

Circumstances and consequences of falls among people with chronic stroke

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Abstract—Falls are common after stroke; however, circumstances and consequences are relatively unknown. Our objectives were to identify the differences between fallers and non-fallers among people with chronic stroke, identify the circumstances of fall events, and examine the consequences of the falls. This is a secondary data analysis; all participants included sustained a stroke. Variables included demographics, stroke characteristics, and comorbidities. Falls were collected via self-report, and circumstances and consequences were derived from participant description of the event and categorized as appropriate. Among 160 participants, 53 (33%) reported a fall during the 1 yr period. Circumstances of falls were categorized as intrinsic or extrinsic. Location and circumstance of the fall were included: 70% occurred at home and 40% were associated with impaired physical or mental state (e.g., inattention to tying shoes). Additionally, 21% of falls were associated with activities of daily living and mobility and 34% with slips or trips. The majority who fell sustained an injury (72%). Injuries ranged from bruising to fractures, and 55% of those with an injury sought medical care (32% to emergency department). Poststroke falls are associated with an alarming rate of injury and healthcare utilization. Targeting mental and physical states may be key to fall prevention.

Key words: activities of daily living, circumstances, consequences, disability, emergency, falls, injury, mobility, rehabilitation, stroke.

INTRODUCTION

Falls are a common and serious complication after stroke, with up to 76 percent of people falling poststroke [1–2]. Both the fall risk and associated risk for fall-related injuries persist into the chronic phases of stroke recovery. Moreover, people with stroke who fall have continued increased incidence of serious adverse outcomes, including fractures, depression, and mortality, compared with adults without stroke [3]. People with stroke have a seven-fold increase in the risk of fracture than those without stroke [4]. Additionally, poststroke falls are associated with lowered rehabilitation potential and functional recovery [5] and contribute to poststroke dependence in activities of daily living (ADLs), instrumental ADLs

Abbreviations: ADL = activity of daily living, DBP = diastolic blood pressure, DSM = Diagnostic and Statistical Manual of Mental Disorders, GAD = Generalized Anxiety Disorder, IADL = instrumental activity of daily living, mRS = modified Rankin Scale, NIHSS = National Institutes of Health Stroke Scale, VA = Department of Veterans Affairs.

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(IADLs), and decreased participation in society [6]. Post-stroke falls contribute to the development of fear of falling, ADL limitations, and increased dependence [7].

The circumstances and characteristics of fall events for older adults and nonstroke populations (e.g., people with multiple sclerosis) have been studied [8–10]. However, the literature is limited regarding differences between fallers and non-fallers in the poststroke population, as well as in the circumstances that surround poststroke falls. Hyndman and Ashburn, in a study of 48 poststroke individuals, found that 50 percent of their sample reported a history of a fall since the stroke and that falls were associated with decreased balance and divided attention [11]. In another study, Hyndman et al. found that people with chronic stroke who fell more than once ($n = 10$) had worse mobility, arm function, and ability to complete ADLs, as well as greater anxiety and depression, than those with one or no falls [5]. While it is known that falls are common poststroke [1–2] and fall risk factors are numerous [5,11] a key step in the development of effective interventions to reduce poststroke falls is to identify the circumstances under which people fall after stroke.

The objectives of the study were to (1) identify the differences between fallers and non-fallers among people with chronic stroke, (2) identify the circumstances of fall events, and (3) examine the consequences of the falls.

METHODS

Design

Data for the current study were collected as part of a prospective longitudinal randomized trial focused on sleep apnea identification and management among veterans with a history of cerebrovascular disease and hypertension [12]. The methods of the clinical trial have been described elsewhere [12]. As part of this trial, participants were contacted at least every other month for the 1 yr study period to inquire about adverse events. During these in-person or telephone contacts, participants were specifically asked about fall events.

Participants

Study participants were recruited from two Veterans Health Administration medical centers (West Haven, Connecticut, and Indianapolis, Indiana). Inclusion criteria for the randomized trial included history of stroke or

transient ischemic attack and a diagnosis of hypertension or blood pressure $\geq 140/90$ mm Hg. Individuals were excluded if they had known sleep apnea, had a sleep disorder other than sleep apnea (e.g., narcolepsy), had a life expectancy less than 6 mo, were unable to wear a nasal or facial continuous positive airway pressure mask, did not speak English, or were unable to provide informed consent. Only individuals with a history of stroke were included in the current analyses.

Measures

Baseline assessments for all study participants included patient interviews and examinations and medical record reviews.

Demographics

Demographics include age, sex, education, race, and marital/coupled status.

Stroke and Health Characteristics

The time since stroke event was collected on the basis of both chart review and patient interview. Stroke-related disability was assessed with the modified Rankin Scale (mRS) [13], a validated measure of the degree of poststroke disability and dependence [14]. The mRS includes six categories of disability that we dichotomously defined as functional independence if the score was ≤ 2 and moderate to severe disability if the score was >2 [15].

Stroke severity was assessed with the National Institutes of Health Stroke Scale (NIHSS) [16]. The NIHSS is valid and reliable, with 11 items that include assessment of consciousness, vision, language, sensory, and motor function. Increasing scores represent greater stroke severity. We examined both the total NIHSS score and individual components possibly related to fall risk (e.g., leg weakness, ataxia).

Comorbidity information was assessed using the Charlson Comorbidity Index [17]. A higher score is indicative of great comorbidity burden. In addition, we included specific variables for diabetes and alcohol use, again given a priori hypotheses regarding their potential association with fall risk. Additional health-related variables include cognition and general pain, assessed with the Saint Louis University Mental Status Examination and the 3-item Brief Pain Inventory, respectively [18]. General health status was assessed with the 12-item Short Form Health Survey [19]. Daytime sleepiness was

assessed with the Epworth Sleepiness Scale, which has been demonstrated to be reliable and valid [20].

Blood Pressure

Blood pressure measurements were taken at baseline and at the end of the study by trained research staff both manually and with a 24 h ambulatory monitor. Sitting blood pressure measurements were taken twice with a sphygmomanometer and stethoscope, using the right arm when possible. Arm and position were noted, and when possible, the same arm and position were used for each measurement for an individual patient. Orthostasis (yes/no) was also recorded.

Positive and Negative Affect

Because falls have been associated with mood, anxiety, and depression, we included measures to assess these variables. We included the Positive and Negative Affect Schedule [21], a 20-item scale used to measure stability of affect at this moment, today, and in the recent past. Anxiety was assessed with the 7-item Generalized Anxiety Disorder (GAD) [22]. The seven items are based on Diagnostic and Statistical Manual of Mental Disorders (DSM) criteria for anxiety disorder [23], and it is a brief and reliable measure validated as a screening measure for GAD. Higher scores indicate increased anxiety. The Patient Health Questionnaire was used as a measure of poststroke depression; it is valid and reliable for the stroke population [24]. Items are based on the DSM, with higher scores indicating worse depression symptoms.

Falls

As described previously, falls were identified and recorded as a part of the routine adverse event collection and reporting protocol. In addition to identification of a fall event, reasons for the fall, location of the fall, and follow-up care were identified through interview questions and chart review. Individuals who sustained at least one fall were considered a “faller” for these analyses. The fall event information was categorized for these analyses to describe both the circumstances and the consequences of falls; the categories were developed explicitly based on the literature [5,9–10,25] and implicitly based on examination of the collected data.

Fall circumstances were separated into intrinsic or extrinsic, personal, and environmental categories, including falls with ADLs (e.g., getting into a car), with movement (e.g., going down stairs), due to trips or slips (e.g.,

slips due to a wet surface), related to a physical or mental state (e.g., syncope or inattention), location of the event (e.g., at home), and season during which the fall occurred (e.g., winter). These categories are not mutually exclusive. For example, if a person fell while walking down wet stairs, the fall would be classified as a fall with movement (related to the stairs) and due to trips or slips (related to the slippery surface).

Consequences of falls included the occurrence of a fall-related injury, which was further classified according to type of injury (e.g., laceration, fracture) and whether the participant sought or received medical care for the fall-related injury (e.g., emergency department visit).

Data Analyses

Data were analyzed with SPSS version 19 (IBM Corporation; Armonk, New York). Descriptive statistics (mean \pm standard deviation, frequencies, and proportions, as appropriate) were used for demographic data and stroke and health characteristics. The baseline characteristics of fallers were compared with non-fallers using *t*-tests and chi-square tests. For those who reported a fall, the circumstances and consequences of falls are included as a frequency and percentage. All falls data are based on the first reported fall.

RESULTS

Falls

Among the 225 participants in the main trial, 160 (71%) sustained a stroke and were included in these analyses. This was a chronic stroke population with a mean time from stroke event to study enrollment of 6.8 ± 8.9 yr. Among the individuals with stroke, 53 sustained at least one fall (33%). Among the 53 individuals who reported a fall, 19 (36%) reported multiple falls during the 1 yr study period.

Table 1 includes demographic and stroke and health characteristic data for the sample and a comparison between fallers and non-fallers. Fallers were more likely to be white (fallers vs non-fallers: 87% vs 69%, $p = 0.02$). They were older (fallers vs non-fallers: 71 vs 67 yr, $p = 0.05$) and more likely to be married or part of a couple (fallers vs non-fallers: 58% vs 43%, $p = 0.07$), but not significantly different in these variables. Surprisingly, only three stroke and health variables were significantly different between fallers and non-fallers, with fallers

Table 1.

Demographic and stroke characteristics. Data presented as either mean \pm standard deviation or *n* (%).

Variable	All (<i>n</i> = 160)	No Fall (<i>n</i> = 107, 67%)	Fall (<i>n</i> = 53, 33%)	<i>p</i> -Value
Demographics				
Age (yr)		67.74 \pm 9.70	71.51 \pm 12.23	0.05
Sex (male)	155 (97)	103 (96)	52 (98)	1.00
Education (some college)		51 (47)	23 (43)	0.54
Race (white)	120 (75)	74 (69)	46 (87)	0.02
Married (yes)		46 (43)	31 (58)	0.07
Time Since Stroke (mo)	82.27 \pm 101.91	78.90 \pm 103.12	89.10 \pm 100.05	0.55
Stroke and Health Characteristics				
Stroke Disability (mRS independent)	129 (81)	92 (86)	37 (70)	0.02
NIHSS (score)	2.55 \pm 3.23	3.43 \pm 0.33	2.81 \pm 0.39	0.97
Leg Weakness (yes)	34 (21)	19 (18)	15 (28)	0.13
Ataxia (any)		22 (21)	14 (27)	0.40
Vision Loss (yes)	17 (11)	9 (8)	8 (15)	0.19
Sensory Loss (yes)		9 (8)	3 (6)	0.75
Charlson Comorbidity Index (score)	2.51 \pm 2.14	2.24 \pm 1.98	3.06 \pm 2.34	0.03
Diabetes (yes)		43 (40)	28 (51)	0.13
Alcohol (any)	117 (74)	78 (74)	39 (74)	0.92
SLUMS Cognition (score)		22.24 \pm 5.06	22.58 \pm 5.18	0.69
BPI-3 Chronic Pain (score)	1.68 \pm 0.48	0.49 \pm 0.05	0.48 \pm 0.06	0.79
SF-12 General Health (score)		0.89 \pm 0.87	0.80 \pm 0.11	0.53
SF-12 Physical (score)	38.41 \pm 9.40	9.75 \pm 0.96	8.85 \pm 1.28	0.46
SF-12 Mental (score)		11.42 \pm 1.12	11.51 \pm 1.66	0.79
SBP (mm Hg)	134.11 \pm 18.66	134.39 \pm 17.47	133.36 \pm 21.03	0.72
DBP (mm Hg)	73.16 \pm 11.75	74.82 \pm 11.48	69.79 \pm 11.67	0.01
Orthostasis (yes)	49 (31)	29 (27)	20 (38)	0.17
ESS (score)	7.92 \pm 4.43	7.66 \pm 4.22	8.43 \pm 4.83	0.30
PANAS (score)	31.04 \pm 8.14	8.19 \pm 0.79	8.09 \pm 1.11	0.57
PHQ (score)	6.96 \pm 5.63	5.65 \pm 0.55	5.60 \pm 0.77	0.26
GAD (score)	5.53 \pm 5.84	5.98 \pm 0.58	5.57 \pm 0.77	0.62

BPI-3 = 3-item Brief Pain Inventory, DBP = diastolic blood pressure, ESS = Epworth Sleepiness Scale, GAD = Generalized Anxiety Disorder, mRS = modified Rankin Scale, NIHSS = National Institutes of Health Stroke Scale, PANAS = Positive and Negative Affect Schedule, PHQ = Patient Health Questionnaire, SBP = systolic blood pressure, SF-12 = 12-item Short Form Health Survey, SLUMS = Saint Louis University Mental Status Examination.

being less independent (mRS of fallers vs non-fallers: 70% vs 86%, $p = 0.02$), having lower diastolic blood pressure (DBP) (fallers vs non-fallers: 69.79 \pm 11.67 vs 74.82 \pm 11.48 mm Hg, $p = 0.01$), and greater comorbidity (fallers vs non-fallers: 3.06 \pm 2.34 vs 2.24 \pm 1.98, $p = 0.03$). Those who had sustained a fall were more likely to be orthostatic, but there was not a significant difference between groups.

Circumstances of Falls

Tables 2 and 3 describe the circumstances surrounding the reported falls. Circumstances are reported both as a proportion of the number of people who fell as well as a proportion of people who identified the circumstance. For

example, falling while doing a chore like gardening was reported by 4 of the 53 (8%) fallers, and 4 of 11 (36%) people reported a fall during an ADL. Of individuals who fell, 21 percent reported a fall while completing an ADL such as toileting, gardening, or going out into the community for banking or shopping. Similarly, 21 percent reported a fall with movement, such as while walking, going up or down stairs, or using a ladder. Tripping or slipping was common (34%), with icy or rainy weather (9%) being the primary reason. The most common intrinsic circumstance related to a fall was impaired mental or physical state: 40 percent of all falls were related to things like being inattentive to tying shoes, falling asleep and

Table 2.Personal and intrinsic circumstances (self-reported) of first identified poststroke fall ($n = 53$ fallers).

Intrinsic or Personal Circumstances of Falls	Descriptive Information*	Frequency, n (%)	Within Circumstance, n (%)
Fall With Activity ($n = 11$ [21%] fell while completing activity)	Household Chores/Gardening	4/53 (8)	4/11 (36)
	Community Living/Mobility (going to bank, grocery store, etc.)	3/53 (6)	3/11 (27)
	Getting In/Out of Car	2/53 (4)	2/11 (18)
	Activities of Daily Living	2/53 (4)	2/11 (18)
Fall With Movement ($n = 11$ [21%] fell while moving)	Up or Down Stairs	5/53 (9)	5/11 (45)
	Walking	3/53 (6)	3/11 (27)
	Ladder/Step Stool	2/53 (4)	2/11 (18)
	Reaching	1/53 (2)	1/11 (9)
Fall Due to Trip or Slip ($n = 18$ [34%] fell after trip or slip)	Weather (ice/rain)	5/53 (9)	5/18 (27)
	Slip Out of Bed/Chair	3/53 (6)	3/18 (17)
	Own Feet	3/53 (6)	3/18 (16)
	Uneven Surface	2/53 (4)	2/18 (11)
	Slippery/Wet (not weather-related)	2/53 (4)	2/18 (11)
	Object in Path	1/53 (2)	1/18 (6)
	Curb	1/53 (2)	1/18 (6)
Fall Related to Mental or Physical State ($n = 21$ [40%] fell due to impaired mental or physical state)	Cords	1/53 (2)	1/18 (6)
	Balance	6/53 (11)	6/21 (29)
	Hip/Leg/Knee/Ankle Gave Out	4/53 (8)	4/21 (19)
	Sleepy/Fell Asleep	2/53 (4)	2/21 (10)
	Not Using Assistive Device (forgetting or not wanting to)	2/53 (4)	2/21 (10)
	Dizzy	2/53 (4)	2/21 (10)
	Inattentive	1/53 (2)	1/21 (5)
	Weakness	1/53 (2)	1/21 (5)
	Sick	1/53 (2)	1/21 (5)
	Syncope	1/53 (2)	1/21 (5)
Alcohol	1/53 (2)	1/21 (5)	

*Each person's fall may be under more than one category.

Table 3.Environmentally related circumstances (self-reported) of first identified poststroke fall ($n = 53$).

Environmental Circumstance of Fall	Descriptive Information*	Frequency, n (%)
Home/Away	Home (inside or outside)	37/53 (70)
	Away from Home (inside or outside)	9/53 (17)
	Unknown	7/53 (13)
Location	Inside (home or away)	27/53 (51)
	Outside (home or away)	17/53 (32)
	Unknown	9/53 (17)
Season†	Spring	13/53 (25)
	Summer	12/53 (23)
	Autumn	14/53 (26)
	Winter	14/53 (26)

*Each person's fall may be under more than one category.

†Not weather-specific, i.e., it may snow in spring or fall.

falling out of a chair, forgetting to use an assistive device, or using alcohol.

It is not surprising that the environment plays an important role in falling. The majority of falls occurred at home (70%). Many falls occurred indoors (51%), but the location varied (i.e., inside home, bank, or hospital). No differences were observed in fall rates across seasons.

Consequences of Falls

The majority of fallers sustained some degree of injury (72%) (**Table 4**). No specific injury was more common than others, but injuries ranged from bruising and sprains and/or strains to fractures. Of the 38 people who sustained an injury, the majority sought medical attention (55%), including 43 percent who sought care in the emergency department or required hospitalization.

DISCUSSION

In this chronic stroke population, 33 percent reported a fall during the 1 yr time period. This observed fall incidence was lower than the 76 percent that has been reported in poststroke populations [1–2] but was similar to the 30 percent rate reported for community-dwelling

older adult populations [26–27]. This may have been the case because the average time since stroke was close to 7 yr and individuals might have learned to manage some fall-risk factors. A key and unexpected finding was that nearly three-quarters of individuals who fell reported an injury, and over half of these injuries required some level of medical attention. The rate of 55 percent seeking medical attention was much higher than the 20 percent that has been reported in the older adult literature [9–10,25]. These results may indicate that although fall rates may level off over time for people with chronic stroke and may approach rates observed in older community-dwelling populations, the severity of the fall and fall-related injury may be increased in the poststroke population. These findings provide robust support for the need for further work to develop effective poststroke fall risk prevention programs.

We were surprised that neither stroke severity nor any of the individual components of the neurological examination (such as leg weakness or ataxia) were associated with fall risk. Hyndman et al. found similar results, with no differences in mobility or motor control, between fallers and non-fallers [5]. However, those who fell in this cohort were more likely to have greater disability and more comorbidities, making it likely that the stroke and

Table 4.

Consequences of first identified poststroke fall.

Consequences of Falls	Descriptive Information	Frequency, <i>n</i> (%)
Injury Reported Related to Fall (<i>n</i> = 53)	Yes	38/53 (72)
	No	15/53 (28)
Injury (<i>n</i> = 38)	Sprain/Strain/Twist	3/38 (8)
	Laceration/Cut/Abrasion	6/38 (16)
	Bruise	4/38 (11)
	Sore/Pain	15/38 (39)
	Fracture	2/38 (5)
	Unknown	8/38 (21)
Injured Body Part (<i>n</i> = 38)	Head	6/38 (16)
	Back	4/38 (11)
	Upper Limb	6/38 (16)
	Lower Limb	8/38 (21)
	Multiple Locations	7/38 (18)
	Unknown	7/38 (18)
Medical Intervention Necessary (<i>n</i> = 38)	Yes (medical intervention necessary)	21/38 (55)
	Emergency Department	12/38 (32)
	PCP/Other (not emergency department)	5/38 (13)
	Hospital	4/38 (11)
	No Medical Treatment	17/38 (45)

PCP = primary care physician.

related disability do contribute to falls. It is also of interest that DBP, but not orthostatic hypotension, was associated with fall risk. Our prior work indicates that individuals with stroke and orthostasis are more likely to sustain a fall [28].

This relationship between fall risk and disability is evident when considering the circumstances under which falls occur. We anticipated that falls would most likely occur related to ADLs, such as toileting and showering, or during IADLs, such as doing household chores or community-based activity. Although people did fall with these ADLs, they were more likely to fall due to a trip or a slip. The high frequency of trips and slips, including those related to a crack in the sidewalk, a curb, carpeting, cords, and tree roots, has been reported in the geriatric literature [10,29–30]. In this chronic poststroke cohort, a third of the fallers fell due to a slip or trip, and these events were due to uneven or wet or icy surfaces, cords, curbs, or objects such as a garden gnome. Perhaps these slips and trips are related to visual or sensory impairment, but inattention to detail and surroundings may also be involved.

Very commonly, fallers reported that falls were related to impaired mental or physical states. This includes being inattentive to details like using an assistive device or tying shoes, falling asleep or being sleepy, or drinking too much alcohol. These data support the concept that fall prevention after stroke should not only focus on strength or range of motion but also fall-risk factor modification. Management of fall-risk factors may include enhanced training while using an assistive device but should also include education about the importance of using assistive devices and verbal or tactile cues to remember to take the actual device out of the house. Individuals also identified balance impairment or their legs or knees giving out as contributing factors to fall events; perhaps additional training to transfer to the stronger side or the continuation of balance programming could attenuate fall risk for these individuals with chronic stroke.

LIMITATIONS

There are limitations to these analyses and results. First, this is an all-veteran sample from two hospitals, the majority of the sample is male and white, and results may not be generalizable to nonveteran stroke populations. Second, the fall data are based primarily on self-report and not all of the relevant details were known for each fall event. For instance, if someone reported a fall while

in Mexico on vacation, we know they were not at home, but do not necessarily know whether or not they were inside or outside. In addition, a participant may forget that a fall was sustained or the details of a fall, although there are no cognitive differences between those who did and did not sustain a fall. Third, although this is a chronic stroke population, the majority were classified as independent according to the mRS. As a group, they may be higher functioning than other poststroke populations, potentially leading to a lower than expected fall rate. Additionally, individuals classified as independent likely engage in different ADLs in more complex environments than those considered dependent. As a result, different fall-risk factors may apply. Finally, we were not able to distinguish between cause and effect of the intrinsic circumstances of the falls; for example, we do not know whether a fall led to ADL restriction and subsequent decreased balance or whether the decreased balance led to the falls.

CONCLUSIONS

People with chronic stroke commonly sustain a fall and are at great risk for incurring an injury requiring medical attention. When seeking to reduce fall risk, mental and physical states may be more important to address than mobility or strength issues. Issues such as not using an assistive device or forgetting to tie shoes might potentially be addressed through self-management training in addition to more typical balance- and strength-training programs for fall prevention. Self-management interventions focused on poststroke fall risk should be developed and assessed.

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