Use of the NeuroCom Balance Master™ Training Protocols to Improve Functional Performance in a Person with Multiple Sclerosis

Jordan Larsen-Merrill PT, DPT
Rolando Lazaro PT, DPT, GCS
Samuel Merritt College – Oakland, CA

ABSTRACT

Study Design: Case Report. Background: Decreased functional abilities such as impaired balance, transfers and ambulation and are common problems for people with Multiple Sclerosis (MS). Previous studies have shown that the use of high technology equipment such as the NeuroCom Balance Master™ may be beneficial in examining and improving a patient’s functional performance. However, research on the use of the training protocols in people with multiple sclerosis is lacking. The purpose of this Case Report is to investigate the use of NeuroCom Balance Master™ training protocols as an intervention for a patient with Multiple Sclerosis presenting with decreased balance, transfers and ambulation. Case Description: A 30-year-old man with an acute exacerbation of relapsing-remitting MS presented with impaired strength, balance, transfers and gait. His goal was to independently ambulate community distances. A physical therapy intervention was designed using the following NeuroCom Balance Master™ training programs: weight bearing squat, sit to stand, limits of stability and rhythmic weight shifting to improve balance, sit to stand transfers, weight bearing thru right lower extremity and gait. Patient underwent physical therapy three times per week for eight weeks. Outcomes: Patient demonstrated improvements in dynamic sitting balance, static and dynamic standing balance, transfers, gait and functional performance. Conclusions: The use of the NeuroCom Balance Master™ training protocols included a variety of task goals that require propulsive movements of the body’s center of gravity, narrowed base of support and high velocity movements and movements on unstable surfaces. The use of the protocols resulted in the improvement of the patient’s balance, transfers and gait.

Introduction

Multiple Sclerosis (MS) is a demylenating disease affecting the central nervous system (CNS) that is both progressive and chronic in nature. This autoimmune disorder leads to destroying myelin, oligodendrocytes and axons. MS is a neurological disease that may result in severe disability and affects more than 400,000 people in the United States. Demylenation compromises nerve fiber function by slowing axonal conduction velocity. Altered conduction of demylenated motor and sensory tracts in the CNS can disturb gait, balance, and therefore increase the risk of falls in this patient population. Symptoms that may be seen in a patient with MS include balance deficits, fatigue, sensory deficits, paresis, spasticity and visual loss. Fifty percent of individuals who have MS will need assistance with ambulation or require an assistive device in order to ambulate short distances within 15 years of the onset of the disease. Management of the disease consists of treating symptoms and acute exacerbations. Research has shown that physical therapy (PT) is beneficial in helping a patient with MS manage symptoms and regain functional mobility and independence. It is therefore important for the physical therapist to design an intervention that is focused on the
patient’s functional limitations and impairments.³

Balance is described as the ability to control one’s center of gravity over the base of support in a given sensory environment. A decreased ability to control one’s balance may lead to an increased fear of falling, which in turn can lead to a decline in mobility. Whipple suggests that the bulk of balance testing and interventions inadequately reproduce the challenges one faces with everyday activities.⁷ It is suggested that balance-training designs must include “constant changes and challenges and involve multiple sources of stimulation… Balance interventions must incorporate a variety of tasks that require movement of the center of gravity, narrowed base of support and movements on unstable surfaces.”⁸

The clinical literature has published many approaches that have been developed for improving balance and functional performance. Some of these approaches involve simple equipment, while some require sophisticated equipment that can provide measurable findings as well as visual and auditory feedback. In 1987, NeuroCom International (Clakamas, OR) unveiled the Balance Master™, which is a computerized piece of equipment used for the assessment and treatment of balance dysfunctions. In its most recent design, the Balance Master™ has the ability to manipulate where a person moves their center of gravity, the speed of the movement, the base of support and the type of surface the person is moving on. Research on the Balance Master has shown its utility in providing objective measures of balance.⁹,¹⁰

In addition to the assessment capabilities of the Balance Master, the company has also developed different training protocols to improve selected functional tasks. There is research on the use of these training protocols in persons with stroke¹¹ but research is lacking in the use of these training protocols in persons with MS.

The purpose of this Case Report is to investigate the use of NeuroCom Balance Master™ training protocols as an intervention for a patient with Multiple Sclerosis presenting with decreased balance, transfers and ambulation.

Case Description

The patient is a 30-year old man who was referred to outpatient physical therapy after a three-week stay in an acute hospital facility after an exacerbation of relapsing-remitting Multiple Sclerosis. His height was 2.05 meters (6 feet 9 inches) and his weight was 133.81 kg (295 pounds). The patient was first diagnosed with MS in 2007. He developed optic neuritis during the exacerbation and was treated with corticosteroid pulse therapy in the acute setting. Studies have suggested that a short course of the corticosteroid methylprednisolone administered intravenously followed by a tapered course of oral steroids may help reverse the inflammation and restore vision.¹² The patient is involved in an experimental study and is receiving intermittent doses of Rituxan. Rituxan is now being studied as a possible treatment for MS.¹³ Current phase II research showed a 91 percent relative reduction in lesions in patients between 18-55 years of age with relapsing-remitting MS. There is evidence that suggests B-lymphocytes are involved in the pathogenesis of MS. Rituxan is a monoclonal antibody that selectively targets and depletes CD20 + B lymphocytes.¹³
The patient’s past medical history included depression, gastroesophageal reflux disease (GERD), migraine headaches and hyperlipidimia. After being diagnosed with MS the patient had to quit his job and lived with his sister. He is currently living in a single story home with 5 stairs to enter with a railing. The patient stated, “I don’t leave my house except to go to doctor’s appointments.” Before this exacerbation, the patient was able to ambulate independently without an assistive device, and complete all activities of daily living without any assistance.

An outpatient physical therapy initial examination was conducted one-week after the patient was discharged from an acute hospital. He was using a wheelchair to get to and from appointments, and inside his home. He was alert and oriented to person, place and time, although responses were delayed and speech was slightly slurred. There were no complaints of pain. The patient stated that fatigue and temperature had not affected him.

The patient signed a Case Report Authorization Form and a video consent form to allow consent form to allow the physical therapy student to collect data for the purpose of writing and presenting a Case Report. This CR is a capstone project for the student’s Doctor of Physical Therapy degree.

**Tests and Measures**

Functional mobility testing was performed on a mat and graded according to the FIM,\(^{14}\) which is a measure of function. This test is based on a 7-point scale, with 1 indicating total assistance or not testable, to 7 which indicates complete independence. Rolling to the right and left was given a FIM score of 4, with rolling to the right being less difficult for the patient. Supine to sit transfer score was a 5.

Sitting static and dynamic balance were testing using the functional balance test as described by O’Sullivan.\(^{15}\) This test is measured in a 0-4 scale, with 0/4 being unable, to 4/4 being normal. Sitting static balance was scored 4/4 (normal), as the patient was able to maintain steady balance without support.\(^{15}\) Dynamic sitting balance was scored ¾ (good), as the patient was able to accept moderate challenges.\(^{15}\) Sit to stand transfer was performed and required moderated assistance of one person and the use of a front wheeled walker (FWW). Standing static balance was 2/4 (fair); the patient was able to maintain balance with handheld support and occasional minimal assistance. Dynamic standing balance was not tested secondary to patient safety. The patient was able to ambulate 5 steps with FWW and moderate assistance of one person. Observational gait analysis was performed according protocol.\(^{16}\) Noted gait abnormalities included the following: decreased step length bilaterally, wide base of support, decreased weight bearing through right lower extremity, inability to place toes on the floor and produce toe off and eye contact was on the ground. It was also noted that ataxic type movements were present with ambulation. Range of motion was tested using a goniometer following the guidelines of Norkin et al.\(^{17}\) Tables 1 and 2 show the results.

Passive range of motion of lower extremities (LE) was tested in the supine position and was within functional limits (WFL). Active range of motion and passive range of motion were also tested for upper extremities (UE) on a flat mat. Passive ROM was tested and was WFL.
Strength was tested using the guidelines stated in the textbook by Reese. Right shoulder flexors and extensors, elbow flexors and extensors, wrist flexors and extensors, hip flexors, extensors, abductors, adductors, knee flexors and extensors and ankle dorsiflexors and plantarflexors were 3/5. Left shoulder flexors and extensors, elbow flexors and extensors, wrist flexors and extensors, hip flexors, extensors, abductors, adductors, knee flexors and extensors and ankle dorsiflexors and plantarflexors were 4/5. Light touch and superficial pain sensation were tested using the examination of sensory function and were intact from C4-S2 bilaterally. Cranial nerve testing was performed following the guidelines of Reese on cranial nerves II, III, IV, VI (Optic, Oculomotor, Trochlear and Abducens). All cranial nerves were intact.

The activity-specific balance confidence (ABC) scale questionnaire was given to the patient to assess patient self-efficacy in balance. The ABC is a 16-item questionnaire with total scores ranging from 0% (no confidence) to 100% (completely confident). A patient is asked to answer how they feel about their balance while performing 16 functional tasks. The patient had a score of 20% indicating a low level of physical functioning. He scored 10% on being able to bend down, pick a slipper up off the floor, and reach for a can on a shelf at eye level with the use of a FWW.

The Tinetti Performance Oriented Mobility Assessment (POMA) tool was administered to test balance and gait. This test is scored on a 3-point scale to assess the patient’s ability to perform specific tasks. A score is given to balance and gait. The scores are added together to determine if the patient is at risk for falls. The patient scored 12/28 indicating a high risk for falls.

**Table 1. Lower Extremity Active ROM at initial examination**

<table>
<thead>
<tr>
<th></th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip flexion</td>
<td>0-50</td>
<td>0-115°</td>
</tr>
<tr>
<td>Knee flexion</td>
<td>0-105°</td>
<td>0-130°</td>
</tr>
<tr>
<td>Knee extension</td>
<td>105–0°</td>
<td>130–0°</td>
</tr>
<tr>
<td>Dorsiflexion</td>
<td>0-10°</td>
<td>0-18°</td>
</tr>
<tr>
<td>Plantarflexion</td>
<td>0-30°</td>
<td>0-50°</td>
</tr>
</tbody>
</table>

**Table 2. Upper Extremity Active ROM at initial examination**

<table>
<thead>
<tr>
<th>Active Assistive Range of Motion</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder flexion</td>
<td>0-85°</td>
<td>0-170°</td>
</tr>
<tr>
<td>Elbow flexion</td>
<td>0-110°</td>
<td>WFL*</td>
</tr>
<tr>
<td>Elbow extension</td>
<td>110-0°</td>
<td>WFL*</td>
</tr>
<tr>
<td>Wrist flexion</td>
<td>0-50°</td>
<td>WFL*</td>
</tr>
<tr>
<td>Wrist extension</td>
<td>0-40°</td>
<td>WFL*</td>
</tr>
</tbody>
</table>

*WFL - within functional limits
The Modified Clinical Test for Sensory Interaction on Balance (mCTSIB), sit to stand, weight bearing squat, limits of stability and rhythmic weight shift were tested using the NeuroCom Balance Master™. The mCTSIB provides information regarding a patient's balance control for basic safety with activities of daily living in varied lighting and surface environments. This test involves somatosensory, vision and vestibular systems and evaluates the ability to remain stable and control the position of center of gravity under different surfaces and visual conditions. The patient demonstrated difficulty maintaining static balance under all four conditions. His center of gravity sway was over his left lower extremity. Results can be seen in Figure 1.

The patient then underwent a Sit to Stand Test using the Balance Master, and results are presented in Figure 2. This test evaluates several measurable attributes of the sit to stand movement. Two things are worth noting in this test. First, the Initial Sway Velocity shows the degree of sway that the patient presents immediately upon standing. Second, the % Left/Right Symmetry shows how much weight is borne by each
extremity with the sit to stand motion. Upon initial testing the patient had difficulty maintaining balance after rising, and had more weight through his left lower extremity. The results are abnormal, based on the norms for the patient’s gender and age.

Next, the Weight Bearing/Squat test was done. This test provides an objective measure of the patient’s ability to perform squats while maintaining equal weight on both extremities, at different degrees of knee flexion. During this test the patient was not able to maintain equal weight through bilateral lower extremities, with the patient weight-bearing more on the left side. Results can be seen in Figure 3.

Figure 2. Sit to stand results at initial examination. Sway Velocity and % Left/Right Symmetry results are abnormal.
The patient then did the Limits of Stability test. This test measures the ability of the patient to move his center of gravity (COG) to his stability limits without losing balance. This test revealed that the patient was not able to lean his COG over his right lower extremity, or forward onto his toes. Results can be seen in Figure 4.

The patient then underwent the Rhythmic Weight Shift test, which objectively assesses the patient’s ability to move his COG rhythmically forward to backward and left to right at three distinct paces. Results indicate that the patient was not able to complete the forward backward component of the

**Figure 3.** Results for weight bearing squat at initial examination, showing the patient putting more weight on the left side while squatting.
rhythmic weight shifting test without falling and also had difficulty with directional and velocity control with lateral weight shifting. Results can be seen in Figure 5.

The data collected at initial examination revealed functional limitation with regards to balance, sit to stand transfers, gait, and impairments on strength and motor control. The Guide to Physical Therapist Practice was used to classify the patient in the neuromuscular practice pattern E (impaired motor function and sensory integrity associated with progressive disorders of the central nervous system). The “Guide” indicates a range of 6-50 visits needed to reach anticipated outcomes. A frequency and duration was set at three times per week for 8 weeks, which was well within the parameters stated in the Guide. The prognosis that the patient would be able to independently community ambulate with an assistive device in eight weeks was good given the patient’s willingness to participate in physical therapy, positive outlook and family support and the patient’s positive response to medical interventions. The plan of care that was developed focused on improving functional limitations such as balance, transfers and gait. The long terms goals were set to be achieved in 8-weeks and short term goals were set to be achieved in 4-weeks. The goals are represented in Tables 3.
Each physical therapy session lasted one hour. The patient wore a gait belt for all intervention activities. Interventions were performed using the NeuroCom Balance Master™ with version 8.0 software. The balance platform consists of a 18”x 60” long force plate. Comprising this long force plate are four individual sections that are positioned on force transducers. The force transducers measure vertical and horizontal ground reaction forces that are used to calculate center of pressure (COP) and center of gravity (COG) sway angles. During balance activities a screen is positioned in front of the patient and gives continuous visual feedback. The patient was allowed to use his FWW as needed.

**The Balance Master™ Training Protocols**

This portion describes each of the training protocols used in the intervention. As mentioned previously, the limits of stability test (LOS), provides an objective measure of the maximum distance a person can intentionally displace their COG without losing balance. The parameters measured within this test and training protocol include reaction time, COG, movement velocity, directional control, endpoint excursion and maximum excursion. LOS was used to measure multiple areas of dynamic balance. The LOS test and training protocols required

---

**Figure 5.** Results for rhythmic weigh shifting at initial examination. Patient unable to shift weight forward and back
the patient to lean towards 8 targets located forward, backward and laterally.\textsuperscript{22}

The patient demonstrated difficulty with sit to stand transfers. In order to improve transfers the weight bearing squat (WBS) and sit to stand (STS) training protocols were used. The WBS was used to in order for the patient to learn to weight bear thru bilateral lower extremities and then squat in 3 positions of knee flexion. The percentage of body weight going thru bilateral lower extremities is measured with the patient at 30, 60 and 90 degrees of knee flexion. Patients with generalized or unilateral weakness will demonstrate impaired motor control for sit to stand transfers.\textsuperscript{22} The STS was used to test and train the patient’s ability to rise from a seated position. Accurate control of COG is very important in rising up from a seated position and is key in maintaining postural control.\textsuperscript{22}

Rhythmic weight shifting (RWS) was used to improve the patient’s ability to shift his COG laterally, forward, and backwards. RWS was implemented to increase the amount of weight the patients was bearing thru his right lower extremity. By increasing the patient’s ability to weight bear thru his right lower extremity his stride length and gait speed would improve.

In addition to the Balance Master training protocols, additional physical therapy interventions also included general strengthening exercises using manual resistance, cuff weights and elastic weights, and endurance programs using the exercise bike and ambulation training.

### Outcomes

At discharge the patient demonstrated improvement in transfers, balance and ambulation. NeuroCom Balance Master™ testing revealed that the patient was able to maintain static balance in all conditions for the mCTSIB except with his eyes closed and on foam. He was able to complete the forward/backward portion of the rhythmic weight shifting, he produced equal weight
bearing through bilateral lower extremities at 30 and 60 degrees of knee flexion on the weight bearing squat and improved on all aspects of the sit to stand transfer. At discharge the patient was able to ambulate 1,000 feet without an assistive device and was producing a step through gait pattern. The patient also improved on the ABC questionnaire and the Tinneti POMA. NeuroCom Balance Master™ results can be seen in Figures 6, 7, 8 and 9. Gait, ABC, Tinetti and balance outcomes can be seen in Tables 4 and 5.

Figure 6. mCTSIB results at discharge, showing better standing balance except eyes closed on foam
Figure 7. Rhythmic weight shift results at discharge, showing that patient can now shift forward-backward

Table 4. Outcome results for the ABC, Tinetti and Balance

<table>
<thead>
<tr>
<th>Test</th>
<th>Baseline</th>
<th>Midterm</th>
<th>Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABC</td>
<td>20%</td>
<td>50%</td>
<td>80%</td>
</tr>
<tr>
<td>Tinetti POMA</td>
<td>12/28</td>
<td>19/28</td>
<td>24/28</td>
</tr>
<tr>
<td>Balance</td>
<td>Sitting (D*) ¾, Standing (S*) 2/4, Standing (D*) NT*</td>
<td>Sitting (D) 4/4, Standing (S) 3/4, Standing (D) 2/4</td>
<td>Sitting (D) 4/4, Standing (S) 4/4, Standing (D) 3/4</td>
</tr>
</tbody>
</table>

*D-Dynamic  
*S-Static  
*NT-Not tested
**Figure 8.** Weight bearing squat results at discharge, showing more equal weight distribution

**Table 5. Gait Outcomes**

<table>
<thead>
<tr>
<th>Week</th>
<th>Distance</th>
<th>Time for 50 feet</th>
<th>Assistive Device</th>
<th>Gait Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>50 feet</td>
<td>1 minute 52 seconds</td>
<td>FWW</td>
<td>Step to</td>
</tr>
<tr>
<td>Three</td>
<td>120 feet</td>
<td>1 minute 5 seconds</td>
<td>FWW</td>
<td>Step to</td>
</tr>
<tr>
<td>Six</td>
<td>236 feet</td>
<td>43 seconds</td>
<td>Quad Cane</td>
<td>Step thru, not equal step length</td>
</tr>
<tr>
<td>Eight</td>
<td>1,000 feet</td>
<td>21 seconds</td>
<td>None</td>
<td>Step thru, equal step length</td>
</tr>
</tbody>
</table>
Discussion

The purpose of this Case Report was to determine the effect of using the NeuroCom Balance Master™ training protocols as intervention to improve balance, transfers and gait in a patient with MS. Following eight weeks of physical therapy intervention using the NeuroCom Balance Master™ training protocols, outcomes indicated that the patient showed improvement in balance, gait and transfers. The advantage of using the Balance Master is that it allowed the patient to receive constant visual feedback during activities regarding balance, sit to stand transfers and weight shifting. The patient felt that the visual feedback aided in his ability to make corrections during functional activities. The patient did get frustrated when he did not score well during the tests and protocols, however, the visual feedback he was given allowed him to make corrections.

As the patient demonstrated improvement when comparing the pretest and posttest Balance Master™ results, it appears that the training also showed carryover into other functional tasks as evidenced by improvement in the patient’s gait pattern, gait speed, distance ambulated and his confidence in his balance.

There are several limitations that are worth noting in this Case Report. The patient was involved in an experimental drug study.

Figure 9. Sit to Stand results at discharge, showing more equal weight bearing
(Rituxan) during the same time that physical therapy interventions were administered. Rituxan could have played a role in improvements seen in functional outcomes. It is also possible that spontaneous recovery due to the remission of the MS could account for the functional improvements.

Other interventions such as a general strength and endurance programs were used concurrently with the NeuroCom Balance Master™ training programs. Improvements in strength and endurance could have played a role in improving the patient’s ability to complete functional tasks such as balance, transfers and ambulation. Another potential limitation was the use of the same test on the Balance Master as an intervention. In order to control for this limitation, the level of difficulty was manipulated once the patient scored 100% on the protocols. Also, additional tests (Tinetti POMA, ABC and gait analysis) were used as outcome measures, but not used as interventions. Lastly, the results of this Case Report cannot be generalized to a broader population with MS. More research with greater number of subjects is needed to truly validate this intervention.

References


