Targeting Dynamic Balance in Falls-Prevention Interventions in Multiple Sclerosis

Recommendations from the International MS Falls Prevention Research Network

Davide Cattaneo, PT, PhD; Johanna Jonsdottir, PhD; Susan Coote, PhD, PT

***Balance deficits are common in people with multiple sclerosis (MS) and are associated with past and future falls. People with MS tend to fall during activities of daily living and recreation that involve transitions between body positions and during walking and turning. The evident deficits in dynamic balance may be partly due to impairment in the collection or integration of sensory inputs or the execution of appropriate movements in moments of distraction. There is growing evidence that dynamic balance is modifiable and that improvements in dynamic balance are associated with reduction in falls. Consequently, it is imperative that balance measures be appropriate to capture changes in components of dynamic balance. There are numerous ways to measure dynamic balance. When selecting the appropriate dynamic balance measure for an MS falls-prevention trial, the inclusion criteria and content of intervention will inform the choice of measure. The International MS Falls Prevention Research Network (IMSFPRN) suggests that measures of dynamic balance be included as an outcome measure for use in falls-prevention trials. Int J MS Care.* 2014;16:198–202.**

Balance dysfunction is common in people with multiple sclerosis (MS). Studies suggest that most of them will have balance problems over time and that these are present even early in the disease course.[1] People with MS report that balance dysfunction is one of their greatest concerns, and that it contributes significantly to reduced mobility.[2] Balance, or postural control, involves many subsystems to allow the collection and integration of sensory information, the selection of appropriate motor synergies, and the execution of these motor synergies via the musculoskeletal system.[3] Multiple sclerosis can affect one or all of these subsystems, leading to a wide array of balance deficits that can vary over time. A review of balance and postural control[4] concluded that MS is associated with increased postural sway in standing, decreased ability to move toward one's limits of stability, slowed responses to postural perturbations, and slow walking, all of which have been suggested to be related to falls.

Corresponding to balance deficits, falls are of particular concern in people with MS. The best estimate of falls incidence comes from a combination of prospective data from 537 people with MS from four countries (Australia, Great Britain, Sweden, and the United States) and is estimated at 56%.[5] Given the wide-ranging and significant consequences of falls, it is important that we develop and evaluate interventions to reduce the rate of falls and injurious falls among people with MS.

This article will present the rationale for including dynamic balance as an outcome in MS falls-prevention trials. It will build on discussions at the inaugural meeting of the International MS Falls Prevention Research Network (IMSFPRN) and review the literature on the

From the Don C. Gnocchi Foundation, Rome, Italy (DC, JJ); and Department of Clinical Therapies and Centre for Physical Activity and Health Research, University of Limerick, Limerick, Ireland (SC).
Correspondence: Davide Cattaneo, PT, PhD, Don C. Gnocchi Foundation, I.R.C.C.S. Via Maresciallo Caviglia, 20100 Rome, Italy; e-mail: dcattaneo@dongnocchi.it.

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relationship between balance and falls. Additionally, we will review the context of falls for people with MS and the evidence from studies on ways to improve balance and reduce falls. Cumulatively, this information will be used to inform the selection of an appropriate measure of dynamic balance for use in MS falls-prevention trials.

Balance and Falls in People with MS

Balance can be defined as the ability to control the center of mass in relation to the base of support. Generally balance is considered as either static or dynamic. Static balance refers to maintaining the center of mass within the base of support while the body is not moving. In contrast, dynamic balance refers to situations in which either or both the center of mass and base of support are in motion—for example, transitioning between postures or positions and walking.

Two meta-analyses[6,7] of risk factors for falls in people with MS have found that balance is significantly linked to falls. Gunn et al.[7] combined data from four studies and found pooled odds ratios of 1.07, suggesting an association between impaired balance and falling. Similarly, Giannì et al.[6] found that fallers had worse performance on balance tests, and they noted the following specific balance deficits: a) impaired balance during transitions as measured with the Berg Balance Scale (BBS); b) impaired balance during fast walking and turning as measured with the 10-m walking test and the Timed Up and Go (TUG) test; and c) impaired sensory strategies as measured by stabilometric platforms in an eyes-closed condition. More recently, Dibble et al.[8] have demonstrated that fallers have worse scores on the BBS and Dynamic Gait Index (DGI)—both measures that consider dynamic balance—further supporting that dynamic balance deficits are linked with falls in people with MS. As the BBS, timed walks, DGI, and TUG consider transitions and/or walking, these data support the notion that dynamic balance is particularly related to falls in people with MS.

Falls Attributions and Context

The characteristics of activities of daily living (ADLs) during which people with MS are more prone to falls have been investigated in several cohort or cross-sectional studies. These studies have shown that people with MS are more prone to falls during activities that involve transitioning between postures and walking in different situations rather than during quiet standing and sitting. Nilsagård and colleagues,[9] in one of the first prospective studies, showed that falls are more frequent in physical and leisure pursuit activities. Gunn and colleagues[10] studied a cohort of 150 people prospectively over 3 months and showed that the majority of falls occurred at home, during the day, and in activities such as turning, walking, stair climbing, or transitions between body postures. Matsuda et al.,[11] in a retrospective study of 265 participants, also reported a high prevalence of falls during transitions, with the percentage of people reporting falls during transitions double that reporting falls during standing.

Additionally, studies using the Activities-specific Balance Confidence (ABC) scale have suggested that situations requiring dynamic balance are associated with reduced balance confidence and fear of falling among people with MS. People with MS report less confidence during dynamic activities, such as walking through the mall, using an escalator, or walking on slippery sidewalks,[12] further supporting the need to include dynamic balance as an outcome in falls-prevention studies. The finding that people with MS tend to fall during ADLs that involve tasks requiring dynamic balance indicates a need for outcome measures that capture that component.

Measuring Dynamic Balance in an ADLs Context

Activities involving transitions and walking are associated with falls in people with MS; therefore, in choosing an outcome measure for dynamic balance, these components are essential. Activities of daily living, however, also include dual tasking and the use of a range of sensory outputs. It may be important for measures of dynamic balance to incorporate these elements.

The activities during which people with MS fall require dynamic balance and have a natural requirement for dual tasking. Given the prevalence of cognitive dysfunction in people with MS, it is not surprising that they present with difficulties with dual tasking.[13] Several studies have investigated the relationship between dual tasking and falls. Nilsagård et al.,[9] in a simple logistic regression, found that the TUG Cognitive predicted fallers (OR 1.05, 95% confidence interval [CI] 1.0-1.13), and Wajda et al.[14] found that the dual cost of walking was associated with fall risk. However, in a large prospective study of fall risk,[15] dual task interference was not predictive of future falls. As dual tasking is intuitively linked with tasks requiring dynamic balance and falls, the IMSFPRN suggests that outcome measures that capture this

element of dynamic balance may have an advantage over those that do not.

Activities of daily living also require the processing of multiple sensory inputs from the visual, vestibular, and somatosensory systems, and sensory disturbances play a significant role in decreasing dynamic balance in people with MS. Sensory disturbances affect walking performance when subjects move their heads up and down or right and left. In these cases the vast majority of people with MS show a decrement in dynamic balance as measured by the DGI.[16] A deterioration in balance control with the eyes closed, which necessitates greater use of somatosensory or vestibular information, has been associated with a greater risk of falling in three out of four studies that have evaluated fall risk factors.[3] For example, Prosperini and colleagues[17] studied 100 people with MS using static posturography with eyes-closed and eyes-open conditions. They found that increased sway in the eyes-closed condition predicted fallers over a 3-month prospective follow-up. As sensory disturbances are associated with falls in people with MS, dynamic balance measures that capture this element may be preferable over those that do not.

Therefore, the IMSFPRN suggests that measures of dynamic balance for use in MS falls-prevention trials incorporate elements of transitions and walking, and that those that incorporate dual tasking and sensory challenges may have an advantage over those that do not.

Measuring Dynamic Balance

There are a number of available measures that have the potential to capture improvements in dynamic balance.

Computerized force platforms are an option; however, they only consider dynamic balance in which the center of mass and not the base of support is in motion, and their cost may be prohibitive for use across a number of sites for a multicenter trial. Inertial sensors are cheaper and easier to use and capture balance during everyday activities. They have not been used so far in multicenter studies on falls prevention in MS, and their psychometric properties require further evaluation. They may be considered as an option in the future for quantitative dynamic balance assessment.

To date, researchers have used the BBS, TUG, DGI, stabilometry, and timed walking tests as clinical dynamic balance measures. A relatively new dynamic balance measure is the Balance Evaluation Systems Test (BESTest), which takes up to 30 minutes, and its shorter version, the mini BESTest (MBT), taking a more feasible 10 to 15 minutes. The MBT also considers dynamic balance and has the advantage of capturing anticipatory transitions, postural responses, sensory orientation, and walking. The MBT has been shown to be a valid measure of dynamic balance for people with MS and to correctly identify fallers with 86% specificity,[18] although it has not been used widely to evaluate the effects of interventions to date.

Other measures such as the ABC scale, the Falls Efficacy Scale,[19] and the Dizziness Handicap Inventory[20] have been used to capture the wider construct of balance; however, as the aim of this article is to evaluate measures of dynamic balance specifically, these will not be discussed further.

A summary of the possible clinical measures of dynamic balance is presented in Table 1. The BBS has the advantage of being used widely in clinical and research practice to date but has the disadvantage of presenting with ceiling effects for those with mild balance limitations in other neurologic populations.[21,22] Preliminary data from an outpatient clinic found that in 52 people with MS, 38% had maximal scores on the BBS before therapy, while none scored maximally on the MBT (E Ross, S Coote, unpublished data, 2014). All participants improved their MBT score after physical therapy, while only seven had a change in the BBS, suggesting that the BBS has a ceiling effect in ambulatory people with MS. In contrast, however, the MBT and DGI[23] may demonstrate a floor effect for those with greater balance dysfunction, as the tasks require a higher level of postural control than some of those in the BBS.

A disadvantage of these tests (BBS, MBT, and DGI) is that they require a therapist/researcher to interpret the subject's performance and to allocate a score on that basis. In contrast, the TUG has the advantage of not having a ceiling or floor effect and being an objective, timed measure and offers the possibility of adding the TUG Cognitive to capture the impact of dual tasking on dynamic balance.

The MS Evaluation Database to Guide Effectiveness task force[24] summarized the possible outcome measures for use with people with MS. They recommend that the TUG (and TUG Cognitive), BBS, and DGI have sufficient psychometric properties for use in MS research trials, but that the BESTest and MBT require further

***Table 1.* Characteristics of possible dynamic balance measures for use in multiple sclerosis falls-prevention trial**

Measure	Summary	Transitions	Walking	Dual tasking	Multiple sensory inputs	Associated with falls
Berg Balance Scale	14 items scored 0–4, maximum score 56, of which 7 involve dynamic balance	Yes	No	Elements with head turns in quiet standing	Eyes closed and head turns	Yes
Timed Up and Go	Time taken to stand, walk 3 m, turn, walk 3 m, turn, and sit down	Yes	Yes	No, but TUG Cognitive adds this	Head turns	Yes
Dynamic Gait Index	8 items scored 0–3, maximum score 24, of which 10 consider dynamic balance	Yes	Yes	Elements with head turns during gait	Horizontal and vertical head turns	Yes
Mini Balance Evaluation Systems Test	14 items scored 0–2, maximum score 28	Yes	Yes	Yes	Eyes closed, foam surface, head turns	Yes

psychometric testing. Ultimately the selection of dynamic balance outcome measures will be influenced by the inclusion criteria in terms of disability (or dysfunction of postural control) and the content of the intervention.

The Effect of Interventions on Dynamic Balance and Falls

Several MS falls-prevention studies have included elements of dynamic balance in their interventions and have found a reduction in falls or falls risk. This further supports the argument that dynamic balance should be an outcome in falls-prevention studies.

One of the earliest studies of balance and falls in people with MS was conducted by Cattaneo et al.[25] Inpatients with MS were randomly allocated to three groups: a control group that did not receive a specific balance rehabilitation program and two experimental groups. The first experimental group received balance exercise in different sensory contexts, while the second group received balance exercises focusing on motor strategies. At the end of the study, both groups showed greater improvement in dynamic balance as measured by the BBS than did the control group. A reduction was found in the number of people who fell in both balance intervention groups, suggesting a link between change in BBS score and reduction in falls.

A community intervention by Coote et al. found that a group physiotherapy program involving balance and strengthening exercises using functional positions resulted in an increase in BBS score[2] and reductions in the number of fallers and falls.[26] Sosnoff et al.[27] used a home program designed to target balance, walking, lower-limb/core muscle strength, and spasticity. They found improvements in dynamic balance using both the Timed 25-Foot Walk test and the BBS that led to reductions in fall risk in the intervention group. Nilsagård et al.[28] evaluated a group balance intervention targeting core stability, dual tasking, and sensory strategies. They found significant improvement in dynamic balance indexed with several measures including the BBS and TUG Cognitive after the intervention and at 7-week follow-up. Importantly, this improvement in dynamic balance was associated with significant reductions in the number of falls and fallers.

While these findings require confirmation by larger studies with matched controls and using prospective falls diaries as an outcome, the results support the notion that exercises that improve dynamic balance also reduce falls,

PracticePoints

- Impairments in dynamic balance are linked to falls in people with MS, and people with MS fall in situations involving control of dynamic balance.
- MS falls-prevention studies should use measures of dynamic balance as an outcome, particularly those measures that capture transitions and walking.
- There are a range of measures of dynamic balance to choose from; ultimately, the inclusion criteria of the trial and the nature of the intervention will influence which measure to use.

and that therefore dynamic balance should be an outcome in falls-prevention programs.

Conclusion

It is clear that deficits in dynamic balance are linked to falls in people with MS. The use of dynamic balance as an outcome in falls-prevention trials is further supported by the fact that people with MS experience falls during ADLs and in situations that involve transitions between postures and walking.

There are a number of ways of measuring dynamic balance. The IMSFPRN recommends that measures that capture transitions and walking should be considered, and suggests that measures that incorporate multiple sensory inputs and dual tasking may have an advantage over those that do not. The level of disability of the study participants and the content of the intervention will ultimately determine which of a range of measures should be used. Thus, the rationale for the use of dynamic balance as an outcome for falls-prevention trials is further supported by studies that have demonstrated improvements in dynamic balance and a concurrent reduction in falls. □

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