Risk Factors for Falling in Home-Dwelling Older Women With Stroke  
The Women’s Health and Aging Study  
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Background and Purpose—Much of our knowledge of risk factors for falls comes from studies of the general population. The aim of this study was to estimate the risk of falling associated with commonly accepted and stroke-specific factors in a home-dwelling stroke population.

Methods—This study included an analysis of prospective fall reports in 124 women with confirmed stroke over 1 year. Variables relating to physical and mental health, history of falls, stroke symptoms, self-reported difficulties in activities of daily living, and physical performance tests were collected during home assessments.

Results—Risk factors for falling commonly reported in the general population, including performance tests of balance, incontinence, previous falls, and sedative/hypnotic medications, did not predict falls in multivariate analyses. Frequent balance problems while dressing were the strongest risk factor for falls (odds ratio, 7.0). Residual balance, dizziness, or spinning stroke symptoms were also a strong risk factor for falling (odds ratio, 5.2). Residual motor symptoms were not associated with an increased risk of falling.

Conclusions—Interventions to reduce the frequency of balance problems during complex tasks may play a significant role in reducing falls in stroke. Clinicians should be aware of the increased risk of falling in women with residual balance, dizziness, or spinning stroke symptoms and recognize that risk assessments developed for use in the general population may not be appropriate for stroke patients. (Stroke. 2003;34:494-501.)

Key Words: epidemiology ■ rehabilitation ■ stroke

Preventing falls should be an important goal of acute, rehabilitative, and chronic stroke care. Approximately 40% of people fall within the first year of a stroke and are up to 4 times more likely to sustain a hip fracture after a fall. The combination of hip fracture and stroke results in disproportionately high levels of disability. To date, research to establish risk factors for falling in stroke populations has concentrated on rehabilitation and acute hospital settings. However, not all people are treated in hospital for stroke. Falls remain a common feature in the life of people with stroke after discharge from hospital, certainly to 30 months and most likely well beyond.

Studies of the general population have identified the predominant importance of predisposing risk factors for falling. Including gait and balance impairments, sedative and hypnotic medications, difficulties in activities of daily living, inactivity, incontinence, visual impairments, and reduced lower limb strength. The relevance of these factors in stroke populations is unclear. For example, Tutuarima et al reported that sedative medications reduced the risk of falling in stroke patients in a hospital setting, whereas these medications are consistently reported as a risk factor for falling in the general population. Performance tests of chair rising may indicate increased risk of falling in stroke, but these suggestions are evidenced only in cross-sectional studies. The aim was to investigate the relevance of known predisposing risk factors for falling (any, single, or repeated events) and stroke-specific factors in a population of women with a history of stroke.

Materials and Methods

Sample
We used data collected as part of a larger study of disability in later life called the Women’s Health and Aging Study (WHAS). Sampling for WHAS was as follows. The Health Care Financing Administration enrollment file was used to obtain a random sample of all female...
Depressive symptoms were assessed with the geriatric depression score. If the score was 14 or greater, the participant was considered to have depressive symptoms.

Cognitive Impairments
A cut point of 24 on the MMSE was used to indicate the presence of cognitive impairment.

Incontinence
Women were asked if they experienced any difficulties with control of urine or feces. The responses were coded yes or no.

Balance Problems
Women were asked about the frequency with which they had difficulty balancing when walking and dressing. Responses were always, very often, often, sometimes, or never. For the statistical analysis, this variable was dichotomized as versus no difficulty.

Physical Activity and Alcohol Consumption
Physical activity was summarized as the number of city blocks walked in the last week, with =8 blocks used to denote higher levels of activity. Women were asked the number of alcoholic drinks they consumed per week. Because of the low level of consumption, the variable was dichotomized as versus no drinks.

Visual Acuity
A portable Snellen chart was used to assess vision. Women sat 10 ft from the chart and, if customary, were given glasses for the test. Acuity was evaluated for 20/20, 20/40, 20/60, and 20/200.

Performance Test of Dressing Ability
Women were asked to remove their outer clothing and were given a standard blouse of the correct size to put on over the clothes they were wearing. The women could stand or sit but were not permitted to use a mirror. If the women were unable to or took >4 minutes to put on the blouse, they were coded as unable to complete the test.

Maximum Isometric Knee Extensor Strength
Each woman sat in a hard-backed chair with the hip flexed to 90° and knee flexed to 85°. A hand-held muscle dynamometer (Nicholas Manual Muscle Tester, model BK-7454, Fred Sammons Inc) was placed a few inches above the ankle joint between the medial and lateral malleolus. The women were encouraged strongly to extend with maximum effort against the dynamometer using the break technique. The maximum force (recorded in kilograms and converted to Newtons) was recorded for two 5-second contractions from each leg. Sufficient time was allowed between contractions for recovery. The better of 2 readings was chosen for the weaker leg, and a cut point of ≥4.9 kg (the lower tertile) was used to identify women with the lowest strength. This muscle testing protocol has been shown to have excellent reliability in frail older people.

Pinch Grip Strength
Pinch grip was measured with a standard 0- to 60-lb pinch gauge (model 81441, Adaptability). Women were seated with the elbow tucked into the side and bent to 90°. Maximal pinch was recorded from the better of 2 attempts by the nondominant arm. Women were defined as being weak if they scored ≤3 kg and stronger if they scored ≥3 kg. This cut point identified the weakest tertile of the distribution.

Performance Tests of Balance
Women attempted to maintain standing balance for 10 seconds in 3 positions: side by side, semitandem, and tandem. Women who held the position for ≥10 seconds were coded as being able to complete each test. A composite balance score was used in some analyses to reflect a broader range of abilities, where 0 = unable to side-by-side stand for 10 seconds, 1 = able to side-by-side stand for 10 seconds, 2 = able to stand in semitandem for 10 seconds, 3 = able to tandem stand for 3 to 9 seconds, and 4 = able to tandem stand for 10 seconds.
Performance Tests of Walking
Usual-paced walking speed was assessed over a 4-m course. Two trials were undertaken, and the fastest speed used. Women who were unable to walk or had speed $\leq 0.25$ m/s were coded as having poor walking ability, representing the lowest tertile of the distribution.

Performance Test of Chair Rising
Women were asked to rise from a hard, armless chair with their arms crossed over their chests. Women were coded as unable to rise if they could not get up from the chair or needed to use their arms.

Falls Data
Data were collected at baseline and at 6- and 12-month follow-up. At baseline, participants were asked if they had fallen during the last 12 months and at each follow-up were asked to report falls occurring in the interim period. Falling was defined as falling on the ground or at some other level such as a chair. Participants were considered repeated fallers if they reported 1 fall in the 12-month period.

Statistical Analysis
The Mann Whitney or $\chi^2$ test was used to establish the statistical significance of possible loss to follow-up bias. For women with complete data at the 12-month follow-up, bivariate, unadjusted odds ratios and 95% confidence intervals were calculated for the risk of falling associated with each independent variable using the cut points already described. Risk factors statistically significant at $P<0.1$ were entered into multivariate logistic regression models adjusted for age and physical activity. Three models were tested: no fall versus any fall, a single fall, and repeated falls only. Model fit was tested with the Hosmer-Lemeshow statistic and found to be acceptable. Sensitivity analyses were run to ensure that models were stable when including correlated predictor variables and varying assumptions about missing data. Statistical analysis was undertaken with the SPSS package for Windows, version 10. Statistical significance was defined at $P<0.05$.

The Institutional Review Board of The Johns Hopkins University approved the study, and all women gave informed consent to be included.

Results
Characteristics of the Sample
The sample of 124 women included 32 women who had not been treated in hospital. Women not hospitalized were less likely to report residual symptoms but were no different in the numbers of falls or disability reported. Fifty-five percent of the women were white, 43% were black, and 2% were of other races. The majority of women (74.5%) reported their stroke to have occurred at least 1 year previously. Twenty-two percent of women reported no residual stroke symptoms, 22.5% reported nonmotor symptom symptoms only, and 12.6% reported motor symptoms only. The remainder had a mixture of residual motor and nonmotor symptoms. In the 74 women who could recall the side of the body affected by the stroke, the left side was most commonly affected (59.4%), followed by the right side (31%) and both sides (15%). The most common form of residual nonmotor symptom was balance, dizziness, or spinning sensations.

Loss to Follow-Up
By the 12-month follow-up, 12 women (9.6%) had died and 18 (14.5%) had dropped out of the study. Table 1 shows the characteristics of the women at baseline by loss to follow-up status. Women lost to follow-up tended to have higher levels of depression and fewer strokes. Otherwise, there were no significant differences. Women who died in the follow-up period were more likely to have reported falls in the year before the baseline interview, but this difference was not statistically significant ($\chi^2=1.06$, $P<0.3$). The remainder of the results is devoted to women with complete 12-month data ($n=94$).

Fall Rates in the Follow-Up Period
Forty-five women (48% of the sample) fell during the 12-month follow up, with 19% falling once and 29% suffering repeated falls. Nearly 28% of the cohort experienced an injury as a result of a fall. In those who fell, the mean number of falls was 2.83 per person per year (range, 1 to 13). There were no major differences in characteristics of women who had single or repeated falls.

| TABLE 1. Baseline Characteristics of 124 Women by Follow-Up Status |
|-----------------------------|-----------------------------|-----------------------------|
|                             | Followed up to 1 Year (n=94), Median (Range) | Lost to Follow-Up or Died (n=30), Median (Range) | $P$ |
| Age, y                      | 76 (65, 91)                  | 78 (66, 95)                  | 0.66 |
| General health              | 4 (1, 5)                     | 4 (1, 5)                     | 0.65 |
| No. of strokes              | 1 (1, 10)                    | 1 (1, 8)                     | 0.11 |
| Months since first stroke   | 48 (0, 331)                  | 36 (1, 190)                  | 0.46 |
| No. of falls in previous year | 0 (0, 12)                  | 0 (0, 6)                     | 0.45 |
| Folstein Mini-Mental State Examination | 27 (18, 30)                  | 26 (18, 30)                  | 0.60 |
| Geriatric Depression Scale score | 7 (0, 25)                  | 10 (3, 22)                   | 0.06 |
| Balance score (out of 5)    | 1 (0, 4)                     | 1 (0, 4)                     | 0.45 |
| Mobility score (out of 3)   | 1 (1, 3)                     | 1 (1, 3)                     | 0.72 |
| Body mass index             | 29 (14.1, 47.1)              | 26 (15.5, 42.9)              | 0.15 |
| Residual motor symptoms, n  | 1 (0, 9)                     | 1 (0, 9)                     | 0.90 |
| Residual nonmotor symptoms, n | 1 (0, 9)                     | 1 (0, 9)                     | 0.91 |
| Frequency of balance problems dressing | 4 (0, 16)                  | 4 (0, 16)                     | 0.83 |

Data are the median and range unless otherwise stated.
Risk Factors in Bivariate Analysis

Table 2 shows bivariate associations. Risk profiles were similar for those with 1 fall only and those with repeated falls. Performance tests of balance were not predictive of falling, even when used as a composite scale; neither was muscular strength in the hand or quadriceps. Stroke-specific factors were important. Having residual nonmotor or a combination of residual nonmotor and motor symptoms was associated with a strong risk of falling (fall rates, 53.3% and 62.2%, respectively). Persistent balance, dizziness, or spinning sensations were a particular problem. Women with no residual or only motor symptoms had rates of falling (33.3% and 35.3%, respectively) comparable to that of the nonstroke population of the WHAS cohort (35.9%). In the subset of women able to recall the side of their stroke, a stroke on both sides was associated with an increased risk of falling ($\chi^2=8.56$, $P<0.03$; see the Figure).

Multivariate Models

For any fall, risk factors were frequent balance problems while dressing, residual balance problems resulting from the stroke, and difficulties grasping. When stratified by single or
repeated falls, the results of the multivariate analysis (Table 3) were broadly consistent, with difficulties in balancing while dressing and residual balance problems being the strongest risk factors. A difference was that difficulty grasping was a risk factor for a single fall, whereas problems transferring were a risk factor for repeated falls.

**Predictive Ability**

The best predictions of falling were obtained from models that contained 2 factors: residual balance problems after the stroke and difficulty balancing while dressing (shown in Table 4). The risk of falling increased as the number of risk factors increased ($\chi^2=21.9$ for trend; $P<0.001$).

**Discussion**

The needs to identify people at increased risk of falling within the stroke population and to develop therapeutic approaches are well recognized. Most stroke-specific research has been conducted in hospital cohorts followed up to discharge from hospital or rehabilitation care. The analyses presented here are the first to examine risk factors prospectively for 1 year and to include people who have not been managed in hospital for their initial stroke. Cohorts using hospital inpatients as the only source of recruitment result in overrepresentation of acute but not necessarily disabling strokes.22 The contribution of our analysis is to suggest (1) broad clusters of stroke symptoms that are risk factors for falling, (2) that predisposing risk factors for falling reported in the general population may have little relevance to stroke populations; and (3) possible interventions to reduce falling in stroke.

Unlike the literature relating to falls in the general population,11 there was little evidence to suggest systematic or marked differences between women who had single or repeated falls. We undertook preliminary analyses of the risk associated with stroke symptoms at the time of the most recent stroke and persisting symptoms, but in all analyses, it was residual and not previous balance symptoms that predicted falls. A number of risk factors identified in acute stroke care settings,7,8,23 notably motor symptoms, had limited predictive validity in our home-dwelling sample. Possible explanations are that people with motor symptoms limit the amount of physical activity they undertake, thus reducing their exposure to the risk of falling. Our analyses were adjusted carefully to account for this fact, so it seems an unlikely explanation. Alternatively, strokes resulting in motor symptoms only may be less severe, or people who suffer motor-only strokes may be more aware of their physical incapacitates and take more care when moving. Information on stroke symptoms was collected from participants and validated against a physical examination, medical records, and scans. It was not possible to collect detailed information from neurological examinations that would be needed to classify stroke syndromes according to more conventional criteria,24 but the pattern of impairments suggests that posterior stroke syndromes are associated with increased risk of falling. A number of women were unable to recall the side of their body affected by the stroke, and this variable was not included in multivariate models. Accordingly, the results relating to the side of body affected by the stroke should be interpreted with caution.

Commonly reported risk factors for falling in the general population, including incontinence, medications, and previous falls, were not predictive in multivariate models of falling in stroke, suggesting the need for a disease-specific approach. There is a strong body of evidence to support the use of performance tests of balance to predict falling in the general population.11,21,25 We used several tests and found that within a stroke population they had minimal utility. One possible explanation is that a single test session is not sufficiently accurate. A recent study in the general population demonstrated that attaining acceptable repeatability requires 2 measures repeated over a short time period.26 Another explanation is that we did not include all possible measures of balance. A notable exception was the functional reach test,27 which we found difficult to complete in the home setting because of limited wall space. The predictive power of performance tests of balance was not improved by use of a composite scale, and it was notable that most of our study participants were unable to complete all but the most basic tests.

Measure related to self-perceived balance, in particular, the frequencies of balance problems during dressing, were stronger than any other risk factors. There are 2 possible

**TABLE 3. Multivariate Logistic Regression Models**

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Any Fall</th>
<th>Single Fallers</th>
<th>Repeat Fallers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent problems balancing while dressing</td>
<td>7.0 [2.27, 21.2]</td>
<td>5.9 [1.43, 24.04]</td>
<td>6.0 [1.65, 21.55]</td>
</tr>
<tr>
<td>Difficulty grasping small objects</td>
<td>3.6 [1.29, 10.09]</td>
<td>5.1 [1.12, 22.54]</td>
<td>NS</td>
</tr>
<tr>
<td>Unable to stand from a chair</td>
<td>NS</td>
<td>NS</td>
<td>3.3 [0.99, 10.79]</td>
</tr>
</tbody>
</table>

Only risk factors statistically significant in the final models are shown. All models were adjusted for age and physical activity. NS indicates not statistically significant at $P<0.05$. 

Association between location of stroke symptoms and prospective risk of falling in 74 women able to recall location of symptoms. Bars show the percentage of women who fell in each category.
explanations for this. First, dressing itself is a hazardous task, and the risk is specific to this task. In this case, it would be expected that people would report falling when dressing. Future studies should try to ascertain what activities were being undertaken during a fall. Alternatively, the method of assessment involving self-perceptions of balance problems during dressing is the most sensitive method of conveying the complex array of risk factors that contribute to falls. Other complex tasks may elicit the same type of response, but it is not possible to conclude this from the data presented. Difficulty in performing simultaneous motor and cognitive tasks has been suggested as a possible risk factor for falls in the general population, although this was not found to be the case in people with Parkinson’s disease. Our data suggest that questions relating to the frequency of balance problems during complex tasks such as dressing would be a useful addition to the clinical examination of stroke patients. The sensitivity of predictions based on frequency of balance problems and residual nonmotor symptoms was, compared with other published scores, acceptable. The relevance of including a screening item relating to difficulty in balancing while dressing needs to be established in other cohorts, particularly hospital based.

One limitation of this study was that we included older women only. Age was not a significant factor in any of the models. We suggest that the findings should be generalizable to younger women. Although WHAS eligibility criteria excluded women with severe cognitive impairment, this amounted to only a small fraction of home-dwelling women. Because cognitive impairment is a strong risk factor for falling, we may have underestimated the true rate of falling in home-dwelling women with stroke and the importance of cognition. Given the high prevalence of cognitive impairment in nursing home populations, the findings are not generalizable to institutional populations. Male sex is an independent risk factor for falling in hospital cohorts. It seems biologically implausible that balance difficulties and symptoms would be risk factors in women only, unless greater muscle mass in men protects against the loss of balance. These possibilities should be considered in future studies.

Bias can result from inappropriate handling of loss to follow-up data. The results were not sensitive to the method of handling missing data. In all modeling, the sample size was small and reduced our ability to detect subtle risk factors and interactions. Bias may also result from selective recall of falls. Ideally, the method of collecting fall data would benefit from being supplemented by a weekly fall diary. We could not include all possible risk factors in our model. Selective serotonin reuptake inhibitors maybe associated with falls. Too few women were using them (0.5%) to enable us to consider them. We chose to focus on predisposing as opposed to situational or environmental risk factors. Predisposing factors are useful in identifying items for screening methods and components of preventive interventions. We selected a 12-month follow-up to reflect the annual screening cycle that occurs in many countries. An important caveat is the lack of temporal association between the risk factors and falls.

In conclusion, therapies need to be developed to address balance during complex activities and residual balance symptoms after stroke and tested in randomized studies. Cognitive-behavioral therapies that use pacing and coping strategies could help minimize the stress induced by stroke symptoms. Understanding and improving postural stability and perceptual skills that contribute to complex activities and encouraging the adoption of safer behaviors may also have a role. However, until further research demonstrates otherwise, therapeutic strategies need to be directed at a range of complex tasks.

**References**

15. Guralnik JM, Fried LP, Simonsick EM, Kasper JD, Lafleerty MF. The Women’s Health and Aging Study: Health and Social Characteristics of
The article by Lamb and coworkers1 from the Women’s Health and Aging Study deals with a very important topic. Falls and fall-related injuries are among the most common and often very serious complications after stroke.2 A hip fracture after stroke often constitutes a serious drawback in rehabilitation progress, and stroke patients are often at increased risk of suffering new complications after the hip fracture such as postoperative delirium and healing complications. Falls and fall-related injuries also increase the fear of falling, which in turn might result in inactivity and social isolation.

The present study is of elderly female stroke victims living in their own homes who were extensively assessed for fall risk factors at baseline and then followed up for falls for 1 year. The most interesting finding in the article is that frequent balance problems while dressing constituted the strongest risk factor for falling. In most stroke patients, balance is disturbed, and the patient needs to compensate for this change by paying greater attention when performing a variety of activities. Stroke also often reduces cognitive capacity, i.e., the capacity to simultaneously perform tasks that demand different levels of attention. This knowledge is important in the assessment of patient fall risk after stroke. Several studies published during the last months have highlighted the importance of identifying stroke survivors with an increased risk of falling.3–6

There are, however, some limitations to the present study. The sample includes only home-dwelling older women without serious cognitive impairment; thus, the study excludes some stroke patients with the highest risk of falling and of suffering hip fractures. A recent study from Sweden has shown that almost half of the elderly people suffering femoral neck fractures are admitted from institutional care, and an New Zealand study has reported that the risk of suffering hip fractures is up to 10 times greater among older people in residential care than among older people living in their own homes.7,8 This means that the present study, despite the high incidence of falls, underestimates the impact of this serious health problem in society.

Previous studies have shown that stroke increases the risk of suffering hip fractures by up to 4 times and that almost all hip fractures in this population are caused by falls and usually affect the paretic side.9 It has been suggested that this pattern is due to a combination of an increased risk of falling toward the paretic side, a reduced ability to break the fall, and the presence of hemicosteoporosis. The inability to break the fall results in many hip fractures but few wrist fractures. The risk of serious head injuries, especially in stroke patients on anticoagulant therapy, is also probably greatly increased.

A recent Swedish study has reported that the proportion of stroke patients among those suffering femoral neck fractures more than doubled between 1980 and 1997, from 16% to 39%.9 This finding means that the topic of the present article appears to be increasingly important, but it also indicates that more knowledge is needed in the field of treatment and rehabilitation for people with hip fractures and hemiparesis. What anesthetic and operation techniques should be used and what rehabilitation methods are effective after a hip fracture if the patient has hemiparesis with or without spasticity?

It is always important in fall research to study multiple fallers. One fall could be a chance occurrence, but repeated falls are “a bad habit.” In studies that compare single fallers with nonfallers, few differences are to be found, but if multiple fallers are compared with nonfallers or single fallers,
there is a greater chance of identifying important fall risk factors. Risk factors (predisposing factors) for falls may change during the course of a year; thus, the baseline assessment might not be valid when falls that occur several months after inclusion are analyzed. We have found among frail elderly people that the prediction of falls is relevant for only a few months, which means that patients with stroke should be assessed regularly, at least several times a year, for any increased risk of falling. We have also found that the staff who know the patient best, at least in residential care, without the aid of any assessment of fall risk factor, are very good at identifying old people who stand an increased risk of falling.10

Probably even more interesting in the prevention of further falls is the analysis of precipitating factors for falls such as epileptic seizures, urinary infections, new strokes, and acute drug side effects. By conducting postfall assessments, we can often detect and eliminate important precipitating factors for falls.11,12 Because only 1 fall in about 20 results in a serious injury, it is usually profitable to conduct postfall assessments in an attempt to reduce further falls.

Selective serotonin-reuptake inhibitors are a common group of drugs frequently prescribed to patients after stroke and are associated with an increased risk of falling in several modern studies on drugs and falls.12–15 Until further studies on the association between drugs and falls in stroke patients are presented, we recommend that selective serotonin-reuptake inhibitors be used with caution, at least in stroke patients with an increased risk of falling.

The combination of impaired balance and gait and impaired cognition, often including perception difficulties, increases the fall risk and, in combination with fast-developing hemi-osteoporosis, means that people who have suffered stroke are particularly prone to suffer fractures. The present study shows that home-dwelling elderly women who have suffered a stroke and have an increased risk of falling can easily be identified, which is in agreement with current studies that have reported instruments for the identification of fall-prone stroke patients in institutional care.3–6 Almost everyone who has suffered a stroke should be suspected of having or being in the process of developing hemi-osteoporosis.15 This knowledge means that it is unacceptable to do nothing regarding the prevention of falls and injuries and the prevention and treatment of osteoporosis in people who have suffered stroke.16

A recent fall and injury prevention study that included a large proportion of older people with impairments after stroke living in residential care facilities resulted in a significant reduction in the incidence of falls and hip fractures.17 This is the first successful fall intervention study to include frail elderly people living in residential care facilities. The intervention consisted of a multifactorial fall-prevention program comprising staff education, environmental adjustment, exercise, drug review, aids, hip protectors, and postfall problem-solving conferences. Similar intervention studies should be conducted among stroke survivors to develop stroke-specific fall-prevention strategies. However, the use of hip protectors seems to be a cheap and effective way of preventing hip fractures that should be recommended for use in all elderly people at increased risk of falling, especially those who also have osteoporosis.

Studies evaluating the most effective strategies for prevention of hemi-osteoporosis should be encouraged and should probably be included in the immediate poststroke treatment in the acute stroke unit, as previously suggested.16 The state of our knowledge demands that prevention of falls and injuries be included in routine assessment, treatment, and rehabilitation of people suffering stroke.

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