Falls, aging, and disability

Marcia L. Finlayson, PhD, OTR/L[a] and Elizabeth W. Peterson, MPH, OTR/L [b]

[a] Associate Professor, Department of Occupational Therapy, University of Illinois at Chicago

[a] Clinical Associate Professor, Department of Occupational Therapy, University of Illinois at Chicago

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Corresponding author:

Marcia Finlayson
Department of Occupational Therapy
University of Illinois at Chicago
1919 W. Taylor Street, Mail Code 811
Chicago, IL, USA
60612-7250
Phone: (312)996-4603
Fax: (312) 413-0256
E-mail: marciaf@uic.edu

Co-author address:

Elizabeth Peterson
Department of Occupational Therapy
University of Illinois at Chicago
1919 W. Taylor Street, Mail Code 811
Chicago, IL, USA
60612-7250
Phone: (312) 996-4503
Fax: (312) 413-0256
E-mail: epeterso@uic.edu

SYNOPSIS

Falls are a major public health problem, contributing to significant morbidity and mortality among older adults in the US. This paper summarizes and compares – (a) fall prevalence rates, (b) fall risk factors, (c) consequences of falls, and (d) current knowledge about fall prevention interventions - between community-dwelling older adults and people aging with physical disability. In this latter group, we focus on individuals with multiple sclerosis, late-effects polio, muscular dystrophies and spinal cord injuries.

A. INTRODUCTION

Falls are a major public health problem. In the US, falls are the leading cause of injury deaths for adults over age 65 and the most common cause of nonfatal injuries and hospital admissions for traumatic injuries [1]. Non-fatal fall injuries are associated loss of independence [2] as well as significant use of healthcare services [3]. By the year 2020, the combined direct and indirect costs of injurious falls among people over the age of 65 are expected to exceed $54.2 billion dollars in the US [4].

A fall is an unexpected event during which the individual comes to rest on the ground, floor, or lower level [5], typically during the performance of basic daily activities (e.g., walking, getting up from a chair, bending down) [6, 7]. To date, the vast majority of falls-related research has focused on older community dwelling adults. Only recently have researchers started to study falls among adults and older adults with chronic illness and/or existing physical disability.

The purposes of this article are to summarize and then compare – (a) fall prevalence rates, (b) fall risk factors, (c) consequences of falls, and (d) current knowledge about fall prevention interventions - between community-dwelling older adults and people aging with physical disability. In this latter group, we focus on individuals with multiple sclerosis (MS), late-effects polio, muscular dystrophies and spinal cord injuries. These groups have been selected because they are the target populations for the work currently being conducted through the Rehabilitation Research and Training Center on Aging with Physical Disability, based at the University of Washington at Seattle. To locate falls-related information on these populations, a MEDLINE search was conducted using the index term “accidental falls” in combination with one of the following index terms: “multiple sclerosis,” “postpoliomyelitis syndrome,” “muscular dystrophies,” or “spinal cord injuries.”

B. PREVALENCE OF FALLS

B. 1 – Prevalence of Falls among Community Dwelling Older Adults

Approximately 30% of community-dwelling adults age ≥65 years fall each year [8, 9]. Among individuals aged >75 years, the proportion increases to 50% [10, 11]. Based on data from the 2006 Behavioral Risk Factor Surveillance System (BRFSS) survey, which was drawn from interviews involving 92,808 persons aged ≥65 years, Stevens et al. [12] found that approximately 5.8 million (almost 16%) of people aged ≥ 65 years reported falling at least once during the preceding three months. Recurrent falls are common. For example, in one study conducted over a 48 week period, researchers followed 409 community-dwelling persons aged 65 years or more and found that 11.5% fell two or more times [13].

B. 2 – Prevalence of Falls among People Aging with Physical Disability

B.2.1 - Multiple Sclerosis – Rates of falls have been reported in three cross-sectional studies [14-16] and one longitudinal study [7] of people with MS. In one of the cross-sectional studies, an Italian research team found 54% of 50 participants (20 from the community, 30 from an extended care ward) reported at least one fall in the previous two months, and 32% of these fallers experienced recurrent falls. The average age of the fallers was 40 years (sd=11). The other two cross-sectional studies were conducted by a US research team. In one of their studies, the researchers found 52% of 1,089 participants aged 45 to 90 from the US Midwest had experienced a fall over the previous six month period [16]. Using a national US sample, this same research team reported that 64% of 354 study participants, aged 55 to 94 years, reported at least 2 falls per year. Of these individuals, 30% reported falling once a month or more [15].

The longitudinal study was conducted in Sweden with 76 participants, ranging in age from 25 to 75 years [7]. Falls data were collected prospectively over 9 months. In this period,

63% (48/76) of participants reported at least one fall. Among the fallers, 32 participants fell two times or more, and 11 fell 10 times or more. A total of 2,352 near fall incidents were reported across the study period [7].

B.2.2 - Late-effects polio – Two cross-sectional studies were identified that reported on fall prevalence rates among people with late-effects polio. In the first study, an Australian team reported prevalence of falling among 40 people with prior polio, who had an average age of 50.7 years. Of these individuals, 47.5% reported falling 3 or more times in the previous year, and an additional 20% reported falling twice. The remaining participants either experienced a single fall or no falls at all (not reported separately) [17]. In the second study, a US team reported that 84% of 172 survey respondents experienced a fall over the previous year. Average participant age is not reported, although the median age of post-polio syndrome onset was 48 years [18].

B.2.3 - Muscular dystrophies – Only one study was located that reported fall prevalence rates among adults with a form of muscular dystrophy [19]. In this study, 13 adults with myotonic dystrophy, with a mean age of 46.5 years (sd=1.68), reported retrospectively on falls and also monitored falls prospectively for 13 weeks. Retrospectively, five of 13 (38%) participants reported that they fell and injured themselves more than once in the past six months. Over the prospective monitoring period, 10 of 13 (77%) participants experienced a total of 127 stumbles, and 6 of 13 (46%) participants experienced a total of 34 falls. On average, participants experienced a total of 12.2 events over the 13 weeks (falls and stumbles combined) [19].

B.2.4 - Spinal cord injuries – Only one study was located that reported the prevalence of falling among people with spinal cord injury. In this retrospective survey study, 75% of 119 individuals with incomplete spinal cord injury (average age 52.2 years), reported falling in the past year [20].

B. 3 – Summary and Comparison

Although the time periods considered across the studies reported in this section vary from 2 months to one year, findings suggest that the fall rates are considerably higher among people aging with physical disability compared to community-dwelling older adults aged 65 years and over. From the findings reported here, it appears that in some cases, the fall rates of people aging with physical disability may be double that of their community-dwelling older adult peers. Even if one considers only the fall rates among community-dwelling older adults 75 years and older, the rates for people aging with physical disability are still often greater.

C. FALL RISK FACTORS

Research to identify risk factors for falls has been fairly consistent in showing that most falls result from multiple, interacting factors [21]. Fall risk factors are typically classified as intrinsic (within-subject) or extrinsic [22]. Overall, balanced attention to both intrinsic and extrinsic risk factors is warranted because the interaction between a person's physical abilities and their exposure to environmental stressors appears to influence fall risk [23].

C. 1 - Fall Risks among Community Dwelling Older Adults

To date, epidemiologic research to inform fall prevention efforts among community-dwelling older adults has focused heavily on intrinsic fall risk factors. This research has led to understanding of both modifiable and non-modifiable fall risk factors, and the realization that the risk of falling increases dramatically as the number of risk factors increases [8, 24]. For community-dwelling older adults, non-modifiable risk factors include being female, having a history of falls and higher age [22, 25, 26]. Several cohort studies have identified gait and balance disorders, functional impairment, visual deficits, and cognitive impairment as the most important intrinsic risk factors for falling [8, 27-29]. Often, these risk factors are modifiable.

Data from a prospective cohort study of community dwelling older adults (N=1,285) that was undertaken to construct a fall-risk model suggests that key risk factors for men and women may differ [27]. Findings indicated that previous falls and visual impairment were the strongest predictors for women (area under curve = 0.66), whereas previous falls, visual impairment, urinary incontinence, functional limitations, and low level of physical activity were the strongest predictors for men (area under curve = 0.74). Other research has suggested that psychosocial risk factors, including depressive symptoms [30], fear of falling (i.e., a lasting concern about falling that leads to an individual to avoid activities that he/she remains capable of performing) [31] and low falls self-efficacy (i.e., perceived self-efficacy or confidence to avoid falls during essential, nonhazardous activities of daily living) [32] may also place community dwelling older adults at increased risk for falls. Growing evidence suggests that fear of falling and low falls-self efficacy are experienced by both fallers and non-fallers [33, 34].

With respect to extrinsic fall risk factors for community-dwelling older adults, polypharmacy (i.e., four or more medications) and certain classes of drugs, especially psychotrophic medications, increase the risk of fall [35-37]. Although home hazards have received wide attention as an extrinsic fall risk factor, no consistent association has been found between common household hazards and falls in several prospective studies [8, 24, 38-40] Current thinking suggests that most falls in the home result from an interaction between environmental stressors and physical abilities or risk taking behaviors [23]. Furthermore, hazards in the home may not present equal risk to all older adults. Findings from secondary analyses of data from two prospective studies suggest that environmental hazards contribute to falls to a greater extent in older vigorous people than in older frail people [41, 42].

C. 2 - Fall Risk Factors among People Aging with Physical Disability

C.2.1 – Multiple Sclerosis – Three studies were identified that examined risk factors for falls among people with MS; two cross-sectional ones [14, 16] and one longitudinal [7]. With the exception of the large study by Finlayson et al.[16], which used self-report through telephone interviews, the other studies used a combination of self-report instruments and performance-based evaluations. The variability in sample size, age range, study designs, data collection methods, and time periods examined may explain the variability in fall risk factors identified across these studies (See Table 1). Despite the variability in findings, several consistencies are noteworthy.

<Insert Table 1 here>

All studies found that mobility devices were in some way associated with falling. Cattaneo et al [14] found that more fallers used a cane than non-fallers, and Nilsagard et al [7] found that individuals who used walking aids either indoors or out had double the risk of a fall compared to those who used no walking aid. In comparison to people who always used a wheelchair for mobility, Finlayson et al [16] found that never users and sometimes users had approximately 2 times greater risk of a fall. Together with other findings regarding balance and ambulation across these studies, it is clear that further investigation of role of mobility device use in fall risk is warranted. While the findings may simply reflect that mobility device users are more disabled, and therefore at greater risk, Finlayson et al. [16] also suggest that mobility device decision-making (e.g., to use any device, to use a more supportive device under specific circumstances) may also be playing a role.

Other factors that were found to increase risk of a fall in at least two of the studies include being male and MS status/disability. Findings about the role of specific symptoms are variable, and will require further investigation in the future.

B.2.2 - Late-effects polio – Only one study was identified that examined risk factors for falls among people previously affected by polio [17], and it focused primarily on the role of lower extremity strength. The study included 40 people with prior polio and 38 age and sex matched controls. To examine predictors of falls within the polio group, researchers divided the group into people experiencing 0 or 1 fall in the past year (n=13), those who fell twice (n=8), and those who fell multiple times (n=19). Compared to people who fell twice, the multiple fallers had reduced strength in ankle dorsiflexors, greater lower extremity weakness, slower hand and foot reaction times, slower foot-tapping speed, and increased body sway on a compliant surface under both eyes open and eyes closed conditions. Of these differences, the ones with the greatest discriminating power were body sway and composite strength. The authors concluded that weakness has a direct association with falls among people with prior polio, as well as an indirect effect mediated through increased body sway.

B.2.3 - Muscular dystrophies – Only one study was identified that examined fall risk factors among people with myotonic dystrophy type 1 [19]. The study included 13 people with myotonic dystrophy and 12 healthy volunteers matched for sex, weight and body mass index. In bivariate analyses, fallers (n=6) and non-fallers (n=7) within the myotonic dystrophy group were compared. Findings showed that fallers were more likely to have a lower Rivermead Mobility Index score, more likely to use mobility devices or a person to aid mobility indoors or outdoors, have a slower self-selected gait speed, and higher depression [19]. Although the authors also report

regression analysis, the small sample size and large number of variables raise questions about the validity of the findings.

B.2.4 - Spinal cord injuries – Only one study was identified that examined fall risk factors among people with spinal cord injury, specifically those with incomplete injury. Using a mail-out survey, researchers gathered information on falls and fall risk factors among 119 people. Three multivariable logistic regression models evaluated differences between fallers and non-fallers.

The first model examined differences in demographic and injury characteristics, and no statistically significant differences were found. The second model examined differences in health-related data, and found that fallers were more likely to have had more days of poor physical health in the past year, have greater numbers of medical conditions, have arthritis, experience dizziness, report lower self-rated health and report worse health compared to the previous year. The third model examined differences in physical activity and found that fallers exercised less frequently, were fearful of falling, limited activities because of fear of falling, used a cane (versus not), and used a walker (versus not). When the significant variables from all three models were combined into a final model, the most significant factors associated with a fall among people with incomplete spinal cord injuries were exercising less than 8 times per month and not using a walker.

C.3 - Summary and Comparison

A surge in fall-related research over the past 10-15 years has dramatically enhanced understanding of fall risk factors, particularly among community dwelling older adults. It is clear that knowledge related to fall risks among people aging with physical disability is lagging far behind. To date, the literature on fall risk factors among people aging with multiple sclerosis,

late-effects polio, muscular dystrophies or spinal cord injuries has not addressed extrinsic risk factors, including the potential role of multiple medication use and home hazards in increasing fall risk. Among intrinsic factors across these four groups, vision has not yet been investigated, and the evaluation of the role of cognition, fear of falling, falls self-efficacy, depression, and functional status has been inconsistent at best. Future work needs to address these gaps in knowledge, and consider the application of consistent frameworks for organizing thinking about risk factors (e.g., intrinsic versus extrinsic, modifiable versus not) and how they interact and build on each other to influence an individual's fall-related risk.

D. CONSEQUENCES OF FALLS

Overall, the incidence and severity of fall-related consequences increases with age, level of disability and extent of functional impairment [43, 44]. Consequences range from physical, psychological and broader social impacts.

D. 1 – Consequences of Falls among Community Dwelling Older Adults

Consequences of falls among older adults range from loss of confidence and fear of falling [33, 34, 45] to overt physical injuries, activity curtailment and deconditioning [46, 47], to the loss of functional ability and, in some cases, the need for supervision or institutionalization [48, 49], to death [50]. For many older adults, a fall can represent the introduction to old age and a decline in quality of life [51, 52].

D. 1.1 - Physical consequences - Many of the physical consequences of falls among older adults occur as a result of the combination of high incidence and high susceptibility to trauma [53]. While only about 10% of falls among the elderly result in major injuries [8, 40, 54], the effects of injurious falls can be devastating.

Fall-related mortality is high in older adults. Sampalis et al. [55] compared mortality between two groups of older adults who were treated at regional Level I (tertiary) trauma centers – those who sustained trauma from a fall and those who experienced motor vehicle collision related injuries. Researchers found that being injured in a fall was a strong predictor for mortality, with an odds ratio of 5.11 (95% C.I. = 1.84 –14.17, P = 0.002). Furthermore, among individuals aged $\geq$ 65 years, falls are the leading cause of head injuries [56], and a factor in over 90% of fractures of the distal forearm, proximal, humerus, and hip [57].

In 2006, nearly 1.8 million (nearly 5% of all older adults) sustained some type of fall-related injury [12]. Schiller, Kramarow and Day [48] found that 32% of older adults who sustained a fall-related injury required help with activities of daily living afterwards. Of these individuals, 58.5% were expected to require help for at least six months. Other researchers have observed that fall-induced injuries are one of the most common causes of restricted activity and disability in older adult populations [47, 58]

D.1.2 - Psychological consequences - Many older people experience psychological difficulties related to falls. These difficulties are often operationalized as fear of falling and reductions in falls self-efficacy. The concept of falls self-efficacy was originally defined by Tinetti, et al. [32] who developed the Falls Efficacy Scale. When introduced, the Falls Efficacy Scale was intended as a measure of fear of falling, however evidence now suggests that falls-self-efficacy and fear of falling are separate constructs [59] and that falls self-efficacy may act as a mediator to reduce fear of falling [60].

Overall, the etiology of fear of falling and falls self-efficacy is not well understood. Two qualitative studies among community dwelling older adults have explored the nature of fear of falling provide some insights regarding the development of this fear. Tischler and Hobson [61] and

Lee, Mackenzie, and James [62] found that fear of falling is expressed as fear of losing independence or becoming dependent upon others. It was also experienced as fear of physical injury, fear of being unable to get up or get help after a fall, fear of being institutionalized, and fear of bring confined to a wheelchair or unable to walk [61].

Prospective research involving community-dwelling older adults suggests that people who are afraid of falling or who have low falls-self-efficacy enter a debilitating spiral characterized by restriction of physical activities and social participation, physical frailty, falls, and loss of independence [33, 34, 45]. For these reasons, fear of falling and low falls self-efficacy are critical to understanding falls among older adults and considering the potential consequences of a fall experience.

D. 2 – Consequences of Falls among People Aging with Physical Disability

Rates of fatal falls in the U.S. are rising for white men and women aged $\geq$ 45 years and in black and Asian women aged $\geq$ 65 years [50]. The increase has been partially attributed to a greater proportion of older adults living with chronic diseases, which leaves them at greater risk for falling and less likely to survive the injuries resulting from a fall [63]. Despite this knowledge, there is a remarkable lack of documentation about the consequences of falls among people aging with multiple sclerosis, late-effects polio, muscular dystrophy or spinal cord injury. Across all four conditions, four papers were found that explicitly addressed the physical consequences of falls [15, 64-66]. Three others discuss the issues of fear of falling and activity curtailment [18, 65, 67]; both of these issues have been identified as psychological consequences of falls in the literature on community-dwelling older adults.

D. 2.1 – Physical Consequences - The studies of fall-related injuries have examined middle aged and older adults with MS (age 55-94 years)[15], people with incomplete spinal cord

injury (average age of 51.6 years) [65], and veterans with spinal cord injuries (average age at time of fall = 57 years) [64]. In the first two studies, injury data as a consequence of a fall were self-reported. The study of veterans was based on retrospective chart review over a 10-year period. Another study of fatal accidents among people with MS in Denmark included analysis of fall-related deaths [66].

In an interview study, a total of 177 of 354 (50%) of people with MS reported fall-related injuries that required medical attention, with 41 of these individuals doing so in the six month prior to the interview [15]. Injuries sustained included fractures, soft tissue injuries (e.g., bruises, sprains), lacerations requiring stitches, and head injuries. Across the 177 individuals, 12 hip fractures, 40 lower extremity fractures (not including hip), and 28 other fractures were reported. In multivariable analysis, only two factors increased the risk of a recent injurious fall: fear of falling (OR=1.94, 95% CI = 1.27-2.96) and osteoporosis (OR=1.65, 95% CI = 1.03-2.62) [15].

Among people with spinal cord injuries, two studies address fall-related injuries. In the first study, 89 of 119 (75%) individuals with incomplete spinal cord injuries reported experiencing at least one fall in the previous year and 18% (n=16) of fallers sustained a fracture as a result. Other reported injuries included soft tissue injuries (e.g., bruises, cuts, scrapes), strains or sprains, dislocations, and loss of consciousness. Overall, 32 people required medical attention for their injuries [65]. In another study of people with spinal cord injuries, fall-related fractures were identified through a retrospective chart review of records from a Veteran's Health Administration orthopedic department [64]. Over a 10 year period, 45 people sustained a fracture and 24 of these were the consequence of a fall (53%). These 24 individuals represented 2.7% of the population of spinal cord patients from the center (N=889). A total of 31 fractures were reported, with 4 people experiencing 2 fractures each. In all 4 cases, both fractures occurred in

the lower extremities. All but one of the fractures occurred in the lower extremity; the remaining one was of the 7th rib. Tibia and/or fibula fractures accounted for 55% of the lower extremity fractures [64].

The most extreme consequence of a fall is death. This physical consequence was examined in one study that linked data from the Danish Multiple Sclerosis Registry to the Cause of Death Registry (1953 to 1996). Information was obtained about 10,174 people with MS. Standardized mortality ratios were calculated for several types of fatal accidents, including falls. Across the time period, 76 people with MS died from an accident; 17 of these accidents were falls. Although the researchers found that the overall risk of death from an accident was higher for people with MS compared to the general population, the risk for falls was elevated but not statistically significant (SMR=1.29)[66].

D. 2.2 – Psychological Consequences - In addition to injuries, the 89 people with partial spinal cord injury in the study by Brotherton et al [65] also reported high levels of restricted activity as a consequence of their fall experience. For example, 45% of fallers restricted getting out into the community, 46% restricted productive activities, and 35% restricted social interactions [65]. In study of 1064 people aging with MS (aged 45-90 years), cross-sectional data indicated that fear of falling, and activity curtailment associated with fear of falling was very prevalent. Overall, 64% reported fear of falling [67] and among those with fear of falling, 83% curtailed activities due to their fear [67]. Individuals who reported fear of falling were more likely to have had a fall in the six months prior to their interview (OR=1.38, 95% CI= 1.03-1.86).

One study has examined fear of falling among people with post-polio syndrome [18], although no analyses were reported about the association between fear of falling and actual falls experiences. Nevertheless, 95% of 172 people reported fear of falling. Fear of falling negatively

affected quality of life and contributed to activity restriction among 80% and 82% of respondents, respectively. Fear of falling affected participants the most when they were tired, when they were out-of-doors, and when they felt weak [18].

D. 3 – Summary and Comparison

Research on the consequences of falls among community-dwelling older adults has examined a broad range of physical and psychological consequences. To date, very little has been documented about the consequences of falls among people aging with physical disability. In fact, no articles were found about the consequences of falls among people aging with muscular dystrophy, and the paper on fear of falling among people with late-effects did not directly examine whether this fear was associated with actual falls experiences. Risk of mortality from falls has only been documented in one study of people with MS [66]. Other consequences that may occur as a result of an accidental fall such as activity curtailment, deconditioning, need for supervision or institutionalization have not been documented for people aging with multiple sclerosis, late-effects polio, muscular dystrophy, and spinal cord injury. Given the prevalence of these consequences among community dwelling older adults, examination of these consequences among people aging with physical disability is warranted especially since their disease processes and related secondary conditions are likely to compromise their bone strength and/or ability to recover from injury.

E. FALL PREVENTION INTERVENTIONS

E. 1 – Fall Prevention Interventions among Community Dwelling Older Adults

Prevention of falls and injuries has been a major focus of research over the past 10-15 years, and there are now more than 100 high quality randomized trials that offer strong evidence that falls can be prevented among community-dwelling older adults. The recent Cochrane

review [68] provides a useful framework for organizing these interventions. A *single intervention* consists of only one major type of intervention that is delivered to all participants (e.g., exercise programs, withdrawal of some types of drugs for improving sleep, reducing anxiety and treating depression, cataract surgery, and pacemaker insertion). *Multiple interventions* consist of a fixed combination of two or more major types of intervention delivered to all participants (e.g., exercise plus home safety education). *Multi-factorial interventions* include several types of interventions, but participants receive different combinations of interventions based on an individual assessment of fall risk.

Meta-analyses of clinical trials have concluded that both single interventions and multiple interventions are effective in preventing falls among community-dwelling older adults [68, 69]. The meta-analysis conducted by Gillespie et al. [68] concluded that multi-factorial interventions do reduce *rate* (as opposed to risk) of falls in older people living in the community. Across the existing body of knowledge, it appears that many effective fall prevention programs share common features including:

1. Completing a comprehensive home assessment [70-72],
2. Using an environment-person approach that considers the interactions among personal capacities, behaviors and environment [72, 73],
3. Providing assistance in mitigating identified hazards [70-72],
4. Providing follow-up visits or contacts as part of the intervention. Intensity seems to have a direct influence on the effectiveness of interventions. The more effective interventions also include a maintenance or follow-up phase [71, 72, 74, 75], and
5. Raising awareness of fall safety principles and generalization of that knowledge to other situations [72, 75].

There are several notable examples of multiple interventions focused on fall prevention, which provide excellent illustrations of how the above recommendations can be incorporated into a program. Both the *Stepping On* program [75] and the *Matter of Balance* program [76] are multiple interventions that incorporate a self-management approach in their delivery.

Both programs are structured group interventions that use the group process as a mechanism to provide emotional support to participants as they explore their concerns about falls and build fall prevention skills. Both programs also use experiential activities to encourage participants to explore and practice safer ways to accomplish valued activities that expose them to some fall risk. The programs emphasize the importance of building relationships with health care providers and using assertive communication skills to get medical (and other) needs met, as needed.

For multi-factorial fall prevention interventions, members of the American Geriatrics Society /British Geriatrics Society Expert Panel on Fall Prevention [77] recommended (based on literature review) that the following components be included, as indicated by individual risk factor assessment:

1. Environmental assessment and adaptation conducted by a health care professional;
2. Balance training, resistive (strengthening) exercises and gait training;
3. Reductions in psychoactive medications and other medications;
4. Management of vision problems; and
5. Management of postural hypotension and other cardiovascular and medical problems.

The *ABLE* program provides an illustration of some of these recommendations, and also incorporates a self-management perspective. This multi-factorial, home-based intervention targeting community-dwelling older adults (aged 70+) with chronic conditions had two primary

objectives: (a) reduce functional difficulties, fear of falling, and home hazards, and (b) enhance self-efficacy and adaptive coping [78]. Two of the outcomes of interest were fear of falling and home hazards. The 6-month intervention consisted of five occupational therapy contacts (four 90-minute visits, one 20-minute telephone contact) and one physical therapy visit (90 minutes) [78]. Using a randomized trial, several positive findings were observed including reduced fear of falling, reduced home hazards, and enhanced adaptive coping (e.g., home modifications) [78, 79]. The program also positively influenced mortality: People who received the intervention gained an average of 3.5 years of lifespan [80].

E. 2 – Fall Prevention Interventions for People Aging with Physical Disability

The evidence to support fall prevention interventions for people who are aging with multiple sclerosis, late-effects polio, muscular dystrophies or spinal cord injuries is only beginning to be developed. A search of MEDLINE was unable to identify any interventions for people with late-effects polio, muscular dystrophy or spinal cord injuries that explicitly targeted reduction in accidental falls. While several single interventions were located that could be hypothesized to reduce fall risk (e.g., exercise interventions, balance retraining), falls were not an evaluated outcome. One notable exception is a balance exercise program for people with MS that was recently published by an Italian research team [81]. In this study, 44 people with MS, with an average age of 46 years (sd=10.2), were randomly allocated to one of three groups – a balance retaining program to improve motor and sensory strategies, a task-oriented balance retraining program to improve motor strategies, or a conventional therapy program not specifically aimed at improving balance. Falls were one of the primary study outcomes and were frequently experienced by the participants (all groups) prior to intervention. Upon conclusion of the intervention (frequency and duration not specified), all three groups experienced a significant

decline in fall rates. Both groups 1 and 2 experienced significant improvement in balance, and group 1 improved in dynamic gait.

One example of a multiple intervention was identified for middle aged and older adults with MS [82]. The *"Safe at Home BAASE"* program was developed using knowledge of fall risk in MS [15, 16, 67], evidence supporting fall prevention with other populations [83], and the input of a international work group. The *BAASE* acronym reflects areas that are addressed during the program, and their influence on falls and fall risk: behavior (*B*), attitudes (*A*), activity (*A*), symptoms (*S*) and the environment (*E*). The overarching goals of the program are to increase knowledge of fall risk factors, increase knowledge and skills to manage falls and falls risk, and modify current behaviors to reduce personal fall risk. This group-based program is delivered through six, two-hour sessions. The first five sessions are conducted over five consecutive weeks. The final "booster" session is held one month after the fifth session.

A pilot feasibility study included 30 people with MS (mean age = 56.7 $\pm$ 7.4). Twenty-three people completed at least 5 out of 6 sessions. A pre/post intervention design was used, without a control or comparison condition. Participants increased their knowledge and skills to manage falls and falls risk, and reported modification of behaviors to reduce personal fall risk. The most notable behavioral changes reported by participants as a consequence of the intervention included developing an emergency plan in case of a fall, planning the order of daily activities to manage MS symptoms and reduce fall risk, choosing not to do an activity because it may lead to a fall, and selecting and checking mobility devices to reduce fall risk [82].

E. 3 – Summary and Comparison

Although current practice in fall prevention for community dwelling older adults is now informed by findings from over 100 randomized trials and meta-analyses of the most

scientifically rigorous studies [68], very little is known about fall prevention interventions for people aging with MS, late-effects polio, muscular dystrophies or spinal cord injuries. Limited fall prevention research involving people who have experienced a stroke and people living with Parkinson's disease has been conducted [84-87], however the interventions tested in those studies (i.e. vitamin D analogue, exercise-based approaches to fall prevention) have failed to yield to the desired outcomes. Thus, the state of current literature suggests that fall rates need to be added as outcome measures (either primary or secondary) to studies evaluating balance and strengthening programs, general exercise interventions, and other potential single intervention approaches to fall prevention that involve people aging with physical disabilities. In addition, there would be value in attempting to replicate multiple interventions for community dwelling older adults (e.g., *Stepping On, Matter of Balance*) to determine if they are effective and efficacious for people aging with physical disability. The *Safe at Home BAASE* program also warrants additional evaluation. Finally, programs that target the specific fall risk factors experienced by a given group must be developed and tested [1]. In order to move in this direction, additional knowledge will be required about fall risk factors and the context under which falls among people aging with physical disability occur.

F. IMPLICATIONS AND CONCLUSION

The U.S. Department of Health and Human Services specifically targeted fall-related deaths, hip fractures and nonfatal head injuries for reduction in the *Healthy People 2010* Objectives for Improving Health [88]. In 2004, the National Council on Aging (NCOA), in collaboration with other top U.S. health and safety organizations launched the *Falls Free Initiative*™. The initiative led to the development of a national action plan that outlines key strategies and action steps to help reduce fall dangers for older adults [89]. While these efforts

primarily target community dwelling older adults, they do not specifically exclude people aging with physical disability and attention to these individuals needs to occur.

With improvements in health care and life expectancy, the number of people aging with physical disability and chronic conditions is expected to increase. These individuals are experiencing many challenges associated with the interaction of aging and disability, and these challenges may increase their risk of falls, and the severity of the falls that they experience. Yet, this review demonstrates that knowledge of falls and their consequences among people aging with physical disability falls far behind the knowledge for community dwelling older adults.

In order to develop and evaluate theoretically sound and evidence-based fall prevention programs for people aging with physical disability, there is a desperate need for more epidemiological research on falls in these groups. More knowledge is needed about who is falling, when and where they are falling, and what factors are contributing to their falls. Without this information, it will be difficult to prioritize intervention development and choose or develop appropriate outcome measures, regardless of whether interventions are single, multiple or multifactorial.

In addition to these efforts, there is also a need to increase awareness of both people aging with physical disability and their health care providers about the problem of falls and the potential to manage these events (i.e., reduce number and severity). As Wagner and colleagues have noted [90, 91], improved health outcomes for people with chronic illness depends the interactions between informed, activated patients and prepared, proactive health care teams. Barr et al. [92] have further argued that it is not simply the patients and the health care teams that must be interacting, but entire communities. When applied to the problem of falls among people aging with physical disability, the Expanded Chronic Care Model [92] points to the need for multi-

level and multi-factorial fall prevention interventions that can develop personal skills, re-orient health services, build healthy public policy, and create supportive communities that can reduce fall rates as well as the severity of falls that are experienced. Such complex health interventions must be theoretically driven so that mechanisms of action and expected outcomes can be clearly explicated and appropriately tested [93].

Falls are a serious problem for people aging with physical disability. Understanding the problem must occur in order to inform effective prevention and management interventions.

Table 1: Summary of findings regarding fall risk factors among people with MS

Factors increasing the likelihood of reporting the dependent variable	Fall in the past 2 months [a] [14]	Fall in the past 6 months [b] [16]	Fall over 9 months [c] [7].
Age	No	No	No
Gender	No	Being male	Being male
MS status / disability	Not examined	Yes	Yes
Balance	Yes	Yes	No
Cognition	No	Yes	No
Incontinence of bladder	Not examined	Yes	No
Mobility device	Yes	Yes	Yes
Fear of falling	Not examined	Yes	No
Fatigue	Not examined	No	No
Spasticity	No	No	Yes
Disturbed proprioception	Not examined	Not examined	Yes
Ambulation	Yes	Not examined	Yes
ADL abilities	No	Not examined	Not examined

[a] – Retrospective recall, cross-sectional design, N=50

[b] – Retrospective recall, cross-sectional design, N=1089

[c] – Prospective monitoring, longitudinal design, N=76

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