Assessment of Postural Balance in Multiple Sclerosis

Cecilie Fjeldstad, PhD; Gabriel Pardo, MD; Christine Frederiksen, BS;
Debra Bemben, PhD; Michael Bemben, PhD

Compromised postural balance is a common manifestation of multiple sclerosis (MS). Effective quantitative methods of assessing postural imbalance are needed to help clinicians evaluate progression of this impairment. The primary objective of this study was to compare postural balance in MS patients and healthy controls using a standard screening tool, the Berg Balance Scale (BBS), as well as a more technically sophisticated device, the NeuroCom SMART Balance Master (NeuroCom International, Inc, Clackamas, OR). The study participants consisted of 14 individuals diagnosed with MS and 10 healthy controls. Each participant was assessed with the BBS and also underwent six different balance tests using the NeuroCom, most comprising several subcomponent measures. Assessment with the BBS showed significantly more postural instability in the MS group than in the control group (P < .05). Testing with the NeuroCom showed significantly more postural instability in the MS group than in the control group on two of the six tests (four specific balance measures) (P < .05). Moderate-to-high correlations (0.50–0.80) were found between the postural assessments using the standard BBS and the NeuroCom balance tests for the MS group. These results indicate that the BBS is an effective screening instrument for balance problems in people with MS. ***Int J MS Care.* 2009;11:1–5.**

Individuals with multiple sclerosis (MS) often have compromised postural balance. This impairment can be due to lesions in the cerebellum that cause ataxia, or it can be secondary to diplopia, vestibular problems, muscle weakness in the limbs or trunk, decreased proprioception, or lower-extremity spasticity. Several previous studies have examined balance impairment in people diagnosed with MS compared with healthy controls.[1,2] Overall, balance is worse in individuals with MS than in healthy people,[1,2] and patients with primary and secondary progressive MS demonstrate greater impairment, increasing the risk of falling.[1] Various scales and clinical measurement tools have been used to examine balance in the elderly and diseased populations, including the Tinetti Performance Oriented Mobility Assessment (POMA),[3] the Berg Balance Scale (BBS),[3-6] the Timed Up and Go (TUG) test,[4] the Dynamic Gait Index (DGI),[4,5] and the Guralnik Test Battery.[7] The validity[4] and reliability[8] of some of these tools have been previously documented. The frequency and overall risk of falls in individuals with MS have also been studied.[9] Although some of the instruments used have acceptable concurrent validity[4] and have been validated as tools in the geriatric population,[10] they cannot discriminate between individuals who actually fall and those who do not.[4] Therefore, it is difficult to determine which tool is most appropriate for use in the MS population. Most clinical tests examining postural balance have involved noncomputerized devices such as the BBS, TUG, and DGI, which rely on the consistency and expertise of the rater. The use of a more technically sophisticated system that yields objective, quantitative results can be expected to eliminate possible problems related to rater subjectivity, thereby increasing the accuracy and reliability of the findings.

The primary objective of this study was to compare postural balance in MS patients and healthy controls using a standard screening tool, the BBS, as well as a more technically sophisticated device, the NeuroCom SMART Balance Master (NeuroCom International,

From the MS Center of Oklahoma, Mercy NeuroScience Institute, Oklahoma City, OK (CF, GP); and Department of Health and Exercise Science, University of Oklahoma, Norman, OK (DB, MB), USA. *Correspondence:* Cecilie Fjeldstad, PhD, MS Center of Oklahoma, Mercy NeuroScience Institute, 4120 W. Memorial Rd., Ste. 108, Oklahoma City, OK 73120; e-mail: Cecilie.Fjeldstad@Mercy.net.

Inc, Clackamas, OR). A secondary objective was to evaluate correlations between the postural assessment results of the two devices.

Methods

Participants and Setting

The participants in this study were 24 men and women between 21 and 53 years of age: 14 patients who had been diagnosed with MS and 10 healthy controls. All participants were volunteers from the MS Center of Oklahoma, Mercy NeuroScience Institute and surrounding areas in Oklahoma City.

The inclusion criteria for the subjects with MS were diagnosis with relapsing-remitting MS by modified McDonald criteria and age between 18 and 64 years. All MS patients were able to walk without difficulty and without the use of assistive devices. Their mean Expanded Disability Status Scale (EDSS) score was 1.6, with a range of 1 to 3. The mean duration since MS diagnosis was 4.6 years, with a range of 9 months to 23 years. The inclusion criteria for the control group were absence of neurologic disease or gait impairment and age between 18 and 64 years. The actual age range for the control group was the same as that for the MS group.

Research Design

This was a cross-sectional study, and each subject was tested during a single session lasting approximately 45 min. The study protocol was approved by the institutional review board at Mercy Health Center, and all study participants provided written informed consent before testing.

Balance Assessment

Berg Balance Scale (BBS)

The BBS is a 14-item scale that was designed to measure balance in the elderly population in a clinical setting.[11,12] It has also been used to assess postural balance in people with a history of stroke and traumatic brain injury.[13,14] The BBS consists of 14 different tests examining individuals' ability to sit, stand, reach, maintain single-leg stance, and turn.[11] It rates performance on a scale from 0 (cannot perform task) to 4 (normal performance on task). In the elderly population, it has been found to be a good predictor of falling, with good validity and reliability.[10,15-18] The total possible score ranges from 0 to 56; a score of 45 or below indicates an increased risk of falling.[19]

NeuroCom

Six different tests of balance were performed using the NeuroCom, a computerized postural sway assessment device designed to measure postural balance and postural sway with a series of impairment and functional tests. The following balance tests were conducted:

Functional limitation assessment tests. The Walk Across (WA) measures stride speed (in centimeters per second), quantifying characteristics of gait as the individual walks across the length of a sensor-equipped force plate. The Tandem Walk (TW) measures speed of steps (in centimeters per second) as well as end sway (in degrees per second) during tandem walk, quantifying gait characteristics while the subject walks heel to toe across the force plate. The Step/Quick Turn (SQT) records turn time (in seconds) and turn sway (in degrees) to both right and left, quantifying characteristics of the individual's performance while turning. The individual takes two steps forward, quickly pivots 180°, and returns to the starting point.

Sensory impairment assessment tests. The Sensory Organization Test (SOT), measured as an equilibrium score, objectively identifies any abnormalities in the subject's effective use of the three sensory systems (somatosensory, visual, and vestibular) that contribute to the maintenance of postural control. The NeuroCom determines which sensory systems are involved in the loss of equilibrium while the subject stands on the force platform under six different test conditions, three with the platform locked in a stable position and three with the platform moving in rhythm with the subject ("sway referencing"). The six conditions are as follows: 1) fixed surface, eyes open; 2) fixed surface, eyes closed; 3) walls moving, eyes open; 4) surface moving, eyes open; 5) surface moving, eyes closed; and 6) surface and walls moving, eyes open. Greater sway indicated decreased stability, and less sway indicated increased stability.

Motor impairment assessment tests. The Adaptation Test (ADT) examines subjects' ability to minimize sway when they are exposed to sudden, unexpected changes in the standing surface by sequences of platform rotations in the toes-up or toes-down direction, eliciting automatic motor responses. The Limits of Stability (LOS) test examines the maximum distance a person can intentionally displace his or her center of gravity by asking the subject to lean in a given direction as far as possible without losing balance. The percentage of directional control is measured as the subject leans toward the specific target in a clockwise fashion. The test has eight different targets: forward (F), right forward (RF), right (R), right back (RB), back (B), left back (LB), left (L), and left forward (LF).

Statistical Analysis

The results of all descriptive analyses were reported as mean ± standard error for both the MS group and the control group. For outcome measures with multiple trials, as with the NeuroCom balance measures, a one-way repeated-measures analysis of variance (ANOVA) was used to determine whether the scores could be averaged across the three trials. Bonferroni post hoc tests were used to determine significant trial differences when an effect was found. Independent *t* tests were used to compare the two groups of subjects in terms of descriptive data, BBS data, and NeuroCom balance measures. Pearson product moment correlation coefficients were computed for the BBS and the NeuroCom balance measures. All statistical analysis was performed using SPSS, version 12.0 (SPSS Inc, Chicago, IL). The level of statistical significance was set at $P < .05$.

Results

Physical Characteristics

No statistically significant differences were found between the MS and control groups in terms of age (in years), height (in centimeters), body weight (in kilograms), or body mass index (BMI) (in kilograms per square meter) ($P > .05$) (Table 1).

Balance Assessment

On the BBS, the MS group scored significantly lower than the control group ($P < .05$), indicating physical difficulties with some of the tasks. Testing with the NeuroCom revealed statistically significant differences between the two groups, with the MS group demonstrating greater postural sway and slower movements compared with healthy controls on the following tasks: SQT to the right (in degrees), SOT (Conditions 1, 2, and 4) (Table 2).

Table 1. Physical characteristics of multiple sclerosis (MS) and control groups

Parameter	Group	n	Mean	SE	*P* value
Age, yr	Control	10	38.00	3.13	.63[a]
	MS	14	41.35	2.11	
Height, cm	Control	10	169.80	0.03	.58[a]
	MS	14	169.30	2.42	
Weight, kg	Control	10	79.90	4.77	.89[a]
	MS	14	83.22	3.93	
BMI, kg/m²	Control	10	27.54	1.15	.22[a]
	MS	14	29.33	1.80	

Abbreviations: BMI, body mass index; SE, standard error.
[a]$P > .05$.

Table 2. Balance measures showing statistically significant differences between the multiple sclerosis (MS) and control groups

Parameter	Group	n	Mean	SE	*P* value
BBS	Control	10	56.00	0	.034[a]
	MS	14	54.35	0.69	
SQT-right, °	Control	10	15.19	1.51	.044[a]
	MS	14	23.52	3.10	
SOT-1	Control	10	94.83	0.41	.006[a]
	MS	14	92.00	0.82	
SOT-2	Control	10	93.00	0.47	.017[a]
	MS	14	88.00	1.79	
SOT-4	Control	10	85.95	1.62	.021[a]
	MS	14	73.92	3.88	

Abbreviations: BBS, Berg Balance Scale; SE, standard error; SOT-1, Sensory Organization Test, Condition 1; SOT-2, Sensory Organization Test, Condition 2; SOT-4, Sensory Organization Test, Condition 4; SQT, Step/Quick Turn.
[a]$P < .05$.

Moderate-to-high correlations were found between the postural assessment results of the BBS and approximately 70% of the NeuroCom balance tests: SQT (in seconds) to the right and LOS-RF ($P < .05$), as well as TW (in degrees per second), SQT (in seconds and degrees) to the left, SOT (Conditions 1 and 3), LOS-F and LOS-LF, ADT-toes-up and ADT-toes-down, and WA (in centimeters per second) ($P < .01$) (Table 3). These results indicate that the MS group showed significantly more postural instability than the control group.

Discussion

In this study, the MS group showed markedly less postural stability than healthy controls. This result coincides with the findings of Soyuer et al.[1] and Frzovic et al.,[2] who also found impaired balance in individuals diagnosed with MS. Both of those studies, however, used a set of clinical balance tests rather than a computerized balance assessment device. The results from the present investigation showed significant differences between the two groups for both static balance (BBS, NeuroCom) and dynamic balance (BBS, NeuroCom),

Table 3. Correlations between postural assessment results for the Berg Balance Scale and the NeuroCom SMART Balance Master

Parameter	Group	n	*r*
WA, cm/s	Control	10	0.589[a]
	MS	14	
TW, °/s	Control	10	−0.586[a]
	MS	14	
SQT-left, s	Control	10	−0.714[a]
	MS	14	
SQT-right, s	Control	10	−0.447[b]
	MS	14	
SQT-left, °	Control	10	−0.590[a]
	MS	14	
ADT-toes-up	Control	10	−0.582[a]
	MS	14	
ADT-toes-down	Control	10	−0.678[a]
	MS	14	
SOT-1	Control	10	0.582[a]
	MS	14	
SOT-3	Control	10	0.706[a]
	MS	14	
LOS-F	Control	10	0.810[a]
	MS	14	
LOS-LF	Control	10	0.537[a]
	MS	14	
LOS-RF	Control	10	0.463[b]
	MS	14	

Abbreviations: ADT, Adaptation Test; LOS-F, Limits of Stability, forward; LOS-LF, Limits of Stability, left forward; LOS-RF, Limits of Stability, right forward; SOT-1, Sensory Organization Test, Condition 1; SOT-3, Sensory Organization Test, Condition 3; SQT, Step/Quick Turn; TW, Tandem Walk; WA, Walk Across.
[a]$P < .01$.
[b]$P < .05$.

with the MS group showing significantly impaired balance on both types of tasks.

Our finding of moderate-to-high correlations between postural assessment results of the BBS and approximately 70% of all tests performed with the NeuroCom indicates that the BBS remains an effective screening tool for balance. This finding is in agreement with that of Cattaneo et al.,[8] who found the BBS to be a reliable tool for assessing balance in people with MS. Impaired postural balance may increase the risk of falling and thereby decrease quality of life. A study by Bogle Thorbahn and Newton[18] on the use of the BBS in elderly people did not show that the test could definitely predict who would fall but did show that people with BBS scores below 45 were more likely to fall. It should be noted, however, that their results were based on self-reports, which may have influenced the findings. Similar results were seen in a study by Riddle and Stratford,[19] who found the BBS to be better at identifying individuals who do not fall than individuals who do.

A limitation of the present study is that all participants with MS had the relapsing-remitting form of the disease and an EDSS below 3.5, and thus were fully ambulatory. This could have affected the balance measures, as much more disability is seen with progressive forms of MS. In addition, this study did not control for the use of medications, and antispasticity medications such as baclofen could have affected the results. Moreover, fatigue was not controlled for, and testing of subjects was performed at different times of day.

Conclusion

Postural balance relies on proper function of visual, vestibular, and proprioceptive systems, and balance tasks that rely heavily on proprioception seem to be more difficult for individuals diagnosed with MS. Therefore, rehabilitative tasks that focus on improving proprioception should be considered for this population. Various interventions have been shown to improve postural balance, including training using a balance platform,[20,21] whole-body vibration,[22] hippotherapy,[3,23] physiotherapy based on the Bobath concept,[24] locomotor training,[25] aquatic training,[26] dynamic posturography,[27] progressive resistance training,[28,29] and aerobic training. The BBS is an effective and reliable screening

PracticePoints

- Postural instability is common in MS even in individuals with low levels of disability as measured by the Expanded Disability Status Scale (EDSS).
- Imbalance in MS affects both static and dynamic tasks.
- Bedside measurements, such as the Berg Balance Scale (BSS), can properly identify postural instability in MS.
- The use of more technically sophisticated devices that provide more objective, quantitative measures of postural imbalance may improve the ability to monitor its progression over time.

tool for balance problems in people with MS. BBS evaluation is mainly static, however, and does not provide significant information on dynamic functions. Moreover, it is subject to inter- and intrarater variation. The use of more technically sophisticated devices such as the NeuroCom can provide more objective, quantitative measures of postural imbalance and may improve the ability to monitor the progression of balance dysfunction over time. □

Financial Disclosures: The authors have no conflicts of interest to disclose.

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