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Falls in community-dwelling stroke survivors: An accumulated impairments model

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Abstract—Falling has been identified as a major complication in persons who have had a stroke. The purpose of this study was to investigate the effect of accumulated impairments on the risk of falling in community-dwelling stroke survivors. *Methods*: Community-dwelling stroke survivors were identified from the Kansas City Stroke Study, a large cohort study of stroke survivors. We evaluated the subjects within 14 days of stroke onset. Impairments were determined at baseline and were defined as motor = Fugl-Meyer lower-limb score > 28, sensory = sensory score on National Institutes of Health (NIH) Stroke Scale > 0, and visual = hemianopsia score on NIH Stroke Scale > 0. Accumulated impairments were characterized as motor only (n = 101), motor + sensory (n = 88), and motor + sensory + visual (n = 47). The reference group did not possess motor, sensory, or visual impairments. We completed follow-ups at 1 month, 3 months, and 6 months poststroke to determine the fall status of the subjects. *Results*: Two hundred eighty subjects were included. Falls were reported by 142 subjects (51%) between 1 month and 6 months poststroke. Univariate analysis revealed that the risk of falling for subjects with motor impairment only was odds ratio (OR) = 2.2 (95% confidence interval [CI] 1.05 to 4.70), motor + sensory impairments OR = 3.1 (95% CI 1.46 to 6.79), and motor + sensory + visual impairments OR = 2.4 (95% CI 1.05 to 5.83) as compared to the group with no motor, sensory, and visual impairments. In multiple logistic regression, the risk of falling increased with motor impairment only and motor + sensory impairments. However, the motor + sensory + visual impairments group had a lower risk of falling. Secondary analysis revealed a significant difference in mobility scores (Orpington Prognostic Scale—balance) among individuals with motor impairment only, motor + sensory impairments, motor + sensory + visual impairments, and the reference group. This lower risk of falling in stroke survivors with motor + sensory + visual impairments may be explained by more involved strokes, more impaired balance, and subsequently less mobility, therefore, lowering their risk of falling. In conclusion, community-dwelling persons who have had a stroke are at a higher risk of falling. However, the risk of falling is not linearly related to the number of impairments. Individuals with motor, sensory, and visual impairments are less mobile and less likely to fall than those individuals with motor deficits only or motor and sensory deficits.

Key words: *falls, motor impairment, sensory impairment, stroke, visual impairment.*

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INTRODUCTION

Stroke is a common neurological event with approximately 4,000,000 stroke survivors living today [1]. The American Stroke Association reports that approximately 600,000 people suffer new or recurrent strokes each year [1] and that more than 50 percent of survivors are expected to be alive in 5 years [2]. The majority of persons who have had a stroke will possess mild and moderate deficits [3] and will be discharged home (93 and 74 percent, respectively). In spite of their discharge to home, many of these persons still possess limitations in their functional recovery. These limitations may be the result of multiple persisting neurological impairments. These common impairments may affect balance and mobility, therefore, increasing the survivors' risk of falling.

Falls have been identified as a major complication following stroke [4]. The reported percentages of stroke patients experiencing falls in the acute-care setting range from 14 to 64.5 percent [5,6], in the rehabilitation setting from 24 to 47 percent [7–9], and in community-dwelling stroke survivors 73 percent [10]. Of those community-dwelling stroke survivors, 47 percent fell more than once [10]. The community-dwelling stroke survivors who fell reported a higher rate of depression, limited social activities, and an increased caregiver burden [10]. Additional consequences of falls may include injury, hospitalization, impaired mobility, restricted decline, nursing home placement, and fear of recurrent falling [11].

Although falls are a complication of stroke and occur frequently, only a few studies have identified risk factors that increase the risk of falling in stroke survivors. These factors include:

- Prior history of falls [6,10].
- Mental decline [12].
- Confusional state [12].
- Urinary incontinence [5].
- Impaired decision-making ability [6].
- Restlessness [6].
- Generalized weakness [6].
- Increased postural sway [13].
- Abnormal hematocrit level [6].

Risk factors identified that increase falling in the elderly individual without a history of neurological conditions are also common impairments in stroke survivors. These risk factors include:

- Decrease in muscle strength [14,15].
- Limitations in joint movement [15].
- Impairments in balance [14,16].
- Impairments in gait, including slow gait velocity [14–16].
- Impairments in vision [15].
- Cognition [14].

Because of the complex and interactive systems responsible for postural control and the presence of multiple deficits in the stroke population, a useful model for evaluating falls in this population may be to examine the effects that accumulated deficits have on the risk of falling. This concept of accumulated risk factors on falling in stroke survivors has only been examined among an inpatient rehabilitation population [17]. However, multiple studies have shown that the risk of falling in elderly individuals without stroke increases with the number of risk factors [14,16,18,19].

The purpose of this study was to examine the relationship between accumulated neurological impairments following stroke and the increased risk of falling in community-dwelling stroke survivors. Specifically, we examined a physiologically based accumulative deficits model that included components of the motor and somatosensory systems. The specific components of the accumulated impairments model included motor impairments; motor and sensory impairments; and motor, sensory, and visual impairments. Because of the physiological mechanism involved in balance and postural control and the impairments common following stroke, the hypothesis was that the risk of falling would increase with each additional impairment.

SUBJECTS AND METHODS

Study Population

The subjects in this study were selected from participants in the Kansas City Stroke Study. The Kansas City Stroke Study recruited stroke survivors from 12 participating facilities in the Kansas City metropolitan area during a 3-year period (1995 to 1998). The participating facilities included one academic medical center, two Veteran Affairs Medical Centers, one rehabilitation hospital, and eight acute-care hospitals.

People who survived a stroke were identified by admission records; referrals from physicians, nurses, or therapists; and discharge codes. Stroke was defined by the World Health Organization (WHO) as, "a rapid onset and of vascular origin reflecting a focal disturbance of cerebral function, excluding isolated impairments of higher function and persisting longer than 24 hours" [20]. Diagnosis was confirmed by clinical assessment and/or a positive computed tomography/magnetic resonance imaging (CT/MRI) scan. Once potential participants were identified, study personnel, consisting of nurses and physical therapists, reviewed medical records, interviewed patients, and consulted with physicians to determine an individual's eligibility.

The inclusion criterion for enrollment in the Kansas City Stroke Study was a confirmed, eligible stroke as defined by the WHO criteria. An additional inclusion criterion for this study was that subjects had to be living in a community for two consecutive follow-up visits. This criterion was defined by the residence of the subjects and included those living at home or with a relative or friend, those living independently in a retirement home, or those living independently at a board-and-care facility at the time of their follow-ups. Additional inclusion criteria included:

- Confirmed diagnosis of stroke.
- Age $\geq$ 18.
- Stroke onset within 3 to 14 days.
- Stroke etiology not subarachnoid hemorrhage.
- No diagnosis of hepatic failure.
- No diagnosis of renal failure.
- No diagnosis of New York Heart Association (NYHA) III/IV heart failure.
- Expected to be alive in 6 months.
- Did not live in nursing home prior to stroke.
- Able to care for affairs prior to stroke.
- Patient not lethargic, obtunded, or comatose.
- Controlled blood pressure.
- Lived within 70 miles of hospital.

Once eligible, participants (or proxy if appropriate) signed an informed consent approved by the University of Kansas' Institutional Review Board and approved by each participating facility.

Study Design

The Kansas City Stroke Study was a prospective cohort study of stroke survivors. The study design required baseline assessment to occur within 3 to 14 days of stroke onset. Follow-ups were completed 1 month, 3 months, and 6 months poststroke. The follow-up visits occurred at the location in which the participant was currently residing. We categorized the location of the follow-up visits as home, including those living independently in a retirement home, home with a relative or friend, board-and-care facility, intermediate care facility, skilled nursing facility, original admitting acute hospital, acute unit of another facility, chronic hospital, or rehabilitation facility/unit.

At each time period (1 month, 3 months, and 6 months poststroke), we evaluated subjects using a battery of standardized assessments, which were completed by the study nurses and physical therapists who received 2 weeks training in the administration of the measures. The reliability achieved by the personnel who administered the assessments was greater than 90 percent. In addition, all nurses and physical therapists received certification for the administration for the National Institutes of Health (NIH) Stroke Scale. For the purpose of this study, a small subset of these assessments was used. The assessments used are described in the following subsections.

Stroke Severity

The Orpington Prognostic Scale was used to measure stroke severity [21]. It was administered within 3 to 14 days of stroke onset. This measure predicts outcomes as measured by the Barthel Index [21]. The components of this scale include motor deficit in the involved arm, proprioception in the upper limb, balance, and cognition.

In addition, we used the balance score from the Orpington Prognostic Scale in the secondary analysis. The scoring for balance is 0.0 = ability to walk 10 feet without help, 0.4 = ability to stand unsupported for 1 minute, 0.8 = ability to maintain a sitting position, and 1.2 = the inability to maintain a sitting position.

Motor Impairment

For this study, we considered only the lower-limb motor score of the Fugl-Meyer [22]. Motor function was assessed in the involved lower limb. The lower-limb score is obtained by one evaluating functions that require progressively more complex movements, such as flexion and extension synergistic movements, movements combining the flexion and extension synergies (knee flexion and

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ankle dorsiflexion in sitting), movements out of synergy (knee flexion and ankle dorsiflexion in standing), and coordination and speed of heel to opposite knee for five repetitions. Each item is scored on a 3-point scale (0 = cannot perform, 1 = partially performs, 2 = performs faultlessly). The maximum lower-limb score is 34. A motor impairment was considered present if the lower-limb motor score was ≤ 28 [23].

Sensory and Visual Impairments

The NIH Stroke Scale is a systematic assessment tool used to measure neurologic deficits most often seen in persons with an acute stroke [24]. For this study, we used only visual impairment (question 3 of the scale) and sensory impairment (question 8). The visual score (question 3) assesses visual field compromises and tests both the upper and lower quadrants of vision. In this study, we considered a visual impairment present if the subject scored ≥ 1 (partial or complete loss in any sides of the visual fields) [23]. The sensory assessment (question 8) tests tactile sensation and is evaluated by pinprick. We considered a sensory impairment present if the subject scored ≥ 1 (mild, moderate, or severe sensory loss) [23].

Outcome

The outcome measure in this study was fall status. We obtained fall status at the 1-month, 3-month, and 6-month poststroke follow-ups. We assessed fall status using the following self-report question, "Since our last visit, have you (or the subject) fallen?" If the subject was unable to answer, we used the caregiver responses. Subjects were not given a preestablished definition of fall, so the responses collected were the subject's self-perceived definition of fall. Only subjects who were living in a community for at least two consecutive follow-up visits were used. To capture only those falls that occurred while they were living in the community, we used two recurrent time periods, such as 1 to 3 months and 3 to 6 months. Therefore, those subjects who were not available for two consecutive follow-up times were excluded from this study. To further explain, we only included falls if the subject was residing in the community during the entire observation period. For example, if a subject was living in a nursing home between 1 month and 3 months poststroke, any reported fall at the 3-month follow-up was excluded. If however, this subject was discharged home at 3 months poststroke and reported a fall between the 3- and 6-month observation period, the reported fall was included. Therefore, the results from the two follow-up visits were summated into the outcome measure of any falls, yes or no.

Statistical Analysis

Primary analysis included univariate analysis for the characteristics of those subjects that reported a fall (fall group) and those subjects that did not report a fall (no-fall group). We used frequencies for categorical data and the mean and standard deviations for continuous data to describe these characteristics. We used contingency tables using the Chi-square to test for differences in frequencies between groups. The Mann-Whitney Wilcoxon test and Student's t-test were used for the examination of differences in continuous data, when appropriate. To determine the effects that motor impairments only; motor and sensory impairments; and motor, sensory, and visual impairments had on the risk of falling, we used the statistical application software (SAS) procedure PROC LOGISTIC. For preliminary analysis, we controlled for stroke severity. We completed the multiple logistic regression technique to examine the effects that accumulated deficits had on the risk of falling.

To determine the difference of balance/mobility scores in subjects who possessed motor impairments only; motor and sensory impairments; and motor, sensory, and visual impairments, we completed a secondary analysis. The Fischer's Exact test was used for this analysis.

RESULTS

Description of Study Population

Four hundred fifty-nine subjects were enrolled in the Kansas City Stroke Study. Ninety-five subjects were excluded because of not living in the community by the 1-month, 3-month, or 6-month poststroke follow-up. An additional 15 subjects were not available for at least two of the follow-up times. An analysis of the remaining 349 subjects revealed that 69 subjects either did not possess impairments measured for this study (e.g., they may have had only cognitive impairments) or possessed a combination of impairments not included in this study (e.g., motor and visual impairments or sensory impairments only). This resulted in a total of 280 subjects included in this study. **Table 1** shows the characteristics of the subjects included in this study.

Table 1.
Demographics and clinical characteristics.

Variables	Falls Study n = 280
Demographics	
Age: Mean (SD)	68.3 (11.42)
Gender: Male	50%
Race	
Caucasian	77%
African American	19%
Hispanic, American Indian, or Asian	4%
Clinical	
Stroke Severity Orpington Prognostic Scale	
Mean (SD)	3.4 (1.13)
Stroke Type	
Ischemic	95%
Hemorrhagic	5%

SD = standard deviation

Between 1 and 6 months poststroke, 142 (51 percent) stroke survivors reported a fall while living in the community. Of these 142 subjects that reported a fall, 75 (53 percent) reported one fall, 50 (35 percent) reported a fall at two of the follow-up times, and 17 (12 percent) reported a fall at all three time periods (1 month, 3 months, and 6 months poststroke). The demographics and characteristics of those subjects who reported a fall and those that did not are presented in **Table 2**.

Nineteen of the subjects included in this study were not available to complete the 6-month poststroke follow-up. The reasons subjects were not available included expired (eight subjects), refused (seven subjects), refused because of medical complications (one subject), family withdrew from study (one subject), moved out of state (one subject), and unable to locate (one subject).

Univariate Analysis

The accumulated impairments (motor only, motor + sensory, and motor + sensory + visual) distribution between those that reported a fall and those that did not is presented in **Table 3**. The reference group included those subjects that did not demonstrate a motor impairment, sensory impairment, or visual impairment. **Table 4** shows there was a statistically significant difference in stroke severity among those stroke survivors in each of the accumulated impairments model. The stroke survivors with motor + sensory + visual impairments had a significantly more severe stroke than those subjects in the reference group ($p < 0.0001$).

In addition, lower-limb Fugl-Meyer motor scores were significantly lower in the motor + sensory + visual impairment group than the other two groups (motor only and motor + sensory) (**Table 5**). Lower-limb Fugl-Meyer scores between motor only and motor + sensory had no differences.

Table 2.
Demographics and clinical characteristics by fall status.

Variables	Fall n = 142	No Fall n = 138	*p* Value
Demographics			
Age: Mean (SD)	69.2 (10.65)	67.4 (12.14)	0.124*
Gender: Male	48%	52%	0.402‡
Race			
Caucasian	73%	81%	0.297‡
African American	21%	16%	—
Hispanic, American Indian, or Asian	6%	3%	—
Clinical			
Stroke Severity Median	3.6	2.8	0.0001†
Stroke Type			
Ischemic	95%	95%	0.956‡
Hemorrhagic	5%	5%	—

*Student's t-test
†Mann-Whitney Wilcoxon
‡Chi-square test
SD = standard deviation

Table 3.
Distribution of accumulated impairments by fall status.

Accumulated Impairments	Fall n = 142	No Fall n = 138	Total
No Impairments (Reference Group)	14 (32%)	30 (68%)	44
Motor Impairment Only	51 (50%)	50 (50%)	101
Motor + Sensory Impairments	52 (59%)	36 (41%)	88
Motor + Sensory + Visual Impairments	25 (53%)	22 (47%)	47

Table 4.
Stroke severity by accumulated impairments (Mann-Whitney Wilcoxon).

Accumulated Impairments	Stroke Severity Mean (SD)	Median
No Impairments n = 44	2.5 (0.62)	2.4
Motor Impairments Only n = 101	3.3 (0.96)	3.2
Motor + Sensory Impairments n = 88	3.4 (0.96)	3.2
Motor + Sensory + Visual Impairments n = 47	4.6 (1.22)	4.4

p value < 0.0001
SD = standard deviation

Univariately, the effects of motor impairments only (p = 0.53, 95 percent confidence interval [CI] 0.58 to 3.0), motor + sensory impairments (p = 0.064, 95 percent CI 0.96 to 5.15), and motor + sensory + visual (p = 0.685, 95 percent CI 0.37 to 4.45) impairments were not statistically significant in increasing the risk of fall when stroke severity, as measured by the Orpington Prognostic Scale, was included in the logistic regression models.

Multiple Logistic Regression

The risk of falling in stroke survivors increased when a motor impairment (odds ratio [OR] = 2.2), motor + sensory impairments (OR = 3.1), and motor + sensory + visual impairments (OR = 2.4) were present (**Table 6**). However, the risk of falling with the addition of a visual impairment did not surpass the risk when motor and sensory impairments were present.

Secondary Analysis

We completed a secondary analysis to explore the balance and mobility of the subjects. For this analysis, the balance score from the Orpington Prognostic Scale was used. When we compared the balance scores of stroke survivors with the accumulated impairment models and the reference group, a significant difference was present in stroke survivors with motor impairments only, motor + sensory impairments, and motor + sensory + visual impairments (**Table 7**). The frequency of the balance scores revealed that 81 percent of those subjects with motor + sensory + visual impairments were less able to ambulate 10 feet or even maintain a standing position for 1 minute.

Table 5.
Lower-limb motor function by accumulated impairments (Mann-Whitney Wilcoxon).

Accumulated Impairments	Fugl-Meyer Lower-limb Score Mean (SD)
Motor Impairments Only n = 101	18.7 (8.48)
Motor + Sensory Impairments n = 88	17.9 (8.12)
Motor + Sensory + Visual Impairments n = 47	13.0 (8.91)

p value < 0.0001

Table 6.
Multiple logistic regression of accumulated impairments and risk of fall.

Accumulated Impairments n = 280	Parameter Estimate	Standard Error	Odds Ratio (95% CI)	*p* Value
Motor Impairment	0.782	0.380	2.2 (1.05–4.70)	0.040
Motor + Sensory Impairments	1.130	0.390	3.1 (1.46–6.79)	0.004
Motor + Sensory + Visual Impairments	0.890	0.436	2.4 (1.05–5.83)	0.041

Table 7.
Frequency of balance scores per accumulated impairment models.

Accumulated Impairment Model	Score on Orpington Prognostic Scale Balance				*p* Value
	0.0	0.4	0.8	1.2	
No Impairments (n = 44)	33 (75%)	8 (18%)	3 (7%)	0 —	0.001*
Motor Impairment Only (n = 101)	33 (33%)	26 (26%)	35 (34%)	7 (7%)	—
Motor + Sensory Impairments (n = 88)	22 (25%)	20 (23%)	38 (43%)	8 (9%)	—
Motor + Sensory + Visual Impairments (n = 47)	6 (13%)	3 (6%)	27 (58%)	11 (23%)	—

*Chi-square test

DISCUSSION

Falls in the community-dwelling elderly are common. Thirty percent of those individuals over the age of 65 will fall each year [25]. Potential consequences of these falls include death [26], restricted activity, fear of recurrent falls, soft-tissue injuries, or fractures [26–28]. In addition, falls are a contributing factor in 40 percent of the admissions to nursing homes [28]. Since falling in the elderly has been established as a major health problem, extensive studies have identified risk factors that increase the risk of falling in the elderly. Stroke has been identified as an independent risk factor for falling in the elderly [15]. In addition, falls have been identified as a major complication following stroke [4].

The reported rates of falling in stroke survivors have varied, depending on the medical setting in which the studies were completed [5–9]. However, most stroke survivors will be discharged to the community, and little information is available about falls in community-dwelling stroke survivors [3]. In spite of the high rate of return to the community among stroke survivors, only one study has examined the fall occurrence in community-dwelling stroke survivors. Forster and Young reported a 73 percent fall rate in a 6-month prospective study of community-dwelling stroke survivors [10]. Consequences of those falls included a higher rate of depression, limited social activities, and an increase in caregiver burden.

One hundred forty-two (51 percent) of our subjects reported a fall during a 5-month observation period. The difference in fall rates between Forster and Young's study and this study may partially be explained by the difference in the follow-up duration. Yet, both studies revealed that stroke survivors are at a higher risk of falling than the elderly individuals with no history of stroke.

Many individual risk factors for falls have been identified among stroke survivors. However, no study has examined the effects of accumulated impairments on fall risk in community-dwelling stroke survivors, although it has been established that the risk of falling increases with the number of deficits or impairments present in the elderly [15]. The purpose of this study was not to comprehensively evaluate all risk factors (e.g., cognition, urinary incontinence, impaired decision making, etc.) identified to increase the risk of falling, but rather to assess the physiological components of motor, sensory, and visual. Therefore, the impairments that we examined in this study were physiologically based (effector system—motor deficits, somatosensory system—sensory and visual deficits). The combination of these impairments and their accumulation had been used to predict functional recovery in stroke survivors. Reding and colleagues showed a statistically significant difference in level of function achieved and the time needed to reach maximal recovery for those stroke subjects with motor deficits compared to those with motor, sensory, and visual deficits [29]. Our study further used Reding's model of accumulated deficits to examine their effect on falls in community-dwelling stroke survivors.

Our results revealed that those stroke survivors with motor and sensory deficits were at a higher risk of falling as compared to those with motor deficits only. This is in accordance with previous studies that have reported an association of negative functional outcomes, such as falls, incontinence, functional dependence, and balance, with the number of impairments present [30,31]. Rantanen and colleagues found that balance and strength impairments resulted in a much higher risk of severe walking disability than the single impairments [32]. The three times higher risk of falling among those stroke survivors with motor and sensory deficits illustrated that the accumulation of deficits had a greater effect on falling than the individual deficit.

In our study, the risk of falling did not increase with the addition of a visual impairment. Our results revealed that those subjects with motor, sensory, and visual impairments had a much lower mobility status than compared to those subjects with motor impairment only and motor and sensory impairments. In fact, 81 percent of those subjects with motor, sensory, and visual impairments were unable to maintain a standing position for one minute. These results are consistent with those of Reding and colleagues [29]. They reported that only 3 percent of stroke survivors with motor, sensory, and visual impairments achieved independent ambulation by 30 weeks poststroke. This low mobility may actually decrease fall risk. The association between mobility and fall risk has been studied. Studenski et al (33) reported in a study of elderly men that low mobility was actually a protective factor in fall risk. Therefore, the relationship between mobility and falls may not be linear, but may actually be U-shaped.

In our preliminary analysis, we planned to adjust for stroke severity in the assessment of accumulated deficits on the risk of falling in community-dwelling stroke survivors. However, the Orpington Prognostic Scale, Fugl-Meyer, and NIH Stroke scale are all impairment scales and are highly correlated. Therefore, estimates from the logistic regression model evaluating accumulated impairments while controlling for stroke severity (with the use of the Orpington Prognostic Scale) became very unstable.

The results of this study revealed that assessing accumulated impairments identified the increased fall risk in community-dwelling stroke survivors. The results of this study would allow the clinicians to easily identify those stroke patients who are at a high risk of falling. This early identification could facilitate the initiation of preventive measures. In addition, the results from this study provide a foundation for the understanding of accumulated impairments common in stroke survivors on a major complication following stroke.

This study had some limitations that should be considered. The first is the potential for recall bias. The subjects fall status was ascertained at 3 months and 6 months poststroke. The times that elapsed between visits were 2 months and 3 months. Attempts were made to minimize recall bias. If a caregiver was present during the follow-up interview, confirmation of the fall status was obtained. However, it has been suggested that since most falls do not result in injury requiring medical attention, many falls go unreported and that fall rates may be grossly underestimated [34].

The second limitation in this study regarded the outcome measure as a single fall versus multiple or recurrent falls. One may argue the significance of a single-fall occurrence. However, studies have shown that even a benign single fall may have serious consequences. One such consequence is the fear of falling, which may lead to social isolation, immobility, and institutionalization [28]. In addition, Forster and Young reported that a previous fall was an independent risk factor in predicting those community-dwelling stroke survivors who would experience a fall [10]. Future studies could address this funding by examining the effects of accumulated deficits on recurrent falls in community-dwelling stroke survivors.

An additional limitation identified in this study was the time in which deficits were assessed. For this study, the deficits measured were assessed within 3 to 14 days of stroke onset. This time frame did not allow for the natural recovery of stroke and the potential for change (spontaneous recovery) that occurs within the first 30 days poststroke [35]. This may have resulted in an underestimation of the effects of accumulated deficits on fall risk. The deficit group assigned at baseline may have changed during the study duration. For example, a subject assessed at baseline may have possessed motor and sensory deficits and therefore would have been assigned to those deficits for the analysis in this study. However, as recovery occurred, the subject may have had only motor deficits at the 3-month or 6-month poststroke follow-up. This would have resulted in the subject being at a lower risk of falling. In future studies, this could be addressed by assessing deficits at different times and adjusting for recovery over time.

Another limitation of this study was the small number of subjects included in the reference group (n = 44) and the motor and sensory and visual deficits group (n = 47), in spite of the large number of subjects. Subsequently, this may have limited the capability of this study to detect small differences in the effects of accumulated deficits on fall risk.

In conclusion, community-dwelling persons who have had a stroke are at a high risk of falling. This study examined a specific combination of accumulated deficits that are common following stroke. Through the evaluation of a combination of physiologically based accumulated deficits on fall risk in community-dwelling stroke survivors, a foundation has been established to which additional known risk factors may be added. This would provide a more thorough understanding of the effects of the specific risk factors on falling, but more importantly, it would provide the impact that the accumulation of such risk factors has on falling in stroke survivors.

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