



## Distinguishing among multiple sclerosis fallers, near-fallers and non-fallers

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## ARTICLE INFO

## Keywords:

Multiple sclerosis  
Accidental falls  
Falls  
Near-falls  
Walking

## ABSTRACT

**Background:** Fall rates among adults with multiple sclerosis are consistently greater than 50%, but near-falls (i.e. a trip or stumble) are often undocumented. Furthermore, little is known about the circumstances surrounding fall and near-fall events. The purpose of this study was to examine the similarities and differences among non-fallers, near-fallers and fallers with multiple sclerosis, including the circumstances that surround falls and near-falls.

**Methods:** In a single visit, 135 multiple sclerosis participants completed the Hopkins Falls Grading Scale, a custom questionnaire investigating circumstances surrounding falls and near-falls, and performed the Timed Up and Go and Timed 25-Foot Walk tests. Mann-Whitney tests were used to examine differences between fallers, near-fallers and non-fallers. Multiple logistic regression with AIC criterion was used to examine associations of circumstances with the odds of falling vs. near-falling. Cumulative odds ordinal logistic regression was used to analyze the association between each of the walking tests and the susceptibility of the individual for falls or near-falls.

**Results:** 30% of individuals reported falls, while 44% reported near-falls over a 1-year period. Non-fallers completed the walking tests more quickly than near-fallers ( $p < 0.0045$ ), and fallers ( $p < 0.0001$ ); near-fallers and fallers demonstrated similar motor profiles. Individuals were more likely to sustain a fall rather than a near-fall under the following circumstances: transferring outside the home ( $p = 0.015$ ) and tripping over an obstacle ( $p = 0.025$ ). Performing 1-second slower on the walking tests increased the odds of a history of a fall by 6–20%.

**Conclusion:** Near-falls occur commonly in individuals with MS; near-fallers and fallers reported similar circumstances surrounding fall events and demonstrated similar performance on standard timed walking tests. Clinicians monitoring individuals with MS should consider evaluation of the circumstances surrounding falls in combination with quantitative walking measures to improve determination of fall risk and appropriate rehabilitation interventions.

## 1. Introduction

The prevalence of falls among adults with multiple sclerosis (MS) is consistently  $> 50\%$  (Finlayson et al., 2006), resulting in more injuries than age-matched controls (Cameron et al., 2011; Peterson et al., 2008). Many factors have been linked with increased odds of falling including longer disease duration (Gianni et al., 2014), progressive disease (Gianni et al., 2014; Gunn et al., 2013; Matsuda et al., 2011), use of assistive devices (Gianni et al., 2014; Gunn et al., 2013; Matsuda et al.,

2011; Coote et al., 2014; Finlayson et al., 2014), greater overall disability as measured by the Expanded Disability Status Score (EDSS) (Gianni et al., 2014; Kasser et al., 2011), poorer cognition (Finlayson et al., 2006; Gunn et al., 2013; Matsuda et al., 2011; Hoang et al., 2014), bladder dysfunction (Finlayson et al., 2006), slower walking speed or poorer gait performance and endurance (Gianni et al., 2014), and worse performance on balance tests (Gianni et al., 2014; Gunn et al., 2013; Kasser et al., 2011; Hoang et al., 2014). Despite the identification of factors related to falls, less is known about the

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circumstances surrounding fall events and their relationship to measures of walking<sup>1,2,3,4</sup>.

Anecdotally, individuals with MS often report particular circumstances when describing fall-events, such as transfers, stair-climbing, tripping or obstacle avoidance during walking. Knowledge of the circumstances surrounding fall events may direct rehabilitation efforts and improve fall prevention. Information on the circumstances surrounding fall events are growing. One study shows that over a 3-month period, 28% of falls occurred during mobility activities of walking, turning or transferring and 11% of falls resulted in injuries requiring medical attention (Gunn et al., 2014). Additionally, 72% of falls occurred during the day and 62% occurred indoors (Gunn et al., 2014). More than half of the individuals in this sample had an EDSS > 5.5 (Gunn et al., 2014); making it challenging to generalize these results to individuals with lower disability levels. Others have shown that > 45% of falls occurred because of a slip or trip, > 45% of falls occurred when the individual was tired or fatigued, approximately 30% of falls were due to the individual not paying attention and 20–25% of falls occurred when the individual was rushing or not using a needed walking aid (Matsuda et al., 2011). A recent prospective meta-analysis of individuals with MS in four countries with EDSS levels ranging from 0 to 6.5 reported that 65% of falls occurred indoors while 75% occurred during between 6 a.m. and 6 p.m. (Nilsagard et al., 2015). Although they noted associations between falls and EDSS score, no other measures of walking were included in this study.

As opposed to a fall, in which the individual comes to rest on a lower surface, a near-fall occurs when the individual has a trip or stumble, but is able to recover balance. Very few studies examine near-fallers and the circumstances surrounding near-falls are unknown. There are established relationships among reported numbers of near-falls and falls (Nilsagard et al., 2009) and among near-falls and the Timed 25 Foot Walk (T25FW) score in ambulatory individuals with MS (Argento et al., 2014). Although balance, gait and other motor measures may distinguish between MS fallers and non-fallers (Dibble et al., 2013; Prosperini et al., 2013; Cameron et al., 2013), the usefulness of these measures is unclear in individuals with near-falls. Validation of accurate, clinically accessible assessment tools for distinguishing fallers and near-fallers from non-fallers are an important step toward minimizing fall risk and directing individuals into appropriate rehabilitation programs. Individuals who experience near-falls may represent an important target group that has yet to experience a catastrophic fall and could benefit from fall avoidance interventions (Gunn et al., 2014). One way to improve fall risk may be to link measures that are commonly used in the clinic with circumstances known to surround fall events.

Therefore, our objectives were to utilize survey information to a) identify the circumstances surrounding fall or near-fall events; b) identify the prevalence of near-falls in our clinic; and c) examine clinical walking performance in self-identified non-fallers, near-fallers and fallers. We hypothesized that fallers and near-fallers would report similar circumstances leading to falls, which may be amenable to education and rehabilitation; near-fallers would be prevalent in our clinical population, thus identifying an underserved population that should be addressed clinically to prevent injurious falls; and clinical walking performance would distinguish fallers from non-fallers and near-fallers.

## 2. Patients and methods

A convenience sample of participants diagnosed with MS by the 2010 McDonald Criteria (Polman et al., 2011) were included in this observational, cross-sectional quality improvement study. This study

was reviewed by the Johns Hopkins Medicine Institutional Review Board and was determined to be a quality improvement project for which informed consent was not required. All data were collected from current patients at the Johns Hopkins Medical Institute MS Center between December 19, 2012 and May 1, 2013. All participants who were ambulatory with or without an assistive device, lacked orthopedic or other neurologic disorders that would interfere with their walking or their ability to understand survey questions, and able to follow study-related commands were included in this quality improvement study. In a single session, participants completed clinical testing and questionnaires.

### 2.1. Fall questionnaires

The Hopkins Falls Grading Scale divides falls into grades 1–4 by the severity of the fall event, and has established face validity, content validity and excellent interrater reliability (Davalos-Bichara et al., 2013). Grade 1 indicates near-falls, Grade 2 indicates a fall without injury, Grade 3 indicates a fall requiring medical attention, and Grade 4 indicates a fall requiring a hospital admission (Appendix A). An individual was considered a non-faller if they had no falls or near-falls in the past year, a near-faller if they had no falls in the past year but at least one near-fall (Grade 1), and a faller if they had at least one fall (Grade 2–4) within the last year.

A custom survey (Appendix A) that aimed to identify the number and circumstances surrounding fall events was created by two of the study authors based on clinical expertise and administered to all participants. The survey was completed in a single visit without longitudinal monitoring.

### 2.2. Clinical testing

Two standard clinical tests of walking, the T25FW and Timed Up and Go (TUG) were chosen because they are considered gold standards for mobility function in clinical trials of MS (Kapoor et al., 2010; Hupperts et al., 2016).

The T25FW (Polman and Rudick, 2010) requires individuals to ambulate at their quickest, safe speed over 25 feet for two trials. The T25FW has excellent intra (ICC = 0.99) and interrater (ICC = 1.0) reliability (Rosti-Otajärvi et al., 2008). Although no cut-off scores have been established, a recent meta-analysis suggested that MS fallers perform worse than non-fallers on the T25FW (Gianni et al., 2014).

The TUG requires individuals to stand from a chair, walk 10 feet, turn, walk back, and return to a seated position in the chair. The TUG is reliable and valid in persons with MS (Nilsagard et al., 2007); while there is marginal evidence to suggest that TUG scores differ between MS fallers and non-fallers (Gianni et al., 2014), cut-off scores have been reported only for the TUG-cognitive version of this test (Nilsagard et al., 2007).

### 2.3. Statistical analysis

All statistical analyses were performed in R (version 3.0.2; The R Foundation for Statistical Computing). Subjects were subdivided utilizing The Hopkins Fall Grading Scale to separate non-fallers from near-fallers (Grade 1) and fallers (Grades 2–4).

To examine associations of circumstances with the odds of falling vs. near-falling, we considered only individuals reporting at least one fall or near-fall in the past year, as non-fallers could not provide this information. We examined the circumstances surrounding fall-events with descriptive statistics and then a multiple logistic regression was used to model the association of log-odds of falling with the covariates in the model and the circumstances. Due to the large number of predictors in the model, we first used a variable selection procedure, forward selection using the Akaike Information Criterion (AIC) criterion (Akaike, 1974) to identify a subset of predictors used in the final model.

<sup>1</sup> EDSS: Expanded Disability Status Score.

<sup>2</sup> MS: Multiple Sclerosis.

<sup>3</sup> T25FW: Timed 25 Foot Walk TUG: Timed Up and Go.

<sup>4</sup> AIC: Akaike Information Criterion.

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