J Rehabil Med 2013; 45: 452–457

ORIGINAL REPORT

A POPULATION-BASED STUDY OF FALL RISK FACTORS AMONG PEOPLE WITH MULTIPLE SCLEROSIS IN STOCKHOLM COUNTY

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Objective: **To identify factors associated with increased likelihood of reporting a recent fall among people with multiple sclerosis. This study was exploratory in its intent to examine sense of coherence as a contextual influence on fall risk. The study also sought to confirm that variables previously identified as fall risk factors for people with multiple sclerosis persist when tested in a population-based sample.**
Design: **The study was cross-sectional and data was obtained in the context of a population-based study of people with multiple sclerosis living in Stockholm.**
Subjects: **A total of 164 people with multiple sclerosis, age range 19–79 years.**
Methods: **Data were gathered through established instruments. Key instruments utilized included the sense of coherence scale, the Lindmark Motor Capacity Assessment's subscale for balance, and the 10-metre walking test. A logistic regression model examined factors associated with reporting a fall in the past 3 months.**
Results: **Of the participants, 62 (38%) reported experiencing at least one fall in the past 3 months. Reduced walking speed, impaired balance, and weak sense of coherence were associated with falls in the past 3 months.**
Conclusion: **These findings underscore the importance of examining diverse and modifiable influences on fall risk, including walking speed, balance and sense of coherence, in future studies involving people with multiple sclerosis.**

Key words: multiple sclerosis; accidental falls; risk factors; walking; balance, sense of coherence.

J Rehabil Med 2013; 45: 452–457

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Accepted Nov 21, 2012; Epub ahead of print Mar 27, 2013

INTRODUCTION

Falls among people with multiple sclerosis (MS) are common and often require medical attention. Prospective research indicates that at least 48% of people with MS fall each year (1, 2) and findings from cross-sectional studies utilizing self-reported data suggest that up to 19% of people with MS who fall seek medical attention for injuries ranging from soft tissue injuries and lacerations to fractures and head injuries (3, 4).

Three cross-sectional studies (4–6) and two prospective studies (1, 2) have examined risk factors for falls among people with MS. While it is important to recognize the variability in sample size, age, study design, data collection method, and time period, these studies have consistently identified balance as a fall risk factor (1, 2, 4–6).

Overall, physical risk factors are well-represented in studies of fall risk factors among people with MS to date. The International Classification of Functioning, Disability and Health (ICF) (7), however, emphasizes that disability emerges through a relationship between the individual who has a health condition and contextual (personal and environmental) factors. Mobility device use (i.e. use of canes, walkers, wheelchairs), which is considered an environmental factor according to the ICF, has been studied and found to be significant in studies of fall risk among people with MS (1, 4–6). Personal factors, such as psychological characteristics and coping styles, on the other hand, have been largely overlooked in research examining fall risk factors among people with MS. The exception is one study that found fear of falling to be associated with increased likelihood of seeking medical attention for a fall-related injury within the past 6 months (6).

Emerging evidence points to the need to consider an array of influences on adaptive behaviour changes associated with reduced risk of falling (8–10). Falls self-efficacy, as a measure of fear of falling, is widely recognized as an important influence on adaptive fall prevention behaviours, and a fall risk factor (11); however, recent studies (12) and clinical practice guidelines for prevention of falls in older persons (13) have highlighted the importance of determining the extent to which concerns about falling are protective (i.e. appropriate given abilities) or contribute to deconditioning or compromised quality of life, which can occur when an individual curtails involvement in activities he or she is safely able to perform due to fear of falling. Differentiating between protective fear of falling and fear of falling leading to undue activity curtailment is highly salient when working with people living with MS. Further psychometric evaluation of falls self-efficacy measures involving people with MS is called for because lack of confidence and some caution about falls may be appropriate for a

 doi: 10.2340/16501977-1129
 ISSN 1650-1977

person with MS, depending on the person-task-environment interaction (9). Together, appreciation of the complexity of fear of falling and recognition of diverse influences on adaptive fall prevention behaviours highlight the need to expand understanding of personal factors influencing fall risk.

Sense of coherence (SOC) is an important personal factor that warrants careful consideration as a potential fall risk factor among people with MS. SOC is a theoretical construct used to measure the degree to which a person finds the world comprehensible, manageable and meaningful, suggesting that the way people view their lives influences their health (14). An individual with a strong SOC, for instance, is thought to have more resources at hand to adjust successfully to living with a chronic disease, such as MS. SOC was originally presumed to be stable by the age of 30 years, but is considered a disposition rather than a personal trait. More recent studies have shown that SOC can change with life events and health status (15, 16) and may be modifiable through intervention (17, 18). Based on the current literature on risk factors for falls, clinical experience, and qualitative research exploring how people with MS experience living with chronic fall risk (8), we hypothesized that fall experience would be associated with lower SOC among our study participants. Lower SOC could develop *after* a fall, when a fall experience challenges a person's views regarding his or her ability to manage fall risk. Alternatively, lower SOC, could *contribute to* fall risk when a person with MS fails to comprehend the diverse risk factors that can interact to increase fall risk.

The present study aims to examine factors associated with increased likelihood of experiencing a fall in the past 3 months among people with MS. This study is exploratory in its intent to examine the association between SOC and falls. The study also seeks to confirm whether variables previously identified as fall risk factors for people with MS persist as fall risk factors when tested in a population-based sample.

METHODS

Participants

The data for this study were collected in the context of a population-based, cross-sectional study of people with MS living in Stockholm previously described in detail (19). The sample of people with MS ($n=166$) was identified from a stratified 15% of a pool of 2,129 individuals ($n=321$) compiled from lists from various sources, mainly from the Departments of Neurology in Stockholm County. From the medical records it was determined that 125 patients did not fulfil the inclusion criteria, which were: living and registered as a resident in Stockholm; clinical confirmation of MS diagnosis; informed of MS diagnosis; no diagnosis of severe other neurological or psychiatric illness. The inclusion criteria were thus fulfilled by 196 people with MS, and 166 (85%) gave informed consent and agreed to participate. Data collection was performed by home visits by healthcare professionals trained for the purpose. The study was approved by the ethics committee at Karolinska University Hospital, Huddinge, Sweden.

Data collection procedures

Data on occurrence of falls over the past 3 months were collected through interview. Participants were asked, "Do you ever fall?". A fall was defined as an individual coming to rest on the ground or at some other lower level (20). Possible answers were "yes" or "no". Participants who answered in the affirmative were subsequently asked, "How often?" and offered the following response options: at least once in 3 months, every month, several times every month, once a week, several times a week, daily, several times a day. Data on sex, age and diagnosis were collected from the medical records. Diagnosis was determined according to the Poser criteria (21). Disease severity was assessed by means of the Expanded Disability Status Scale (EDSS) (22) and scores were verified by a senior neurologist. To assess SOC, the 13-item version of the SOC-scale was used (23). The questionnaire consists of 13 items covering the 3 main subcomponents of SOC, i.e. comprehensibility (cognitive), manageability (instrumental/behavioural), and meaningfulness (motivational). The items are rated on a Likert scale from 1 (weak) to 7 (strong). The total score ranges from 13 (weak SOC) to 91 (strong SOC). The Lindmark Motor Capacity Assessment (LMCA) is a measure of global motor capacity comprising 4 subscales (24). The subscale for balance was used in this study to assess balance. The subscale consists of 7 items, covering sitting and standing balance, that are scored on a 4-point scale from 0 (no function/cannot perform the activity) to 3 (normal function/can perform the activity without help). The total score ranges from 0 to 21 (no impairment). The 10-m walking test (25) was used to measure walking speed and was performed with a turn on a 5-m course. A static start was used and the participants were instructed to walk as quickly as possible. The use of walking aids and the number of patients unable to perform the walking test were documented.

Statistical analysis

For univariate analyses, the χ^2 test was used for categorical data (disease severity, balance, walking speed, mobility) and the Mann-Whitney *U* test for continuous data (age and SOC). The dependent variable, falls in the past 3 months, was created using the following response options: at least once in 3 months, every month, several times every month, once a week, several times a week, daily, and several times a day. The following criteria were used for categorization of the independent variables: disease severity: EDSS mild (1–3.5)/EDSS moderate (4–5.5)/EDSS severe (6–9.5); balance: impairment, < maximum score on LMCA subscale for balance/no impairment, maximum score on LMCA subscale for balance; walking speed: within age-and sex-related norms, –1 standard deviation (26)/reduced walking speed/cannot perform the walking test; mobility: walk without aid/walk with support/use wheelchair.

Logistic regression was used to explore the association of the independent variables with occurrence of falls in the past 3 months. A set of 7 variables was selected for inclusion for the logistic regression model. These variables represent two categories of characteristics. The first category included 4 factors associated with fall risk in at least 2 out of 5 studies of fall risk factors among people with MS to date: MS severity, impaired balance, limitations in ambulation, and use of mobility devices (1, 4–6). Use of mobility devices was the only contextual (environmental) variable included in that first category of characteristics. The second category included 3 additional contextual (personal) variables: age, sex and SOC.

Univariate logistic regression analyses were performed followed by a multivariate logistic regression analysis with all 7 independent variables. Finally, a multivariate logistic regression analysis was carried out using a stepwise forward selection criteria entering variables with $p \leq 0.05$ and removing variables with $p > 0.10$. Results are presented as odds ratios with 95% confidence intervals. The model depicts the association between the independent variables and having experienced a fall in the past 3 months. The Hosmer-Lemeshow goodness-of-fit is presented as a measure of the overall fit of the final model and the area under the receiver operating characteristic curve is presented as a measure of the predictive accuracy of the model.

Table I. *Characteristics of fallers and non-fallers based on the categorization of the independent variables, and* p-*values*

Independent variables	Fallers, $n=62$	Non fallers, $n=102$	*p*-value
Sex, *n* (%)			
Women	42 (68)	76 (74)	0.35
Men	20 (32)	24 (26)	
Age, years, median (IQR)	52 (43–58)	50 (42–60)	0.94
Sense of coherence ($n=145$), median (IQR)	68 (56–78)	75 (64–81)	0.04
Disease severity, *n* (%)			
EDSS mild, 1–3.5	10 (16)	39 (38)	
EDSS moderate/severe, 4–9.5	52 (84)	63 (62)	0.003
Balance ($n=163$), *n* (%)			
No impairment, maximum score on LMCA – subscale balance	5 (8)	28 (28)	0.002
Impairment, <maximum score on LMCA – subscale balance	57 (92)	73 (72)	
Walking speed ($n=161$), *n* (%)			
Walking speed within normal range (ref.)	10 (17)	41 (40)	
Reduced walking speed	39 (65)	32 (32)	0.001
Cannot perform the walking test	11 (18)	28 (28)	0.34
Mobility, *n* (%)			
Walk without aid (ref.)	27 (44)	59 (58)	
Walk with support	27 (43)	23 (22)	0.01
Wheelchair	8 (13)	20 (20)	0.78

LMCA: Lindmark Motor Capacity Assessment; EDSS: Expanded Disability Status Scale; IQR: interquartile range.

RESULTS

Description of the sample

Out of the 166 people with MS eligible for this study, 2 were excluded due to missing data on falls in the past 3 months. The 164 participants ranged in age from 19 to 79 years and 72% ($n=118$) were female. The majority, 97% ($n=159$), lived in their own homes and 40% ($n=66$) were working full- or part-time. Participants had a mean disease duration of 19 (standard deviation 11.2) years and 40% ($n=66$) were being treated with immunomodulatory drugs. The majority, 74% ($n=111$), reported moderate/strong SOC and mobility aids were used by 52% ($n=86$). Of the 38% ($n=62$) participants reporting that they had experienced at least 1 fall in the past 3 months, 8 reported having fallen at least once every month, 5 reported having fallen several times every month, and 3 participants reported that they fell at least once every week.

There was no difference between fallers and non-fallers with regard to EDSS moderate vs EDSS severe and therefore these categories were merged. There were no differences between fallers and non-fallers in terms of age or sex, but fallers and non-fallers differed significantly with regard to SOC, disease severity, balance, walking speed and mobility (Table I).

Factors associated with experiencing a fall in the past 3 months

In the univariate logistic regression analyses lower SOC ($p=0.023$), EDSS moderate/severe ($p=0.004$), impaired balance ($p=0.004$), reduced walking speed ($p<0.001$) and walk with support ($p=0.010$) were significantly associated with falls in the past 3 months. In the multivariate logistic regression analysis with all 7 independent variables, lower SOC ($p=0.029$) and reduced walking speed ($p=0.030$) were significantly associated with falls in the past 3 months (Table II). In the final model using a stepwise forward selection criteria, lower SOC ($p=0.034$), reduced walking speed ($p=0.002$), and impaired balance ($p=0.043$) were significantly associated with falls in the past 3 months. The estimated log-odds and the standard errors were of reasonable magnitude and thus revealed no sign of collinearity. The Hosmer and Lemeshow goodness-of-fit test provided no evidence of a lack of overall

Table II. *Univariate logistic regression and multivariate logistic regression with all independent variables for the association with falls in the past 3 months; odds ratios (OR) and 95% confidence intervals (CI)*

Independent variables	Variable categorization	Falls in the past 3 months Univariate logistic regression OR (95% CI)	Falls in the past 3 months Logistic regression with all independent variables OR (95% CI)
Sex	Men	1.39 (0.70–2.79)	1.24 (0.52–2.98)
	Women	1	1
Age	Years	1.00 (0.98–1.03)	1.00 (0.96–1.03)
Sense of coherence	SOC (for a decrease of 10 points)	0.71 (0.53–0.95)	0.66 (0.46–0.96)
Disease severity	EDSS moderate/severe, 4–9.5	3.22 (1.47–7.06)	0.88 (0.22–3.46)
	EDSS mild, 1–3.5	1	1
Balance	Impairment	4.37 (1.59–12.04)	3.05 (0.77–12.07)
	No impairment	1	1
Walking speed	Cannot perform the walking test	1.61 (0.60–4.30)	0.90 (0.12–6.87)
	Reduced walking speed	5.00 (2.17–11.51)	3.69 (1.13–11.96)
	Walking speed within normal range	1	1
Mobility	Wheelchair	0.87 (0.34–2.23	1.19 (0.14–10.18)
	Walk with support	2.56 (1.25–5.26)	2.18 (0.70–6.89)
	Walk without aid	1	1

EDSS: Expanded Disability Status Scale.

Table III. *Final logistic regression model using a stepwise forward selection criteria for the association of the independent variables and falls in the past 3 months, odds ratios (OR) and 95% confidence intervals (CI)*

Independent variable	Variable categorization	Falls in the past 3 months OR (95% CI)
Walking speed	Cannot perform the walking test	1.09 (0.32–3.69)
	Reduced walking speed	4.62 (1.80–11.91)
	Walking speed within normal range	1
Balance	Impairment	3.30 (1.04–10.52)
	No impairment	1
Sense of coherence (SOC)	SOC (for a decrease of 10 points)	0.69 (0.49–0.97)
C[a]=0.77		

[a]Area under the receiver operating characteristics curve.

fit of the final model ($p > 0.372$). The area under the receiver operating characteristic curve was 0.77 indicating acceptable discrimination with a sensitivity of 57% and a specificity of 80% (Table III).

DISCUSSION

This is the first study to identify factors associated with increased likelihood of reporting a fall among people with MS, to utilize a population-based sample, and to explore the association between SOC and fall experience. Consistent with earlier studies, (1, 2, 4–6) our findings suggest an important relationship between balance and fall experience among people with MS. In addition, walking speed emerged as being associated with fall experience, as did SOC. Two variables expected to be associated with falls based on findings from earlier studies, use of mobility devices (1, 4–6) and MS severity (measured by EDSS scores) (1, 2), were not statistically significantly associated with falls. This study revealed a fall prevalence rate over a 3-month period of 38%, which is considerably lower than the 3-month prevalence rate of 63% reported in a previous study by Nilsagård et al. (1). The difference may be due to the fact that the subjects in the study conducted by Nilsagård et al. (1) presented with more severe EDSS scores, on average, and used a prospective 3-month falls diary. In general, considering the heterogeneity of people with MS and its disease course, identifying differences in prevalence rates and fall risk factors for people with MS of varying EDSS scores will be an important focus for future research.

In this study, the odds for experiencing a fall in the past 3 months was more than 4 times higher in people with MS and reduced walking speed compared with those with walking speed within normal range. Ambulation-related variables have been included in two prior studies of falls in people with MS, (1, 5) and found to be associated with falls in both cases. Given that mobility limitations are thought to be the main factor contributing to physical disability, (27) and since people with MS rank walking as the highest priority compared with other dimensions of functioning, (28) fall prevention interventions related to both walking and fall risk reduction may support programme compliance.

Investigations into the relationship between walking speed and fall risk among people with MS are worthy of being pursued for several reasons. First, walking speed is a key indicator of MS patients' general mobility even at the early phases of the disease (29). Secondly, for people with MS, reduced walking speed is a predictor of perceived difficulties or dependence in ADL performance (30). Thirdly, evidence from randomized trials indicates that walking speed is a modifiable risk factor among people with MS (31, 32). Finally, walking speed is recognized as a primary, objective outcome measure in clinical research and practice involving persons with MS (33). While interventions designed to increase walking speed may hold promise for the purpose of reducing fall risk among people with MS, optimal strategies to improve walking speed need to be identified. In addition, the relative benefit of interventions intended to improve walking speed for people with MS of different levels of walking capacity need to be investigated carefully, since fast walking programmes can increase the rate of falls (34). It is recommended that prescription of walking programmes be accompanied with specific advice to avoid falls (e.g. walking carefully and attending to changes in walking surfaces, carefully selecting footwear) (34).

Our finding regarding the relationship between balance and falls is confirmed by other studies involving people with MS (1, 2, 4–6). The strong relationship between improved balance and reduced fall risk in older adults (35) combined with research demonstrating that people with MS can improve their balance through exercise (36) heightens the imperative to examine the impact of exercise interventions with strong balance components on fall risk among people with MS. We recognize that exercise programmes intended for people with MS must be customized to address the unique needs and abilities of that patient population; however, development of balanced-focused fall prevention programmes for people with MS can be informed by findings from studies involving community-dwelling older adults (35).

This study, which is the first to examine the relationship between SOC and fall risk among people with MS, reaffirms the importance of examining subjective influences on fall risk. Among older adults, fear of falling and low falls self-efficacy are personal factors widely recognized as fall risk factors (37). Earlier cross-sectional studies involving people with MS have documented an association between fear of falling and fall risk (6) and injurious falls (3). Our findings suggest the potential value of expanding consideration of the influence of personal factors on fall risk to include SOC.

SOC is operationalized as consisting of 3 components: manageability, meaningfulness, and comprehensibility; thus, application of the SOC construct has the potential to inform new directions in fall prevention intervention. Manageability of fall risk, for example, could be enhanced by healthcare providers who educate clients with MS about the availability of fall prevention resources and how to access them. Such resources range from community-based exercise programmes and local occupational and physical therapists with expertise in working with people with MS.

Because meaningfulness represents the motivational component of SOC, efforts to enhance meaningfulness require client-centred approaches to fall prevention. The importance of embedding efforts to reduce fall risk in the context of activities that are uniquely meaningful to the person with MS has been highlighted in previous research (8).

Comprehensibility refers to the extent to which the world is interpreted as rational, understandable, and predictable (14). Emerging evidence indicates that comprehensibility is more important than meaningfulness for changes in SOC (38). The value of comprehensibility was demonstrated in a pilot study of a fall risk management programme specifically designed for people with MS. That programme enabled participants to examine how behaviour, attitudes, activity, symptoms, and the environment influence falls and can be modified to reduce fall risk (9). Together, findings from those studies (9, 38) point to the need for intervention research involving people with MS that examines the impact of education efforts designed to increase comprehensibility of fall risk and prevention strategies on SOC.

While this study's use of a population-based sample is a strength, we cannot be assured that our sample is representative of all people with MS. A limitation of this study is its cross-sectional design, which means that we cannot make inferences regarding causality, and precludes the author's ability to record falls using prospective daily recording as recommended by the Prevention of Falls Network Europe and Outcomes Consensus Group (11). Nevertheless, the findings regarding the influence of balance and walking abilities on fall risk among people with MS are consistent with the current fall-related literature, and our findings provide ample ideas for further research on this important topic.

Our findings contribute to the growing body of evidence regarding fall risk factors among people with MS by demonstrating that reduced walking speed and impaired balance were significantly associated with falls in the past 3 months. Our findings also provide evidence of a relationship between SOC, personal factors, and self-reported falls. Increased understanding of modifiable factors, such as walking speed, balance and SOC, that may contribute to falls among people with MS is essential to designing effective intervention programmes.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Kristina Gottberg, Reg. Nurse, PhD; Professor Sten Fredrikson; Professor Hans Link; Magnus Andersson, MD, PhD; and Olof Sydow, MD, PhD, Karolinska Institutet.

This research was supported by grants from the Centre for Health Care Sciences (CfV); the Health Care Sciences Postgraduate School; the Strategic Research Program in Care Sciences (SFO-V); the Swedish Association of Persons with Neurological Disabilities (NHR); the Swedish Research Council [grant number K2002-27VX-14316-01A]; and the Vardal Foundation [grant numbers 1998/52, 2001/0036].

The authors declare no conflicts of interest.

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