 2 specific impairment tests, the Motorneuron Response Assessment and the Fractionated Movement tests which are not traditional impairment tests. The detailed instructions for these tests are provided in the appendix to this document.

The examination describes the tests as they are performed on an adult patient. We believe that the diagnostic categories are relevant to the pediatric population, however, the examination procedures with the pediatric patient need to be modified to be consistent with a child's ability to follow instructions, e.g. deriving information about strength, fractionated movement, and non-equilibrium coordination from observations of play and other movement behaviors rather than from specific testing. Similarly, the specific tasks used in the Task Analysis portion of the examination may need to be modified to reflect a particular child's functional performance. Tasks that require force generating capacity, capacity to stabilize in a static position, timing of postural responses during base of support transitions, and capacity to stabilize under varying sensory conditions will provide the most information about the child's movement system performance.

The examination does not include specific outcome assessment tools. We highly encourage the use of these tools in documenting patient status; however, they are generally not designed to identify specific movement system faults affecting a patient's overall performance.

There is a sample clinical form in the Appendix to this document that illustrates how to implement the examination elements into practice.

## History/Systems Review

From the patient and/or the medical record, obtain the following information:

- medical diagnosis(es)
- medical treatments which have an effect on muscle, nerve, or movement
- prior level of function including use of assistive devices (what and how long)
- complaint of motion sensitivity such as dizziness watching television, in crowds, or with driving

## Objective

### TASK ANALYSIS

Analysis of mobility consists of systematic observation of the kinematic changes that occur during changes in position or alignment. These changes in angles and displacement of limbs and limb segments are the movement components of a task. While we appreciate that there are many movement patterns that a patient may use to be successful in completing a task, we have identified essential movement components for each task. We believe that the essential movement components describe the movement pattern for each task that is the most common, potentially the most efficient given the demands of the task, and the least likely to produce unnecessary stress on the musculoskeletal system.

We have included in the examination, those tasks on which we believe patients of different types perform differently. Our purpose is not to examine every task that a person needs to perform in everyday life, but rather, to examine those tasks we feel are necessary in order to diagnose the patient's movement system problem.

The tasks that are included in the examination are:

- quiet sitting
- sit to stand
- quiet standing
- standing feet together
- step-up
- gait
- complex gait

And for patients with primary upper extremity involvement:

- reach
- grasp
- in-hand manipulation

Additional tasks may be needed to identify deficits, especially for higher level adult patients and in children. This additional testing may especially be necessary when making distinctions among patients with Movement Pattern Coordination Deficit, Force Production Deficit, or Sensory Selection and Weighting Deficit. Examples of these tasks in adults might include:

- Standing on foam
- Standing on a tilt board
- Standing on a narrow beam
- Stair climbing
- Walking on heels and toes

Examples of additional or substitute tasks in children might include:

- Prone on elbows
- Rolling
- Pull to sit
- Creeping
- Floor to stand
- Running
- Jumping
- Hopping

Analysis of movement tasks in phases is useful for precise systematic observation. For all mobility tasks, the tester must observe all 3 of the following phases:

Initiation	those changes that occur in order to overcome inertia of the body at rest
Execution	intersegmental movements that allow for the movement of COM into a new position
Termination	those changes that occur to decelerate the movement of the COM as the body stabilizes into a new position

The following is a description of how to perform the examination of each task followed by guidelines for interpreting the test results. It is important to remember that this is a combinatorial examination. No one test determines the diagnosis but rather, it is the collection of examination results that are important.

### Quiet Sitting:

#### Testing Procedures:

1. Ask the patient to sit quietly with feet supported, arms resting quietly, equal weight bearing on left and right hips, and hips flexed and lumbar spine in slight extension, eyes open, and head up for 30 seconds.

Ask the patient to sit in his most upright posture possible. If the patient has structural deformities such as thoracic kyphosis, scoliosis, etc. note them and use his most upright posture possible (structurally) as the position you are asking him to hold for the 30 seconds.

2. Observe the first attempt and note presence or absence of essential movement components of task:<sup>1</sup>
  - feet and knees hip width apart
  - weight evenly distributed
  - flexion of hips with extension of trunk
  - head balanced on level shoulders
  - trunk still (no oscillation)
3. Give the patient cues and manual guidance to assist with missing components. Allow for 3-4 attempts noting improvement in performance of missing components.

Appropriate cues may include, but are not limited to, the following:

- “keep even pressure on both hips “
- “keep shoulders in line over hips”
- “look straight ahead and stare at ( ) on the wall”
- “relax your arms at your sides”

Manual guidance should be proximal. Patients should be discouraged from using UE to maintain sitting.

#### Quiet Sitting

Observation	Interpretation
gross abnormality; COM shifted significantly from midline	<ul style="list-style-type: none"> <li>▪ Biomechanical deficit (modifier)</li> </ul>
unable to sit unsupported; appears weak; would fall without support	<ul style="list-style-type: none"> <li>▪ Force Production Deficit (FPD)</li> <li>▪ Sensory Detection Deficit</li> </ul>
sits asymmetrically; may require assistance but only minimal	<ul style="list-style-type: none"> <li>▪ FPD if not impacting trunk musculature</li> <li>▪ Fractionated Movement Deficit</li> <li>▪ Sensory Selection and Weighting Deficit</li> </ul>

Observation	Interpretation
sits with center of mass lateral or posterior to midline and resists correction of altered midline position or loss of balance	<ul style="list-style-type: none"> <li>▪ Postural Vertical Deficit</li> </ul>
sits with center of mass posterior to midline and demonstrates stiffness and/or slowness with correction	<ul style="list-style-type: none"> <li>▪ Hypokinesia</li> </ul>
improvement in performance with repetition/practice	<ul style="list-style-type: none"> <li>▪ Movement Pattern Coordination Deficit (MPCD)</li> <li>▪ Fractionated Movement Deficit</li> <li>▪ FPD</li> <li>▪ Sensory Selection and Weighting Deficit</li> </ul>
decrement in performance with repetition	<ul style="list-style-type: none"> <li>▪ FPD (may demonstrate brief initial improvement followed by decrement in performance)</li> </ul>
excessive sway at trunk; requires UE support; no improvement with practice	<ul style="list-style-type: none"> <li>▪ Dysmetria</li> </ul>

### Sit to Stand:

#### Testing Procedures:

1. Ask the patient to come to standing from bed or chair without UE support.
2. Position the patient so that the femoral-tibial angle is no greater than 110°, the buttocks are toward the edge of the surface, and the feet are on the floor as much as possible and hip width apart.
3. Observe first attempt and note presence or absence of essential components of task:<sup>24</sup>
  - feet on floor
  - hip flexion with lumbar and cervical extension
  - movement of knees forward during execution
  - extension of hips and knees for final standing alignment at termination
4. Give the patient cues and manual guidance to assist with missing components. Allow for 3-4 attempts noting improvement in performance of missing components.  
Appropriate cues may include, but are not limited to, the following:
  - “come to the edge of the chair”
  - “place feet flat on floor”
  - “bend forward at your hips”
  - “lift buttocks from chair”
  - “use your legs to stand”
  - “put pressure on the balls of your feet”
  - “do not let your toes come off of the floor”
  - “tuck your bottom under you”
  - “don’t pull back”

Manual guidance may be used to assist with the essential components of the task. Patients should not be allowed to pull themselves up using UEs.

5. If physical assistance is required, give only the assistance necessary at each phase. At each phase, relax or release the assistance at least momentarily and observe patient’s movement response.

## Sit to Stand

Observation		Interpretation
initiation	requires assistance to initiate lift of buttocks from chair; if support removed, patient falls rapidly into chair	<ul style="list-style-type: none"> <li>▪ FPD</li> </ul>
	unable to passively position feet appropriately resulting in a more challenging starting position; may require assistance	<ul style="list-style-type: none"> <li>▪ Biomechanical deficit (modifier)</li> </ul>
	lack of preparatory movements or very slow preparatory movements; may require assistance; if support removed, patient falls slowly into chair	<ul style="list-style-type: none"> <li>▪ Hypokinesia</li> </ul>
	abnormal movement synergy during preparatory movements	<ul style="list-style-type: none"> <li>▪ Fractionated Movement Deficit</li> </ul>
	increased BOS	<ul style="list-style-type: none"> <li>▪ FPD</li> <li>▪ Dysmetria</li> </ul>
	repeated efforts; momentum strategy	<ul style="list-style-type: none"> <li>▪ FPD</li> <li>▪ Hypokinesia</li> </ul>
	excessive trunk sway	<ul style="list-style-type: none"> <li>▪ Dysmetria</li> <li>▪ Sensory Detection Deficit</li> </ul>
	resists assistance of movement of trunk forward or in midline; pushes back or to side with UE	<ul style="list-style-type: none"> <li>▪ Postural Vertical Deficit</li> </ul>
execution	extends knees before hips in first half of movement sequence; may push on legs to extend trunk; may require assistance; if support removed segments rapidly fall in direction opposite of movement	<ul style="list-style-type: none"> <li>▪ FPD</li> <li>▪ Sensory Detection Deficit</li> </ul>
	requires assistance; associated with joint pain or stiffness	<ul style="list-style-type: none"> <li>▪ Biomechanical deficit (modifier)</li> </ul>
	arrest of ongoing movement; may require assistance	<ul style="list-style-type: none"> <li>▪ Hypokinesia</li> </ul>
	altered sequencing of segmental movement (most commonly insufficient DF of leg over foot); improves with guidance and practice	<ul style="list-style-type: none"> <li>▪ MPCD</li> </ul>
	shifts COM toward weaker side or back; resists correction; early PF of tibia relative to foot or may fix foot (feet) and push away; resists changes to strategy with practice and guidance	<ul style="list-style-type: none"> <li>▪ Postural Vertical Deficit</li> </ul>
	shifts COM to one side; improves with practice and instruction	<ul style="list-style-type: none"> <li>▪ Sensory Selection and Weighting Deficit</li> </ul>
	abnormal movement synergy in UE and/or LE; no change with guidance and practice	<ul style="list-style-type: none"> <li>▪ Fractionated Movement Deficit</li> </ul>
	excessive trunk sway	<ul style="list-style-type: none"> <li>▪ Dysmetria</li> </ul>
termination	sway at ankle; may require a step	<ul style="list-style-type: none"> <li>▪ MPCD</li> </ul>
	shifts COM toward weaker side or back; resists correction; may fix foot (feet) and push away	<ul style="list-style-type: none"> <li>▪ Postural Vertical Deficit</li> </ul>
	repeated stepping to find and maintain balance	<ul style="list-style-type: none"> <li>▪ Dysmetria</li> <li>▪ FPD</li> </ul>
	excessive trunk sway at hips	<ul style="list-style-type: none"> <li>▪ Dysmetria</li> </ul>

Observation		Interpretation
	Knee hyperextension against surface; improves with manual cues and instruction	▪ MPCD
	Knee hyperextension against surface; no change with manual cues and instruction	▪ FPD ▪ Sensory Detection Deficit
	Altered alignment of LE limb position; may require a step to find and maintain balance; no change in limb alignment with practice and guidance	▪ Fractionated Movement Deficit
	Slow and stiff in extending hips and knees; may sustain hip and knee flexion and need UE assist support to reach full extension	▪ Hypokinesia

### Quiet Standing (eyes open/closed):

#### Testing procedures:

1. Ask the patient to stand quietly with feet shoulder width apart, arms at sides, equal weight bearing on left and right, eyes open, and head up for 30 seconds.

Ask the patient to stand in his most upright posture possible. If the patient has structural deformities such as thoracic kyphosis, knee flexion contractures, etc. note them and use his most upright posture as the position you are asking him to hold for the 30 seconds.

Provide support at the patient's trunk until his feet are positioned and he appears to be in a stable position.

2. Observe the patient's first attempt to maintain the standing position and note the presence or absence of essential components of the task:<sup>24</sup>
  - feet under shoulders
  - hips in front of ankles
  - shoulders over hips
  - head balanced on level shoulders
  - erect trunk

3. Give the patient cues and manual guidance to assist with missing components. Allow for 3-4 attempts noting improvement in performance of missing components.

Appropriate cues may include, but are not limited to, the following:

- "keep even pressure on the balls of your feet"
- "keep shoulders in line over hips"
- "look straight ahead and stare at ( ) on the wall"
- "relax your arms at your sides"
- "let your legs support you"

Manual guidance should be proximal. Patients should be discouraged from using UE to maintain stance.

4. If the patient is able to hold the position with eyes open, while he is standing unsupported, ask him to close his eyes and hold for 15 seconds.

## Quiet Standing

Observation	Interpretation
unable to stand unsupported; appears weak; would fall without support	FPD
gross abnormality; COM shifted toward limits of stability	Biomechanical Deficit (modifier)
unable to maintain alignment at one or two segments; may appear worse the longer the patient attempts to stand	FPD
altered alignment of LE limb position; may require UE support or repeated stepping to maintain balance; slow with postural responses	<ul style="list-style-type: none"> <li>▪ Fractionated Movement Deficit</li> <li>▪ Hypokinesia</li> </ul>
hesitation or multiple efforts to assume position; improves with practice	MPCD
excessive sway at trunk/hips; repeated stepping to maintain balance; no change with practice or repetition	Dysmetria
shifts COM away from midline; resists correction	Postural Vertical Deficit
increased sway with eyes closed; improves with practice	MPCD
increased sway with eyes closed or loss of balance; no change with practice under this condition	Sensory Detection Deficit
loss of balance in a consistent direction; much increase in sway with eyes closed; improves with a visual target	Sensory Selection and Weighting Deficit

**Feet Together (eyes open/closed):**

Perform this test if the patient is successful with Quiet Standing with eyes open.

Testing procedures:

1. Ask the patient to stand quietly with feet touching at toes and heels, arms at sides, equal weight bearing on left and right, eyes open, and head up for 15 seconds.

Ask the patient to stand in his most upright posture possible. If the patient has structural deformities such as thoracic kyphosis, knee flexion contractures, etc. note them and use his most upright posture as the position you are asking him to hold for the 15 seconds.

Provide support at the patient's trunk until his feet are positioned and he appears to be in a stable position.

2. Observe the patient's first attempt to maintain the feet together position and note the presence or absence of essential components of the task:
  - feet together
  - hips in front of ankles
  - shoulders over hips
  - head balanced on level shoulders
  - erect trunk
3. Give the patient cues and manual guidance to assist with missing components. Allow for 3-4 attempts noting improvement in performance of missing components.

Appropriate cues may include, but are not limited to, the following:

- "keep even pressure on the balls of your feet"
- "keep shoulders in line over hips"
- "look straight ahead and stare at ( ) on the wall"
- "relax your arms at your sides"

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- “let your legs support you.”

Manual guidance should be proximal. Patients should be discouraged from using UE to maintain stance.

4. If the patient is able to hold the position with eyes open, while he is standing unsupported, ask him to close his eyes and hold for 15 seconds.

#### Feet Together

Observation	Interpretation
unable to stand unsupported; shifts COM to side or back; resists correction; may be unable to attempt this test	Postural Vertical Deficit
unable to stand unsupported; appears weak; would fall without support	FPD
unable to maintain alignment at one or two segments; may appear worse the longer the patient attempts to stand	FPD
altered alignment of LE limb position; may require UE support to maintain balance; slow with postural responses	<ul style="list-style-type: none"> <li>▪ Fractionated Movement Deficit</li> <li>▪ Hypokinesia</li> </ul>
hesitation or multiple efforts to assume position; improves with practice	MPCD
excessive sway at trunk/hips; likely needs UE support to maintain balance	Dysmetria
increased sway with eyes closed; improves with practice	MPCD
increased sway with eyes closed or loss of balance; no change with practice under this condition	Sensory Detection Deficit
loss of balance in a consistent direction; much increase in sway with eyes closed; improves with a visual target	Sensory Selection and Weighting Deficit

#### Step-Up:

##### Testing procedures:

The following test should be eliminated if the patient was unable to stand without any support in any fashion for 5 seconds.

1. Put a 4 to 6 inch step in front of the patient. Ask the patient to put the left foot on the step then return it to the floor without UE support then repeat with the right foot for one cycle. The patient may need a demonstration of the task.
2. Observe the first attempt and note the presence or absence of essential components of the task:
  - weight shift to stance limb
  - hip and knee extension on stance limb
  - erect trunk
  - hip flexion on moving limb
  - controlled foot placement of moving limb
3. Give the patient cues and manual guidance to assist with missing components. Allow for 3-4 attempts noting improvement in performance of missing components.

Appropriate cues may include, but are not limited to, the following:

- “shift your weight to your ( )”
- “lift your leg from your hip”
- “don’t let your hip collapse”
- “put your foot down quietly”
- “don’t lean back before you put your foot on the floor”

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Manual guidance should be used to support the patient proximally as needed.

4. If support is needed during the task, momentarily relax the support and note the patient's movement response.
5. Perform 2 cycles, i.e. left-right-left-right.

#### Step-up

	Observation	Interpretation
Initiation	hesitation and/or multiple starts before moving a foot; improves with practice	<ul style="list-style-type: none"> <li>▪ MPCD</li> <li>▪ Sensory Selection and Weighting Deficit</li> </ul>
	hesitation and/or multiple starts before moving a foot; no consistent improvement with practice	<ul style="list-style-type: none"> <li>▪ FPD</li> <li>▪ Fractionated Movement Deficit</li> <li>▪ Sensory Detection Deficit</li> <li>▪ Hypokinesia</li> </ul>
	unable to attempt without UE support	<ul style="list-style-type: none"> <li>▪ Sensory Detection Deficit</li> <li>▪ Hypokinesia</li> <li>▪ Dysmetria</li> <li>▪ Postural Vertical Deficit</li> </ul>
Execution (swing limb)	insufficient hip flexion range of motion; momentum strategy to lift limb; circumduction; lateral trunk flexion toward stance limb; fatigues with practice and repetition	FPD
	increased movement time; insufficient hip flexion range of motion; abnormal movement synergy; no improvement with practice	Fractionated Movement Deficit
	increased movement time; insufficient hip flexion range of motion; limited improvement with repetition	Hypokinesia
	lateral trunk flexion toward stance limb; improves with practice	<ul style="list-style-type: none"> <li>▪ MPCD</li> <li>▪ Sensory Selecting and Weight Deficit</li> </ul>
	excessive movement amplitude and variable movement path	<ul style="list-style-type: none"> <li>▪ Sensory Detection Deficit</li> <li>▪ Dysmetria</li> </ul>
Execution (stance limb)	hip flexion and/or hip drop; lateral trunk flexion; knee flexion	<ul style="list-style-type: none"> <li>▪ FPD</li> <li>▪ Fractionated Movement Deficit</li> </ul>
	hyperextension of knee	<ul style="list-style-type: none"> <li>▪ FPD</li> <li>▪ Sensory Detection Deficit</li> </ul>
Termination	loss of balance in a consistent direction; improvement with a visual target	Sensory Selection and Weighting Deficit
	posterior sway of stance limb; poor control of foot placement; improves with practice and repetition	MPCD
	unable to reach top of step; may need assistance to recover balance	<ul style="list-style-type: none"> <li>▪ FPD</li> <li>▪ Fractionated Movement Deficit</li> <li>▪ Hypokinesia</li> </ul>
	excessive sway at trunk/hips; may overshoot foot placement on step; repeated stepping to maintain balance	<ul style="list-style-type: none"> <li>▪ Dysmetria</li> <li>▪ Sensory Detection Deficit</li> </ul>

**Gait:**Testing Procedures:

1. Ask the patient to walk at least 10-20 feet (but longer if possible) and turn around without an assistive device or assistance from you.
2. Observe the first attempt and note presence or absence of essential components of task:<sup>24</sup>
  - Stance
    - extension of hip throughout
    - lateral shift of pelvis and trunk
    - flexion of knee at heel contact followed by extension then flexion prior to toe off
  - Swing
    - flexion of knee with initial hip extension
    - flexion of hip
    - rotation of pelvis forward on swing leg
    - extension of knee with dorsiflexion prior to heel contact
  - Turns
    - no loss of balance
  - Overall
    - straight line of progression
3. Give the patient cues and manual guidance to assist with missing components. Allow for 3-4 attempts noting improvement in performance of missing components.

Appropriate cues may include, but are not limited to, the following:

- “stay nice and tall”
- “take long even steps”
- “walk heel to toe”
- “push off of the floor”
- “swing your arms”
- “walk faster”

Manual guidance should be used to support the patient proximally as needed. Support should be decreased as much as possible as the test proceeds.

**Gait**

	Observation	Interpretation
Phase	Result	
stance	lateral trunk flexion	FPD
	hip/trunk flexion	FPD
	hip drop	FPD
	altered limb alignment often impacting the position of the foot	Fractionated Movement Deficit
	hyperextension of knees; no change with visual guidance	FPD
	hyperextension of knees; some improvement with visual guidance	Sensory Detection Deficit
swing	circumduction, hip hiking, vaulting	FPD
	insufficient hip flexion and/or DF	FPD
	abnormal movement synergy; short step length	Fractionated Movement Deficit

	Observation	Interpretation
	variable foot placement; improves with practice and cues	MPCD
	variable foot placement; no improvement with practice and cues	Dysmetria
	variable foot placement; some improvement with visual guideline	Sensory Detection Deficit
	multiple stops and starts; decreased step length	Hypokinesia
overall	variable line of progression; improves with practice and repetition	<ul style="list-style-type: none"> <li>▪ MPCD</li> <li>▪ Sensory Selection and Weighting Deficit</li> </ul>
	variable line of progression; no improvement with practice and repetition	Dysmetria
	line of progression deviates toward one side	<ul style="list-style-type: none"> <li>▪ Disregard (modifier)</li> <li>▪ Sensory Selection and Weighting Deficit</li> </ul>
	lack of forward progression; needs UE support	Postural Vertical Deficit

### Complex Gait:

#### Testing Procedures:

While walking, ask the patient to perform the following:

1. turn head to left for 2-3 steps, to center for 2-3 steps, and to right for 2-3 steps.
2. step forward a few steps and step backward a few steps without stopping
3. step over a small obstacle

Give time to settle into a normal walking pattern between each of these tasks. Note change in performance with each task such as decreasing speed, deviation in line of progression, stopping, or stumbling.

#### Interpretation:

<sup>1</sup>Deviation in line of progression while walking with head turning may indicate Sensory Selection and Weighting Deficit if coupled with other positive tests or Movement Pattern Coordination Deficit.

<sup>2</sup>Hesitation or extra steps in changing direction while walking but improvement with practice is indicative of Movement Pattern Coordination Deficit.

<sup>3</sup>Hesitation and inability to step backward or extra steps may be indicative of Force Production Deficit.

Assess weight bearing strength of plantarflexors and consider improvement with practice when making diagnosis.

<sup>4</sup>Hesitation in stepping over obstacle or poor adjustment to step length when stepping over obstacle but improvement in practice is indicative of Movement Pattern Coordination Deficit.

<sup>5</sup>Stopping movement with long hesitation before stepping and lack of support moment at hip of stance limb is indicative of Force Production Deficit.

<sup>6</sup>Hesitation, stopping and starting, small steps, and poor control of momentum associated with Hypokinesia

<sup>7</sup>Difficulty transitioning from one sensory condition to another associated with Sensory Selection and Weighting Deficit

<sup>8</sup>Consistent variability with extra steps for balance and wide base of support without change with practice associated with Dysmetria

## Dual Task Performance:

### Testing Procedures:

While walking, ask the patient to perform the following:

1. walk while performing a cognitive task such as count backward by 3s, say the alphabet backward, or do multiplication tables
2. walk while performing a secondary manual tasks such as carrying a full cup of water, retrieving a coin from a pocket, or retrieve keys from a purse

Give time to settle into a normal walking pattern between each of these tasks. Note change in gait performance with each tasks such as decreasing speed, deviation in line of progression, stopping, or stumbling. Note change in the secondary task such as stopping, having to start the secondary task again, or errors. Note which task takes priority for the patient, ambulation and stability or the secondary task.

### Interpretation:

<sup>9</sup>Deterioration in performance of either ambulation or the secondary task indicates the need for a descriptor, "with dual task difficulty" or similar language. Priority of the secondary task over ambulation stability may indicate a greater risk for falls.

## Reach and Grasp:

### Testing Procedures:

- 1) Ask the patient to perform the following tests:<sup>2</sup>
  - a) point to objects in front, at the ipsilateral and contralateral side, at shoulder height, and overhead
  - b) reach for objects in the front, at the ipsilateral and contralateral side, at shoulder height, and overhead
  - c) lift and release 3 objects of different size, weight, shape, and texture
  - d) stack 3-4 small objects
- 2) Observe the reach and grasp components of each task and determine the following:
  - a) is the motion fractionated
  - b) is there sufficient active range of motion
  - c) is the hand position being shaped during reach
  - d) is the hand position awkward
  - e) is the hand opening wide enough
  - f) do the fingers contact the object before the web space
  - g) is appropriate force applied to the object

### Interpretation:

- <sup>1</sup>Insufficient active range of motion but motion is fractionated is associated with Force Production Deficit.  
<sup>2</sup>Inability to sustain grasp to lift object and motion is fractionated is associated with Force Production Deficit.  
<sup>3</sup>Fractionated movement and dyscoordination of the hand movement during reach or of the hand about objects is associated with Movement Pattern Coordination Deficit.  
<sup>4</sup>Significant failure in accuracy of test indicates Dysmetria.

## In-Hand Manipulation

### Testing Procedures:

- 1) Place a pencil in the open palm of the patient's hand and ask him to adjust the position of the pencil for use. (An alternate test is to place a quarter in the palm and ask the patient to adjust it as if to put it in a vending machine.)<sup>25</sup>
- 2) Observe the task and determine the following:
  - a) is the motion fractionated
  - b) is there sufficient active range of motion
  - c) is the hand movement awkward
  - d) is the hand movement slow
  - e) is appropriate force applied to the object

*Interpretation:*

<sup>1</sup>Insufficient active range of motion but motion is fractionated is associated with Force Production Deficit

<sup>2</sup>Inability to sustain grasp and motion is fractionated is associated with Force Production Deficit.

<sup>3</sup>Fractionated movement and dyscoordination or slowness of the hand are associated with Movement Pattern Coordination Deficit.

**MENTAL STATUS**

Perform traditional tests of mental status and basic cognitive functioning to determine:

- **Level of consciousness (LOC)**
- **Attention**
- **Ability to apply meaning to situational demands**
- **Ability to follow instructions**

*Interpretation:*

<sup>1</sup>Significant deficits may indicate the classification, Cognitive Deficit.

<sup>2</sup>Moderate to significant deficits coupled with other movement related impairments indicate the use of a modifier to the diagnosis, e.g. confusion, cognitive deficits.

<sup>3</sup>Mild deficits are relevant to treatment but are unlikely to be relevant to diagnosis.

**JOINT LIMITATION**

Perform traditional tests of joint range of motion.

*Interpretation:*

<sup>1</sup>Use information about joint limitation to guide the use of a descriptor to the diagnosis, e.g. with biomechanical deficit, hip. Significant limitation should guide the therapist to examine for a specific musculoskeletal diagnosis.

**MUSCLE TONE / HYPEREXCITABILITY**

- **Motorneuron Response Assessment**

For the purposes of diagnosis, assessment of muscle tone / hyperexcitability is important in its relationship to a patient's ability to fractionate movement. Patient's with more signs of hyperexcitability such as spasticity, the inability to relax after effort, and associated reactions, are likely to have difficulty isolating movement of one limb segment from movement of other limb segments.<sup>3</sup> At different points in time of a patient's recovery from a neurological deficit, the signs of hyperexcitability may be apparent before there is return of active movement. In these situations, the signs of hyperexcitability may give an earlier indication of the patient's movement system diagnosis than the patient's ability to fractionate movement. The Motorneuron Response Assessment (MRA) is a tool that is designed specifically to identify the multiple signs of hyperexcitability. The tool is reliable among multiple testers and valid when compared with the Ashworth scale.<sup>4</sup> The MRA is the preferred test for measuring hyperexcitability for the purposes of diagnosis. It is described in the Appendix to this document.

- **Ashworth or Modified Ashworth Scales**

The Ashworth or Modified Ashworth Scales are commonly used measures of spasticity.<sup>5,6,7,8,9,10,11</sup> We have not formally studied the relationship between scores on the Ashworth or Modified Ashworth scale and the results of the Fractionated Movement test.

- **Rigidity**

Rigidity is defined as persistent muscle activity at rest. Determine "yes" or "no" rigidity is present by slowly moving the extremities and observing them at rest. It may be useful to have the patient attend to a secondary task during testing.<sup>12</sup>

yes = resistance is present in both directions and there is the appearance of persistent muscle activity at rest

**Interpretation:**<sup>13,14,15</sup>

<sup>1</sup> MRA Classification of Moderate, Marked, or Severe or Modified Ashworth scores of 3 or 4 are indicative of Fractionated Movement Deficit

<sup>2</sup> MRA Classification of Flaccid is indicative of Force Production Deficit with poor prognosis

<sup>3</sup> MRA Classification of Normal or Mild when there is a CNS lesion is indicative of Movement Pattern Coordination Deficit or Force Production Deficit with good prognosis

<sup>4</sup> If the LE MRA category is different from the UE MRA category, consider making an UE and LE diagnosis.

<sup>5</sup> Patients with rigidity related to brain injury often demonstrate varying levels of muscle tone based on position. In this situation, attempt to measure the amount of excitability during functional tasks and consider that level when making a diagnosis.

**MOVEMENT**

- **Spontaneous Movement**

Determine “yes” or “no” there is spontaneous movement by observing the patient and noting whether the patient can move against gravity.

yes = movement against gravity in at least 2 extremities

- **Fractionated Movement (FM)**

Determine “yes” or “no” there is fractionated movement by completing the following standardized examination detailed in the Appendix.

**Interpretation:**<sup>16,17, 18</sup>

<sup>1</sup> FM is an important test for patients with CNS lesions. Patients who have non-fractionated movement are likely to be associated with higher degrees of hyperexcitability and are likely to have a diagnosis of Fractionated Movement Deficit.

- **Selective Control Assessment of the Lower Extremity (SCALE)**

The SCALE is commonly used in the pediatric population to measure the ability to fractionated movement.<sup>19</sup> We have not formally studied the relationship between scores on the SCALE and the MRA or other muscle tone scale. However, we expect that values  $\leq 5$  for either LE would indicate Fractionated Movement Deficit.

- **Strength**

Follow principles of manual muscle testing as defined by Kendall<sup>20</sup> in testing the following muscle groups: shoulder flexion, elbow flexion, elbow extension, wrist extension, hip extension, hip flexion, hip abduction, knee extension, dorsiflexion, weight bearing plantarflexion. According to these principles, only fractionated movement is tested. Use the following scale:

0 = no contraction felt in muscle

1 = a feeble contraction may be felt or the tendon may become prominent but there is not visible movement

2 = able to move the part through a small arc of motion with gravity lessened

3 = able to move the part into the test position and hold against gravity

4 = able to hold the test position against gravity and moderate pressure

5 = able to hold the test position against gravity and maximum pressure

**Interpretation:**

<sup>1</sup> Muscles grades less than 4/5 in the majority of muscles in one or more limbs or more focal weakness in a key muscle group is indicative of Force Production Deficit with a good prognosis.

<sup>2</sup> A muscle grade less than 3+/5 in the majority of muscles in one or more limbs or more focal weakness in a key muscle group is indicative of Force Production Deficit.

- **Fatigue**

The purpose of this test is to determine if the patient demonstrates signs of skeletal muscle fatigue. Determine “yes” or “no,” the patient demonstrates skeletal muscle fatigue by performing one of the following tests. Two levels of testing are described; the lower level test is used only if the patient cannot participate in the higher level test.

Low level test: the patient is supine

- flex the shoulder to 90° and support the upper arm; ask the patient to **extend the elbow 10 times**
- flex the hip to 90° and support the upper leg; ask the patient to **extend the knee 10 times**

High level test: ask the patient to come to standing from an 18-20 inch surface without UE support 10 times. If the patient cannot initiate standing without UE support, he may use UE support during the initiation phase only.

For either test note a decrease in range of motion of the movement and change in speed.

yes = decrement in range of motion observed

*Interpretation:*

<sup>1</sup>*Fatigue noted during either test is indicative of Force Production Deficit.*

<sup>2</sup>*The purpose of these tests is to draw out skeletal muscle fatigue; if the patient fails for other reasons, such as shortness of breath, increased heart rate, etc, see test for activity tolerance and consider a cardiopulmonary diagnosis.*

- **Motor Planning**

Determine “yes” or “no” the patient has deficits in motor planning as evidenced by difficulty organizing necessary movement patterns into purposeful actions

yes = inconsistency between the degree of fractionated movement produced in isolated testing and in functional activities

*Interpretation:*

<sup>1</sup>*Patients with significant motor planning deficits are not likely to fit into one of the defined categories.*

- **Non-equilibrium Coordination**

**UE Accuracy:** ask the patient to touch the examiner’s finger then touch his (the patient’s) nose. The examiner’s finger should be at a distance that requires the patient to extend his upper extremity fully and should be placed at 5 varying points before the patient.<sup>21</sup> The patient is told to try to hit the target, i.e. the tip of the finger and the tip of the nose. Count the number of times the patient hits the target (nose or finger), and determine if the patient is:

not impaired	0-1 inaccuracies
mildly impaired	2-6 inaccuracies
markedly impaired	7-10 inaccuracies

**LE Accuracy:** ask the patient to place the heel of one foot on the knee of the other leg and slide the heel down and up the tibia 5 times.<sup>19</sup> Tell the patient to be as precise as possible. Count the number of times the heel does not maintain contact with the tibia. Determine if the patient is:

not impaired	0-1 inaccuracies
mildly impaired	2-6 inaccuracies
markedly impaired	7-10 inaccuracies

**UE Reciprocal Movement:** ask the patient to rapidly supinate and pronate the forearm for 10-20 seconds.<sup>19</sup> Determine if the patient is:

normal

slow

**LE Reciprocal Movement:** ask the patient to sit with the heel on the ground and rapidly tap the toe for 10-20 seconds.<sup>19</sup> Determine if the patient is:

normal  
slow

*Interpretation:*

<sup>1</sup>More than mild deficits are indicative Dysmetria.

## SENSATION

- **Joint Position Sense**

Have the patient sit or lie with the heel and leg supported. Grasp the lateral aspect of the great toe and move the toe into flexion and extension passively.<sup>19</sup> Encourage the patient to relax. Show the patient that a position into flexion is “down” and a position into extension is “up.” Ask the patient to close his eyes. Move the toe into flexion or extension randomly 5 times. After each movement, ask the patient to tell you if the toe is up or down. Determine the accuracy of the patient’s responses using the following scale:

not impaired	=	no inaccuracies
mildly impaired	=	inaccurate 1-2 times
moderately impaired	=	inaccurate 3-4 times
severely impaired	=	inaccurate 5 or more times

Repeat the test in the same fashion at the ankle and knee.

*Interpretation:*

<sup>1</sup>More than mild deficits at the toe and ankle or mild deficits at the ankle and knee are indicative of Sensory Detection Deficit.

<sup>2</sup>If a loss of joint position sense is coupled with a marked motor impairment, the diagnosis is most likely to be related to the motor impairment; in this circumstance consider using “with sensory loss” as a modifier to the diagnosis.

- **Contraversive Pushing or Backward Disequilibrium Behavior**

This movement behavior may be observed in either the medial/lateral (contraversive pushing) or posterior (retropulsive pushing) directions. The hallmark of contraversive pushing behavior is: 1) abduction and extension of the limbs in sitting or standing either spontaneously or when changing position and 2) resistance to passive correction. Contraversive pushing behavior can be measured using the Scale for Contraversive Pushing.<sup>22, 23</sup>

Retropulsive pushing behavior is characterized by: 1) trunk extension in sitting or posterior displacement of COM through ankle PF in standing and 2) resistance to passive correction. Retropulsive pushing behavior may be measured using the Backward Disequilibrium Scale.<sup>24</sup>

yes = both hallmark signs of either contraversive or retropulsive pushing behavior present or scores > 0 on the “Use of the nonparetic extremities” and “Resistance to passive correction of tilted posture” subscales on the SCP.<sup>25</sup>

*Interpretation:*

<sup>1</sup>Contraversive or Retropulsive pushing behavior is indicative of Postural Vertical Deficit.

<sup>2</sup>If the deficit related to pushing behavior is significant and coupled with a motor deficit, the diagnosis is most likely Postural Vertical Deficit.

- **Vertical Orientation (without pushing behavior)**

Observe the patient during postural control tests and ambulation for displacement of the center of mass toward one side or in the posterior direction. Provide physical assistance and/or visual cues to see if the patient can correct his vertical orientation.

yes = COM consistently shifted away from the COM alignment; able to correct with physical assistance or cues

**Interpretation:**

*<sup>1</sup>Altered vertical orientation without pushing behavior is indicative of Sensory Selection and Weighting Deficit*

- **Disregard**

Observe the patient's attention to his environment and note any inconsistencies in attention to one side more than the other. Examples may include lying on one side of the bed or positioning himself toward one side of a chair, lack of head turning to one side, inability to clear objects on one side during locomotion.

yes = decreased attention to one side

**Interpretation:**

*<sup>1</sup>Although disregard for a side of the body is often associated with altered perception of midline, it is not always the case.*

*<sup>2</sup>If the test for disregard is positive but the test for midline perception is not, use "with disregard," as a modifier to the diagnosis; in this situation the diagnosis should be consistent with the motor deficit.*

- **Sensitivity to Sensory Stimuli**

Ask the patient to visually track your finger to the side, up and down, and randomly while holding the head still. Ask the patient if he has any symptoms while performing this test such as dizziness, headache, nausea, etc. Note any signs of gaze aversion. If the patient is not impaired in this test but reports other specific motion related triggers of symptoms, modify test in accordance with the patient's specific complaints, e.g. 180° or 360° turns, repeated turns, repeated head turning, etc.

Observe the patient's response to auditory and visual motion cues in the environment. Look for increased postural sway, loss of balance, and/or stoppage of movement in the presence of these sensory cues.

Observe the patient for self-stimulation behaviors such as repeated rocking, spinning, or hitting of the limb or head.

yes = dizziness or dizziness related symptoms and/or signs of movement deterioration related to sensory stimuli while performing any of the above tests

**Interpretation:**

*<sup>1</sup>Symptoms with eye and/or head movements may indicate the diagnosis Sensory Selection and Weighting Deficit.*

*<sup>2</sup>If there are abnormal motor findings with eye movements and no diagnosed neurological pathology, consult a physician.*

*<sup>3</sup>Signs of movement deterioration with sensory stimuli or efforts to increase sensory stimuli may indicate the diagnosis Sensory Selection and Weighting Deficit.*

## PAIN

Ask the patient to rate the severity of pain on a scale of 0 to 10 where:

0 = no pain

10 = extreme pain

Determine "yes" or "no" the pain is musculoskeletal in origin.

yes = pain decreases with change in alignment, positioning, or support

*Interpretation:*

<sup>1</sup>*This test is used as a screening test for musculoskeletal pain; this system of diagnoses does not address musculoskeletal pain syndromes.*

**ACTIVITY TOLERANCE**

Determine “yes” or “no” the patient is able to tolerate activity by assessing vital signs and signs of distress during exertion.

- No = decrease in heart rate, irregular rhythm, or inability to recover to resting rate after two minutes  
 or  
 decrease in systolic blood pressure, increase in diastolic blood pressure greater than 10 mm HG  
 or  
 labored breathing as evidenced by increased use of accessory muscles and increased rate  
 or  
 sustained decreased in O<sub>2</sub> saturation below 90 or other medical guideline  
 or  
 increase in intracranial pressure above 15 or other medical guideline

*Interpretation:*

<sup>1</sup>*This test is a screening test for cardiopulmonary impairments; this system of diagnoses does not address specific cardiopulmonary syndromes.*

## APPENDIX

**Motorneuron Response Assessment**

Following the description and interpretation of the MRA are comments related to other standardized tools used to assess muscle tone and their use for the purposes of diagnosis.

**Motorneuron Response Assessment (MRA)**

The following is the description of the Motorneuron Response Assessment (MRA). The MRA was developed for patients with hemiplegia. The tool as written will be presented first. It will be followed by instructions for how to use the tests of the tool in different patient types.

- 1) Purpose
  - a) examine the overall level of excitability
  - b) tests for spasticity, ability to relax after attempted active movement, and associated reactions
  
- 2) General guidelines
  - a) test all movements in supine
  - b) perform each movement with the uninvolved extremity first in order to compare with the involved extremity
  - c) prior to testing, check the passive range of motion (PROM) of each extremity involved
  - d) explain to the patient that he should remain as relaxed as possible except for those tests in which he is to perform a movement actively
  - e) instruct the patient that with active movements, his effort should be just enough to accomplish the movement requested
  - f) determine that the patient understands the directions before rating his response; if he has difficulty with directions, note this.
  - g) assure the patient that the test will not harm him
  - h) perform each test 3 times in order to measure the consistency of response
  - i) occasionally, during testing of a specific item, a patient may not respond consistently; if one of the responses is atypical, rate the item based on the response during the other movements and not the inconsistent response
  - j) determine the overall classification according to the appropriate criteria
  - k) record any additional information that would influence or help to interpret the results of the test
  
- 3) Upper Extremity (UE) test
  - a) position the UE to be tested in approximately 45° of abduction
  - b) position the upper arm in neutral shoulder rotation and stabilize testing by holding onto the upper arm as needed
  - c) position the forearm in neutral pronation/supination
  - d) there are 5 components to the test; they are as follows:
    - i) **Passive movement of the entire upper extremity (PROM):** Instruct the patient to remain relaxed and not assist with the movements. With the extremity in the described testing position, passively range each joint at varying speeds noting any resistance to stretch. Note all deviations from normal.
    - ii) **Passive flexion of the elbow to 90° and drop into extension (PROM with Drop):** Instruct the patient to remain relaxed, not to push the forearm down, and to let the arm drop. Support the upper arm and passively flex the elbow to 90°. Release the forearm, allowing it to fall into extension. Make sure the patient does not internally rotate the shoulder to extend the elbow. Note the speed of the fall into extension.
    - iii) **Active flexion of the elbow to 90° and drop into extension (AROM with Drop):** From the starting position, ask the patient to bend the elbow to 90° then relax, allowing the forearm to drop into extension. Remind the patient not to “push” the forearm into extension. Stabilize the upper arm with one hand and use the other hand as a “target” to which the patient is to flex the elbow. Note the speed of the fall into extension.
    - iv) **Active hip and knee flexion of the ipsilateral lower extremity (IPSIL LE):** From the starting position, passively flex the involved LE to assess ROM and to demonstrate to the patient the motion you will want him to attempt.

Ask the patient to attempt to flex his involved LE. Note the presence or absence of associated reactions in the involved UE with effort to move the LE. The patient should relax between each attempt.

- v) Active hip and knee flexion of the contralateral lower extremity (**CONTRA LE**): In the same position as describe above, perform the same test with the uninvolved LE. Monitor for activity in the involved UE.

#### 4) Lower Extremity test

- a) position the patient supine with both lower extremities extended and the arms resting in approximately 45° of shoulder abduction, neutral shoulder rotation, elbow extension, neutral supination/pronation, and wrist extension
- b) there are 3 components to the test; they are as follows:
  - i) Passive movement of the entire lower extremity (**PROM**): Instruct the patient to remain relaxed and not to assist with the movement. Passively range each joint at varying speeds and note any resistance to stretch. Note all deviations from normal.
  - ii) Passive extension of the knee and drop into flexion (**PROM with Drop**): Instruct the patient to remain relaxed, not to push the leg down, and to let the leg drop. While supporting the upper leg in approximately 60° of flexion, passively extend the knee. Release the lower leg, allowing it to fall into flexion. Note the speed of the fall into flexion.
  - iii) Activity (**ACT**): Monitor the involved lower extremity throughout the entire examination for the presence of associated reactions.

#### 5) MRA Criteria

- a) Below are listed the criteria for classifying a patient's MRA response.
- b) Because patients do not always meet all the criteria of each classification, those criteria that are most clinically significant are designated. These criteria are marked with an asterisk (\*). If the patient meets the asterisked criteria, he is then classified appropriately.
- c) Note the patient's response on the other items of the test as well, but base the overall classification according to the asterisked criteria.

#### 6) UE Categories

- a) FLACCID
  - PROM: no resistance
  - PROM with drop: falls faster than uninvolved UE \*
  - AROM with drop: unable or falls faster than uninvolved UE
  - IPSIL LE: no activity in UE
  - CONTRA LE: no activity in UE
- b) MILD
  - PROM: resistance \*
  - PROM with drop: falls equal to uninvolved UE
  - AROM with drop: unable or falls equal to uninvolved UE
  - IPSIL LE: no activity in UE
  - CONTRA LE: no activity in UE
- c) MODERATE
  - PROM: resistance
  - PROM with drop: falls slower than uninvolved UE \*
  - AROM with drop: falls slower than uninvolved UE \*
  - IPSIL LE: no activity in UE
  - CONTRA LE: no activity in UE
- d) MARKED
  - PROM: resistance
  - PROM with drop: falls slower than uninvolved UE
  - AROM with drop: falls slower than uninvolved UE
  - IPSIL LE: activity in UE \*
  - CONTRA LE: no activity in UE

- e) SEVERE
  - PROM: resistance
  - PROM with drop: falls slower than uninvolved UE
  - AROM with drop: falls slower than uninvolved UE
  - IPSIL LE: activity in UE
  - CONTRA LE: activity in UE \*
- f) NORMAL
  - PROM: no resistance
  - PROM with drop: falls equal to uninvolved UE
  - AROM with drop: falls equal to uninvolved UE
  - IPSIL LE: no activity in UE
  - CONTRA LE: no activity in UE

## 7) LE Categories

- a) FLACCID
  - PROM: no resistance
  - PROM with drop: falls faster than uninvolved LE \*
  - ACT: no activity
- b) MILD
  - PROM: resistance \*
  - PROM with drop: falls equal to uninvolved LE
  - ACT: no activity
- c) MODERATE
  - PROM: resistance
  - PROM with drop: falls slower than uninvolved LE \*
  - ACT: no activity
- d) SEVERE
  - PROM: resistance
  - PROM with drop: falls slower than uninvolved LE
  - ACT: activity \*
- e) NORMAL
  - PROM: no resistance
  - PROM with drop: falls equal to uninvolved LE
  - ACT: no activity

## 8) Application to patients other than those with hemiplegia

While the MRA has been tested in our clinic on patients with hemiplegia, it is suggested that the test be considered as a series of tests that identify degrees of hyperexcitability. The test could be used on any patient with the Upper Motorneuron Syndrome, and patients with more positive responses on the tests would be considered more severe.

The test position for the drop tests may also be changed in order to observe the speed of fall of a segment while different muscle groups are being stretched, e.g. prone with a lower leg drop test that passively stretches the hamstrings.

## **Fractionated Movement (FM)**

Determine “yes” or “no” there is fractionated movement by completing the following standardized examination:

### 1) General Guidelines

- a) test all movements in sitting with back supported unless medical status prohibits
- b) prior to testing, check the PROM for each extremity and joint involved
- c) beginning with the shoulder, ask the patient to perform isolated movements; instruction may be verbal and/or visual
- d) note the category with which the patient’s movement best corresponds
- e) record any additional information that would influence or help to interpret the results of the test
- f) perform all tests on the involved extremities

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2) Upper Extremity test

a) there are 5 components of the test

- i) Ask the patient to flex his shoulder. Movement is fractionated if the patient moves the shoulder through at least 50% of available range without substitution or other associated reactions.
- ii) Ask the patient to flex and extend the elbow while maintaining neutral supination/pronation. Movement is fractionated if the patient moves the elbow through at least 50% of available range without substitution or other associated reactions.
- iii) Ask the patient to flex and extend the wrist against gravity. Movement is fractionated if the patient moves the wrist through 100% of available range without substitution or other associated reactions.
- iv) Ask the patient to flex and extend the fingers against gravity. Movement is fractionated if the patient moves the fingers through 100% of available range without substitution or other associated reactions.
- v) Ask the patient to flex and extend the index finger with the other fingers fully flexed. Movement is fractionated if the patient moves the index finger through 100% of available range without substitution or other associated reactions.

3) Lower Extremity test

a) there are 3 components to the test

- i) Ask the patient to flex the hip in the sagittal plane. Movement is fractionated if the patient flexes the hip at least 50% of available range of motion without substitution or other associated reactions.
- ii) Ask the patient to extend the knee in the sagittal plane. Movement is fractionated if the patient extends the knee at least 50% of available range of motion without substitution or other associated reactions.
- iii) Ask the patient to dorsiflex the ankle in the sagittal plane. Movement is fractionated if the patient dorsiflexes the foot 100% of available range of motion without substitution or other associated reactions.

4) Fractionated Movement Category Criteria

a) Upper Extremity

Each joint is rated separately. If the patient is able to complete the task as defined, he is given a “yes” on the data sheet for that task. All tasks are rated for each patient.

If the patient is unable to complete the task because he has no movement at a given segment, mark it on the data sheet.

b) Lower Extremity

Each joint is rated separately. If the patient is able to complete the task as defined, he is given a “yes” on the data sheet for that task. All tasks are rated for each patient.

If the patient is unable to complete the task because he has no movement at a given segment, mark it on the data sheet.

SAMPLE CLINICAL FORM - Physical Therapy Initial Examination (Objective, Assessment, Plan)

O:

Observation: \_\_\_\_\_

Vital signs:	rest	HR _____	BP _____	RR _____	O <sub>2</sub> sat _____
	activity	HR _____	BP _____	RR _____	O <sub>2</sub> sat _____
	recovery	HR _____	BP _____	RR _____	O <sub>2</sub> sat _____

Mental status: \_\_\_\_\_ no deficits noted \_\_\_\_\_ impaired in the following: \_\_\_\_\_

Special senses: (vision, hearing, etc.) \_\_\_\_\_

**SUPINE TESTS**

Edema: \_\_\_\_\_ no deficits noted \_\_\_\_\_ present in the following: \_\_\_\_\_

Skin: \_\_\_\_\_ no deficits noted \_\_\_\_\_ problems noted in the following: \_\_\_\_\_

ROM: \_\_\_\_\_ no deficits noted \_\_\_\_\_ deficits noted in the following: \_\_\_\_\_

Muscle tone: \_\_\_\_\_ normal \_\_\_\_\_ abnormal \_\_\_\_\_

Sensation: \_\_\_\_\_ no deficits noted  
 \_\_\_\_\_ impaired in the following:  
 It touch: \_\_\_\_\_  
 pain/temperature: \_\_\_\_\_  
 joint position sense: \_\_\_\_\_  
 protective sensation: \_\_\_\_\_

Strength:	L	R		L	R
Shoulder flexion	_____	_____	Hip flexion	_____	_____
Elbow flexion	_____	_____	Knee extension	_____	_____
Elbow extension	_____	_____	DF	_____	_____
Wrist extension	_____	_____	PF (NWB)	_____	_____
Grip	_____	_____			

**Skeletal muscle fatigue:**

fatigue with 10 reps elbow extension?	left yes	left no	right yes	right no
fatigue with 10 reps knee extension?	left yes	left no	right yes	right no

**Rolling left: (without rails)**

assistance: with task: \_\_\_\_\_

**analysis: (check all that apply)**

- |   |  |
|---|--|
| <input type="checkbox"/> essential movement components present                | <input type="checkbox"/> insufficient shoulder flexion/horizontal add. on initiation |
| <input type="checkbox"/> generates momentum with upper body on initiation     | <input type="checkbox"/> insufficient trunk rotation during execution                |
| <input type="checkbox"/> insufficient head/upper trunk rotation on initiation | <input type="checkbox"/> shifts left hip under right hip during execution            |
|   | <input type="checkbox"/> insufficient hip flexion/pelvic rotation on initiation      |

response to practice: improves fatigues no change

**Rolling right: (without rails)****assistance:** with task: \_\_\_\_\_**analysis:** (check all that apply)

- |   |  |
|---|--|
| <input type="checkbox"/> essential movement components present                | <input type="checkbox"/> insufficient shoulder flexion/horizontal add. on initiation |
| <input type="checkbox"/> generates momentum with upper body on initiation     | <input type="checkbox"/> insufficient trunk rotation during execution                |
| <input type="checkbox"/> insufficient head/upper trunk rotation on initiation | <input type="checkbox"/> shifts left hip under right hip during execution            |
|   | <input type="checkbox"/> insufficient hip flexion/pelvic rotation on initiation      |

<b>response to practice:</b>	improves	fatigues	no change
------------------------------	----------	----------	-----------

**Rolling left: (with rail)****assistance:** with task: \_\_\_\_\_**response to practice:** improves

with set-up: \_\_\_\_\_

fatigues no change

**Rolling right: (with rail)****assistance:** with task: \_\_\_\_\_**response to practice:** improves

with set-up: \_\_\_\_\_

fatigues no change

**Supine to Sit:****assistance:** with task: \_\_\_\_\_**response to practice:** improves

with set-up: \_\_\_\_\_

fatigues no change

**Sit to Supine:****assistance:** with task: \_\_\_\_\_**response to practice:** improves

with set-up: \_\_\_\_\_

fatigues no change

**SITTING TESTS****Special tests:**

Deficits/symptoms noted in the following:

field cut	smooth pursuit	saccades	DVA	head thrust
Dix-Hallpike	tolerance to busy visual backgrounds			

**Fractionated movement:**

	L	R		yes	no
Shoulder flexion	yes	no	Hip flexion	yes	no
Elbow flexion	yes	no	Knee extension	yes	no
Wrist flex/ext	yes	no	DF	yes	no
Hand	yes	no			
Finger	yes	no			

**Non-equilibrium coordination:**

Left UE RAM:	not impaired	slow	
Right UE RAM:	not impaired	slow	
Left FNF:	not impaired	mildly impaired	markedly impaired
Right FNF:	not impaired	mildly impaired	markedly impaired
Left LE RAM:	not impaired	slow	
Right LE RAM:	not impaired	slow	
Left HKS:	not impaired	mildly impaired	markedly impaired
Right HKS:	not impaired	mildly impaired	markedly impaired

**Reach and Grasp:**

<b>Y</b>	<b>N</b>	<b>NT</b>	point to and reach for objects in front and to sides at shoulder height
<b>Y</b>	<b>N</b>	<b>NT</b>	point to and reach for objects overhead
<b>Y</b>	<b>N</b>	<b>NT</b>	lift and release 3 objects of different size, weight, shape, and texture
<b>Y</b>	<b>N</b>	<b>NT</b>	stack 3-4 small blocks or cubes

**analysis:** *(check all that apply)*

- |   |  |
|---|--|
| <input type="checkbox"/> essential movement components present  | <input type="checkbox"/> overshooting for target                         |
| <input type="checkbox"/> motion is non-fractionated             | <input type="checkbox"/> lack of hand positioning during reach           |
| <input type="checkbox"/> insufficient active motion at shoulder | <input type="checkbox"/> awkward hand position on object                 |
| <input type="checkbox"/> insufficient active motion at elbow    | <input type="checkbox"/> insufficient hand opening to grasp object       |
| <input type="checkbox"/> insufficient active motion at wrist    | <input type="checkbox"/> contact with object at web space before fingers |
| <input type="checkbox"/> insufficient active motion in hand     | <input type="checkbox"/> poor modulation of force for object type        |

**response to practice:** improves                      fatigues                      no change

**In-Hand Manipulation:**

<b>Y</b>	<b>N</b>	<b>NT</b>	Adjust pencil from palm to ready for use
<b>Y</b>	<b>N</b>	<b>NT</b>	Rotate pencil in hand

**analysis:** *(check all that apply)*

- |  |  |
|--|--|
| <input type="checkbox"/> essential movement components present | <input type="checkbox"/> overshoots for pencil               |
| <input type="checkbox"/> motion is non-fractionated            | <input type="checkbox"/> movement slow and awkward           |
| <input type="checkbox"/> insufficient active motion            | <input type="checkbox"/> poor modulation of force for pencil |

**response to practice:** improves                      fatigues                      no change

**Postural control:** *(firm surface, feet supported, back unsupported, arms across chest; check all that apply)*

\_\_\_\_\_ unable to sit unsupported; assistance required: \_\_\_\_\_

<b>Y</b>	<b>N</b>	<b>NT</b>	unsupported with eyes open (10 s)
<b>Y</b>	<b>N</b>	<b>NT</b>	move UE or LE without displacing trunk and without loss of balance
<b>Y</b>	<b>N</b>	<b>NT</b>	displace trunk during reaching and return to starting position without loss of balance

**analysis:** *(check all that apply)*

- |   |  |
|---|--|
| <input type="checkbox"/> structural alignment fault                                       | <input type="checkbox"/> COM shifted away from midline; resists correction |
| <input type="checkbox"/> falls without support  | <input type="checkbox"/> excessive sway at trunk; requires UE              |
| <input type="checkbox"/> sits asymmetrically  |  |
| <input type="checkbox"/> COM shifted away from midline; corrects with cues or instruction |  |

**response to practice:** improves                      fatigues                      no change

<b>Sit to Stand: (without UE support)</b>		<b>assistance:</b>	
<b>analysis: (check all that apply)</b>			
<input type="checkbox"/> essential movement components present	<input type="checkbox"/> shifts COM to one side		
<input type="checkbox"/> unable to assume normal starting position; stiffness	<input type="checkbox"/> shifts COM to one side or back; corrects with cues/instruction		
<input type="checkbox"/> absent or delayed preparatory movements	<input type="checkbox"/> shifts COM to one side or back; resists correction		
<b>Initiation:</b>	<input type="checkbox"/> slow		
<input type="checkbox"/> increased base of support	<input type="checkbox"/> abnormal movement synergy		
<input type="checkbox"/> posterior displacement of trunk	<input type="checkbox"/> arrests of ongoing movement		
<input type="checkbox"/> insufficient force production	<input type="checkbox"/> excessive trunk sway		
<input type="checkbox"/> uses a momentum strategy	<b>Termination:</b>		
<input type="checkbox"/> excessive trunk sway	<input type="checkbox"/> steps to find balance		
<input type="checkbox"/> resists assistance of trunk movement forward or to midline	<input type="checkbox"/> repeated stepping to find and maintain balance		
<b>Execution:</b>	<input type="checkbox"/> increased lumbar extension		
<input type="checkbox"/> medial hip rotation	<input type="checkbox"/> inadequate hip extension		
<input type="checkbox"/> hip adduction	<input type="checkbox"/> inadequate knee extension		
<input type="checkbox"/> valgus of knee	<input type="checkbox"/> posterior sway		
<input type="checkbox"/> varus of knee	<input type="checkbox"/> shifts COM to one side		
<input type="checkbox"/> extends knees before hips in first half	<input type="checkbox"/> shifts COM to one side or back; corrects with cues/instruction		
<input type="checkbox"/> pushes on thighs to extend trunk	<input type="checkbox"/> shifts COM to one side or back; resists correction		
<input type="checkbox"/> decreased weight bearing	<input type="checkbox"/> increased BOS with excessive sway at hips		
<input type="checkbox"/> insufficient translation of tibia over foot			
<b>response to practice:</b>	improves	fatigues	no change
<b>Stand to Sit: (without UE support)</b>		<b>assistance:</b>	
<b>analysis: (check all that apply)</b>			
<input type="checkbox"/> essential movement components present	<input type="checkbox"/> insufficient knee flexion on initiation and during execution		
<input type="checkbox"/> insufficient hip flexion during execution	<input type="checkbox"/> inadequate control of descent into chair		
<b>response to practice:</b>	improves	fatigues	no change
<b>Sit to Stand: (with UE support)</b>		<b>assistance:</b>	
<b>analysis: (check all that apply)</b>			
<input type="checkbox"/> essential movement components present	<input type="checkbox"/> shifts COM to one side		
<input type="checkbox"/> unable to assume normal starting position; stiffness	<input type="checkbox"/> shifts COM to one side or back; corrects with cues/instruction		
<input type="checkbox"/> absent or delayed preparatory movements	<input type="checkbox"/> shifts COM to one side or back; resists correction		
<b>Initiation:</b>	<input type="checkbox"/> slow		
<input type="checkbox"/> increased base of support	<input type="checkbox"/> abnormal movement synergy		
<input type="checkbox"/> posterior displacement of trunk	<input type="checkbox"/> arrests of ongoing movement		
<input type="checkbox"/> insufficient force production	<input type="checkbox"/> excessive trunk sway		
<input type="checkbox"/> uses a momentum strategy	<b>Termination:</b>		
<input type="checkbox"/> excessive trunk sway	<input type="checkbox"/> steps to find balance		
<input type="checkbox"/> resists assistance of trunk movement forward or to midline	<input type="checkbox"/> repeated stepping to find and maintain balance		
<b>Execution:</b>	<input type="checkbox"/> increased lumbar extension		
<input type="checkbox"/> medial hip rotation	<input type="checkbox"/> inadequate hip extension		
<input type="checkbox"/> hip adduction	<input type="checkbox"/> inadequate knee extension		
<input type="checkbox"/> valgus of knee	<input type="checkbox"/> posterior sway		
<input type="checkbox"/> varus of knee	<input type="checkbox"/> shifts COM to one side		
<input type="checkbox"/> extends knees before hips in first half	<input type="checkbox"/> shifts COM to one side or back; corrects with cues/instruction		
<input type="checkbox"/> pushes on thighs to extend trunk	<input type="checkbox"/> shifts COM to one side or back; resists correction		
<input type="checkbox"/> decreased weight bearing	<input type="checkbox"/> increased BOS with excessive sway at hips		
<input type="checkbox"/> insufficient translation of tibia over foot			
<b>response to practice:</b>	improves	fatigues	no change

**Stand to Sit:** *(without UE support)***assistance:** \_\_\_\_\_**analysis:** *(check all that apply)*

- |  |   |
|--|---|
| <input type="checkbox"/> essential movement components present     | <input type="checkbox"/> insufficient knee flexion on initiation and during execution |
| <input type="checkbox"/> insufficient hip flexion during execution | <input type="checkbox"/> inadequate control of descent into chair                     |
- response to practice:**                      improves                      fatigues                      no change

**Surface to Surface Transfers:****assistance:**            with task: \_\_\_\_\_

with set-up: \_\_\_\_\_

**analysis:** *(check all that apply)*

- |  |   |
|--|---|
| <input type="checkbox"/> essential movement components present             | <input type="checkbox"/> insufficient force production to initiate transfer |
| <input type="checkbox"/> insufficient weight bearing on LE during transfer | <input type="checkbox"/> poor judgment during transfer                      |
- response to practice:**                      improves                      fatigues                      no change

**STANDING TESTS****Alignment:** *(check all that apply)*

<b>Cervical</b>	<b>Thoracic</b>	<b>Lumbar</b>	<b>Pelvis</b>	<b>Hip/femur</b>	<b>Knee/tibia</b>	<b>Ankle</b>	<b>Foot</b>
head forward	kyphosis	flexion	ant. tilt	medial rot.	hyperextension	plantarflexion	pronation
extension	scoliosis	extension	post. tilt	lateral rot.	flexion		supination
lateral tilt		flat			varus		hallux valgus
		scoliosis			valgus		hammer toes

**Postural control** *(without assistive device): (check all that apply)*

\_\_\_\_\_ unable to stand unsupported; assistance required: \_\_\_\_\_

- |          |          |           |  |
|----------|----------|-----------|--|
| <b>Y</b> | <b>N</b> | <b>NT</b> | unsupported feet hip width apart once placed   |
| <b>Y</b> | <b>N</b> | <b>NT</b> | <b>unsupported feet shoulder width apart with eyes open (30 s)</b>                     |
| <b>Y</b> | <b>N</b> | <b>NT</b> | <b>unsupported feet shoulder width apart with eyes closed (30 s)</b>                   |
| <b>Y</b> | <b>N</b> | <b>NT</b> | move UE or LE without changing base of support without loss of balance                 |
| <b>Y</b> | <b>N</b> | <b>NT</b> | displace trunk during reaching and return to starting position without loss of balance |
| <b>Y</b> | <b>N</b> | <b>NT</b> | <b>feet together with eyes open (15 s)</b>   |
| <b>Y</b> | <b>N</b> | <b>NT</b> | <b>feet together with eyes closed (15 s)</b>   |

**analysis:** *(check all that apply)*

- |   |  |
|---|--|
| <input type="checkbox"/> structural alignment fault                                       | <input type="checkbox"/> increased sway with eyes closed                                     |
| <input type="checkbox"/> hesitation or multiple efforts to assume position                | <input type="checkbox"/> loss of balance with eyes closed; needs to be caught                |
| <input type="checkbox"/> falls without support  | <input type="checkbox"/> UE guarding, grabbing, or reaching                                  |
| <input type="checkbox"/> stands asymmetrically  | <input type="checkbox"/> loses balance in one direction                                      |
| <input type="checkbox"/> shifts COM away from midline; resists correction                 | <input type="checkbox"/> insufficient extension moment at hip/knee                           |
| <input type="checkbox"/> shifts COM away from midline; improves with cues and instruction | <input type="checkbox"/> excessive sway at trunk/hips; repeated stepping to maintain balance |
| <input type="checkbox"/> aversion to eyes closed condition                                |  |

**response to practice:** improves            fatigues            no change

**Advanced Postural Control** (without assistive device): *(check all that apply)*

Y N NT **step-up** (alternate placement of foot on 4-6 inch step)  
 Y N NT one foot (10 s)

additional measures: \_\_\_\_\_

**analysis:** *(check all that apply)*

- |   |  |
|---|--|
| <input type="checkbox"/> prefers wide BOS   | <input type="checkbox"/> posterior sway of stance limb                                       |
| <input type="checkbox"/> hesitation and/or multiple starts when changing BOS or initiating movement | <input type="checkbox"/> loss of balance with forward movement of swing limb during step-up  |
| <input type="checkbox"/> UE guarding, grabbing, or reaching   | <input type="checkbox"/> loss of balance with backward movement of swing limb during step-up |
| <input type="checkbox"/> circumduction or insufficient hip flexion of swing limb for step-up        | <input type="checkbox"/> loss of balance to left or right                                    |
| <input type="checkbox"/> lateral trunk flexion toward stance limb                                   | <input type="checkbox"/> inconsistent foot placement on step during step-up                  |
| <input type="checkbox"/> hip flexion or hip drop on stance limb                                     | <input type="checkbox"/> excessive sway at trunk/hips; repeated stepping to maintain balance |
| <input type="checkbox"/> knee flexion of stance limb  |  |
| <input type="checkbox"/> knee hyperextension of stance limb   |  |

**response to practice:** improves      fatigues      no change

**Modified CTSIB:** *(feet almost touching; hands on hips; record duration patient can stand in each condition up to 30 s; use medium density 4inch Tempur foam)*

Firm surface eyes open      \_\_\_\_\_  
 Firm surface eyes closed      \_\_\_\_\_  
 Foam surface eyes open      \_\_\_\_\_  
 Foam surface eyes closed      \_\_\_\_\_

**Gait:**

**assistance:** with task: \_\_\_\_\_ with set-up: \_\_\_\_\_

**device:** walker    wheeled walker    cane    quad cane    crutches    other \_\_\_\_\_

**speed:** \_\_\_\_\_ft in \_\_\_\_\_seconds (normal for older adults 2.2-3.3 ft/s; MCID 0.32 ft/s)

**analysis:** *(check all that apply)*

- essential movement components present

**Stance:**

- decreased base of support
- increased base of support
- decreased weight bearing
- increased pelvic/lumbar rotation
- lateral trunk shift toward stance limb
- ↓hip extension mid- to terminal stance
- hip drop
- hyperextension of knee
- sustained hip/knee flexion
- decreased plantarflexion
- increased pronation

**Swing:**

- hip hiking
- circumduction
- vaulting
- inadequate hip flexion
- inadequate dorsiflexion
- decreased step length
- increased step length
- Overall:**
- variable foot placement
- variable line of progression
- line of progression deviates left or right

**response to practice:** improves      fatigues      no change

**Six-minute walk test:** (normal for older adults about 1366 ft; MCID 164 ft)

Distance/device: \_\_\_\_\_

RPE and vital signs: \_\_\_\_\_

**Complex Gait: assistance:** \_\_\_\_\_

- Y N NT Walk and turn head side to side
- Y N NT Step forward/backward
- Y N NT Step over obstacle
- Y N NT 180° turn
- Y N NT Carry
- Y N NT Compliant surface
- Y N NT Dim lighting

**analysis:** (check all that apply)

- deviation in line of progression with head turning
- symptoms with head turning
- hesitates or takes extra steps when changing direction
- poor control of momentum when stepping forward or back
- hesitates before stepping over obstacle
- poor adjustment in step length to step over obstacle
- insufficient hip flexion to step over obstacle
- difficulty clearing second limb when stepping over obstacle
- steps to recover balance with stepping over
- insufficient hip/knee extension moment when stepping over
- instability with carrying
- increased loss of balance on varying surfaces
- increased loss of balance in dim lighting
- slow/increased loss of balance when transitioning from one sensory context to another

**response to practice:** improves                      fatigues                      no change

**Stairs: (with rails)**

**assistance:** \_\_\_\_\_

**analysis:** (check all that apply)

- essential movement components present
- insufficient hip flexion of swing limb
- insufficient hip extension on stance limb
- insufficient knee extension on stance limb
- increased sway on stance limb
- Up:**
- Down:**
- medial hip rotation on stance limb
- poor control of forward momentum

**Stairs: (without rails)**

**assistance:** \_\_\_\_\_

**analysis:** (check all that apply)

- essential movement components present
- insufficient hip flexion of swing limb
- insufficient hip extension on stance limb
- insufficient knee extension on stance limb
- increased sway on stance limb
- Up:**
- Down:**
- medial hip rotation on stance limb
- poor control of forward momentum

**Floor to/from stand transfers:**

Stand directly	yes	no	
UE support	yes	no	unable

**Activity tolerance:** (check all that apply)

- No deficits noted
- SOB with recovery within 2-5 minutes
- SOB with recovery > 5 minutes
- Irregular heart rhythm
- Abnormal BP response
- Requires frequent rests during exam

**Pain scale:** (0=none; 10=intolerable) \_\_\_\_/10 noted in the following: (circle)

incision abdomen wound neck shoulder back hip knee feet \_\_\_\_\_ other \_\_\_\_\_

**Type of pain:** dull sharp aching stinging deep \_\_\_\_\_ other \_\_\_\_\_

**Change in pain during session:** \_\_\_\_\_

Other tasks: \_\_\_\_\_

Intervention/Education provided and response: \_\_\_\_\_

\_\_\_\_\_

**A:**

Patient's examination is consistent with a movement system impairment diagnosis/working diagnosis of:

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

Additional data needed to confirm a working diagnosis: \_\_\_\_\_

Patient's movement faults (impairments) associated with the diagnosis are believed to contribute to the following problems:

- decreased independence with mobility
- inability to perform tasks with sufficient:
  - consistency
  - flexibility
  - efficiency
- inability to tolerate continuous activity
- instability in sitting
- instability in standing
- instability with walking
- impaired safety awareness
- need for home exercise program to promote further gains, to maintain status, and to prevent decline
- need for education in \_\_\_\_\_ to promote further gains, to maintain status, and to prevent decline
- need for fall prevention
- need for family instruction in \_\_\_\_\_ to promote further gains, to maintain status, and to prevent decline
- pain during functional activities or at rest

Prognosis for improvement in impairments in body structure/function:                      good      fair      poor

Prognosis for improvement in activity limitations:    good      fair      poor

Patient's personal factors that are likely to contribute to outcome: \_\_\_\_\_

\_\_\_\_\_

Patient's environmental factors that are likely to contribute to outcome: \_\_\_\_\_

\_\_\_\_\_

**P:**

Patient participated in planning and goal setting to the fullest extent possible.

Treatment frequency: \_\_\_\_\_                      Duration of sessions: \_\_\_\_\_

Duration of services: \_\_\_\_\_

**Direct interventions** include:

- functional training
- gait training
- monitored mobility
- aerobic conditioning
- positioning
- postural control activities
- ROM/stretching
- therapeutic exercise
- task practice
- w/c training
- other

**Coordination/Communication:** \_\_\_\_\_

\_\_\_\_\_

Patient related instruction: \_\_\_\_\_

Patient to demonstrate the following:

**STG:**

Activity or Task	Performance Conditions	Assistance Needed	Goal Date

**LTG:** (by final discharge from physical therapy services in \_\_\_\_\_ wks or mos );

Activity or Task	Performance Conditions	Assistance Needed	Goal Date

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<sup>2</sup> Shumway-Cook A and Woollacott M. *Motor Control Theory and Practical Application, second ed* Philadelphia, PA: Williams & Wilkins; 2000:517-537.

<sup>3</sup> Sahrman SA and Norton BJ. The relationship of voluntary movement to spasticity in the upper motoneuron syndrome. *Ann Neurol.* 1977;2:460-465.

<sup>4</sup> Scheets PL, Sahrman SA, Norton BJ. *Phys Ther.* 2007;87:654-669.

<sup>5</sup> Ashworth B. Preliminary trial of carisoprodol in multiple sclerosis. *Practitioner.* 1964;192:540-542.

<sup>6</sup> Bohannon RW, Smith MD. Interrater reliability of a Modified Ashworth scale of muscle spasticity. *Phys Ther.* 1987;67:206-207.

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<sup>8</sup> Bodin PG and Morris ME. Inter-rater reliability of the Modified Ashworth Scale for wrist flexors spasticity following stroke. *World Federation of Physiotherapy, 11<sup>th</sup> Congress.* 1991:505-507.

<sup>9</sup> Gregson JM, Leathley M, Moore P et al. Reliability of the Tone Assessment Scale and the Modified Ashworth Scale as clinical tools for assessing poststroke spasticity. *Arch Phys Med Rehabil.* 1999;80:1013-1016.

<sup>10</sup> Ansari NN, Naghdi S, Moammeri H, et al. Ashworth Scales are unreliable for the assessment of muscle spasticity. *Physiotherapy Theory Practice.* 2006;22:119-125.

<sup>11</sup> Gregson JM, Leathley M, Moore P et al. Reliability of measurements of muscle tone and muscle power in stroke patients. *Age and Ageing.* 200;29:223-228.

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<sup>14</sup> Snyder R et al. The relationship between the motoneuron response assessment and fractionated movement of the upper extremity in subjects with hemiplegia. *Phys Ther.* 1994;74(5 Suppl):S45.

<sup>15</sup> Snyder et al. The relationship between the hemiparetic upper extremity and lower extremity using a tone assessment and fractionated movement. *Phys Ther.* 1994;74(5 Suppl):S46.

<sup>16</sup> Sahrman SA and Norton BJ. The relationship of voluntary movement to spasticity in the upper motoneuron syndrome. *Ann Neurol.* 1977;2:460-465.

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