Higher Incidence of Falls in Long-Term Stroke Survivors Than in Population Controls
Depressive Symptoms Predict Falls After Stroke

Lone Jørgensen, PhD; Torgeir Engstad, MD; Bjarne K. Jacobsen, PhD

Background and Purpose—The incidence of falls among noninstitutionalized individuals with long-standing stroke has not been examined previously, although fractures are more common and the consequences more severe for stroke patients than for elderly people in general.

Methods—For 4 months (September to December 1998), we followed 111 home-living patients who had suffered a stroke a mean of 10 years previously and 143 control subjects randomly selected from the same municipality, matched with respect to age and sex. Falls were registered daily by use of “fall calendars.” Before the fall registration period, information about morbidity, use of medication, and activities of daily living had been registered. Height, weight, vision, blood pressure, motor function, and body sway had been measured, and depressive symptoms as well as cognitive function had been assessed.

Results—During follow-up, 23% of the patients and 11% of the control subjects fell once or more, and the risk of falling at least once was more than twice as high for the patients with stroke, when controlled for potential confounders (relative risk = 2.2; 95% CI, 1.1 to 4.3). Among the stroke patients, depressive symptomatology predicted falls, and the relative risk for falling increased by 1.5 per standard deviation increase in the depression score.

Conclusions—We conclude that falls are more frequent among noninstitutionalized long-term stroke survivors than among community control subjects and that the risk of falling and depressive symptoms are related in stroke patients. (Stroke. 2002;33:542-547.)

Key Words: accidental falls ■ risk factors ■ stroke

Study Population

The subjects included in the present study were all participants in the fourth survey of the Tromsø Study, which took place from September 1994 to June 1995. All inhabitants older than 24 years were invited, and 27 159 subjects, 77% of the eligible population, attended. The letter of invitation contained questions about medical history, and a total of 418 participants reported a history of 1 or more stroke events. As described elsewhere, 14 269 individuals with a self-reported history of stroke and 262 population controls reporting no history of stroke attended a reexamination during 1997–1998. The control subjects had been drawn randomly from the study population and matched to each of the stroke subjects, with age (±2 years) and sex used as matching criteria.

All 269 individuals with stroke and 262 population controls were considered eligible for the present study of fall incidence in late 1998. However, 7 had died, 9 were living in nursing homes, and 66 were excluded either because of a recurrent stroke or because their self-reported stroke or nonstroke status had been disproved. Thus, 209 people with stroke and 240 population controls were invited, of whom 111 and 143, respectively, accepted to participate (Figure 1).
Informed consent was obtained from all participants according to the Second Helsinki Declaration, and the Regional Committee for Medical Research Ethics approved the trial.

**Questionnaire and Interviews**

At the examination in 1997–1998, questions about health status, medical history, and drug prescription were presented in a questionnaire administered by a nurse. Details of morbidity were recorded on a dichotomous scale (present/absent). The questionnaire included questions about coronary heart diseases, lung diseases (chronic obstructive pulmonary disease, asthma), joint disorders (arthritis, arthrosis, fractures), cancer, Parkinson’s disease, and epilepsy. The participants were also asked whether they were teetotallers and, if not, how often they drank alcohol during the last month.

Drugs were classified according to the Anatomical Therapeutic Chemical System, and use of cardiac therapeutics (C01), treatment for hypertension (antihypertensives [C02], diuretics [C03], calcium antagonists [C08], and angiotensin-converting enzyme inhibitors [C09]), hypnotics/sedatives (N05C), analgesics (N02), and antidepressants (N06A) was considered relevant with respect to increased fall risk.

Activities of daily living were assessed by use of the Barthel Index.15 Furthermore, the participants were asked whether they had walked outdoors for at least 15 minutes once a week during the last 3 months (a subscore of the Frenchay Activity Index).16

**Physical Examination**

The physical examination included measurements of body height and weight. Blood pressure was measured with an automatic device (Dinamap Vital Signs Monitor 1846, Crition Inc) in both sitting and standing positions. After 2 minutes of rest, 3 recordings were made (at 2-minute intervals, and the average of the second and the third standing positions). After 2 minutes of rest, 3 recordings were made in both sitting and standing positions. Blood pressure in the standing position was measured after 1 minute. Orthostatic hypotension was defined as a drop in systolic blood pressure of ≥20 mm Hg in the standing position.

Motor function of arms and legs was assessed by use of subscores from the Scandinavian Stroke Scale Score (SSS).17 These scores are graded in 5 categories: paralysis (0); can move, but not against gravity (2); raises arm/leg with flexion in elbow/knee (4); raises arm/leg straight but with reduced strength (5); and raises arm/leg with normal strength (6). If the SSS score of the right and left sides differed, the score of the weakest side was used in the analysis. In addition, motor speed was assessed by the mean number of finger taps of the dominant and the nondominant hands recorded during 60 seconds.18

Postural stability was tested by measuring body sway with the use of a simple sway meter, in which the displacement of the body at the level of the waist was registered.19 The natural logarithm of the sway values was used in our analysis and dichotomized into large body sway (greater than or equal to mean sway) and minor body sway (less than mean sway) according to the values of the control subjects. Four stroke patients, who did not have their sway measured because they were unable to stand up, were categorized in the large-sway group.

Vision was tested by use of a printers’ point score test, in which the participants were asked to read small text extracts, wearing their normal glasses or contact lenses if necessary. The test consists of 10 extracts written with letters of different sizes, varying from 0.6 to 10 mm in height, according to which the score is graded.

The Montgomery-Åsberg Depression Rating Scale (MADRS)20 was used to assess possible depressive symptoms. The scale consists of 10 items, with a maximum score of 60. A score ≥7 indicates depressive symptomatology.21 Finally, the Folstein Mini-Mental State Examination (MMSE),22 which has a maximum score of 30, was administered to assess cognitive function.

**Assessment of Falls**

A fall was defined as an unintentional change in position to the floor or ground. In September, October, November, and December 1998, falls were registered by means of monthly “fall calendars.” The participants were instructed to complete the calendar daily, marking an x for each fall on the date that the fall occurred. At the end of each month, a new calendar for the following month was mailed to each subject, and at the same time they were reminded to send back the previous one. If a calendar was not returned, the participant was called and reminded once more.

Among the 254 participants, 24 cases and 19 controls did not participate for the entire fall registration period. Eleven entered the study later than September 1, and 32 withdrew before the end of the study. The mean time of follow up was 112 days (SD 22) for cases and 117 days (SD 15) for controls. Subjects who decided not to continue for the entire study period were censored (follow-up ended) when we received their latest calendar.

Participants who reported 1 or more falls were interviewed by a physician (T.E.) and questioned about the cause, time, place, and injuries sustained. In accordance with the fall classification system by Lach et al (1991),23 extrinsic falls were defined as environmentally caused falls, whereas falls related to impaired balance and other subject-specific factors were defined as intrinsic falls.

**Statistical Analysis**

Differences between groups were tested by ANOVA and logistic regression analyses with adjustments for age and sex. The subjects included in the study were followed to the date of the first fall or end of follow-up, whatever came first. In a separate analysis, we ended follow-up after the second fall to identify frequent/true fallers. The Kaplan-Meier method of survival estimation was used to describe the risk of falling during follow-up as a function of time, and the log-rank test was used to test the difference in time to first fall between the stroke and the control subjects. A Cox proportional hazards regression model was used to estimate the influence of case status on risk of falling adjusted for potential confounders. Relative risks (RRs) were calculated, and variables that changed the relationship (RR) between stroke status and risk of falling by >10% in a model with age and sex included were considered potential confounders for this relationship. A Cox proportional hazards regression model was also used to examine predictors of falls among the stroke patients only, and adjustments were made for possible confounders (listed in Table 1). A variable was considered a possible confounder if it was related to fall status with P<0.1 after adjustment for age and sex.

**Results**

**Characteristics of the Study Population**

There were no significant differences between the 111 stroke patients who attended the study and the 98 patients who did not
There was, however, a significant difference (P = 0.03) between the age of the 143 attending and the 97 nonattending control subjects (mean, 67 [SD 13] and 63 [SD 15] years, respectively). Furthermore, these groups differed significantly (P = 0.01, adjusted for age) with respect to the MMSE and MADRS scores: the mean MMSE score was 29 (SD 2) and the mean MADRS score was 2 (SD 3), respectively, in the attending control group, whereas the mean MMSE and MADRS scores were 28 (SD 2) and 3 (SD 4), respectively, in the nonattending control group.

Characteristics of the stroke patients and the population controls who participated in the fall registration are presented in Table 1. The study was conducted at a mean of 10 years (SD 8) after the first stroke event.

### Risk of First Fall

During the study period, 25 (23%) of the patients and 16 (11%) of the population controls fell at least once. The risk of falling was significantly higher among stroke patients than among control subjects (P = 0.009), with RR = 2.3 (95% CI, 1.2 to 4.3) when adjusted for age and sex. This is also displayed in Figure 2. The absolute risk of falling at least once was 2/1000 person-days and 1/1000 person-days for the patients and the control subjects, respectively.

All variables presented in Table 1 were considered relevant with respect to the risk of falling. In addition, 1 stroke patient used antidepressant medication, and 2 had orthostatic hypotension. The corresponding numbers for the control subjects were 2 and 0, respectively. Because of these low numbers, orthostatic hypotension and use of antidepressant medication were not considered for the fall risk model.

The variables present coronary heart diseases, SSS leg score, MMSE score, and MADRS score included one by one in the Cox regression model together with age, sex, and stroke status changed the RR for the effect of stroke status on the risk of falling by >10%. However, when these potential

## Table 1. Characteristics of Stroke Patients and Control Subjects

<table>
<thead>
<tr>
<th></th>
<th>Stroke Patients (n=111)</th>
<th>Controls (n=143)</th>
<th>P, Patients vs Controls*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sociodemographics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male sex, %</td>
<td>57</td>
<td>57</td>
<td>...</td>
</tr>
<tr>
<td>Age, mean (SD) (range), y</td>
<td>68 (12) (31–86)</td>
<td>67 (13) (34–93)</td>
<td>...</td>
</tr>
<tr>
<td>Living alone, %</td>
<td>41</td>
<td>29</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Anthropometry</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height, mean (SD), cm</td>
<td>168 (9)</td>
<td>169 (10)</td>
<td>0.9</td>
</tr>
<tr>
<td>Body mass index, mean (SD), kg/m²</td>
<td>27.3 (6.1)</td>
<td>27.0 (4.2)</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Physical function</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Barthel Index score (0–90), %</td>
<td>14</td>
<td>4</td>
<td>0.002</td>
</tr>
<tr>
<td>Walks outdoors &lt;15 min/wk, %</td>
<td>33</td>
<td>16</td>
<td>0.002</td>
</tr>
<tr>
<td>SSS arm score, mean (SD)</td>
<td>5.5 (1.1)</td>
<td>5.9 (0.5)</td>
<td>0.001</td>
</tr>
<tr>
<td>SSS leg score, mean (SD)</td>
<td>5.4 (1.2)</td>
<td>5.8 (0.6)</td>
<td>0.002</td>
</tr>
<tr>
<td>Motor speed score, mean (SD)</td>
<td>42 (11)</td>
<td>49 (11)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Large body sway, %</td>
<td>74</td>
<td>50</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Vision score, mean (SD)</td>
<td>2.7 (1.4)</td>
<td>2.4 (1.2)</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Cognitive function/mood</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMSE score, mean (SD)</td>
<td>28 (3)</td>
<td>29 (2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>MADRS score, mean (SD)</td>
<td>4 (4)</td>
<td>3 (3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Present chronic diseases</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronary heart diseases, %</td>
<td>44</td>
<td>20</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lung diseases, %</td>
<td>32</td>
<td>30</td>
<td>0.9</td>
</tr>
<tr>
<td>Cancer, %</td>
<td>11</td>
<td>8</td>
<td>0.6</td>
</tr>
<tr>
<td>Joint disorders (arthrosis, arthritis, fracture), %</td>
<td>41</td>
<td>58</td>
<td>0.003</td>
</tr>
<tr>
<td>Epilepsy, %</td>
<td>7</td>
<td>1</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Current use of medication</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac therapeutics, %</td>
<td>21</td>
<td>11</td>
<td>0.05</td>
</tr>
<tr>
<td>Treatment for hypertension, %</td>
<td>47</td>
<td>15</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hypnotics/sedatives, %</td>
<td>5</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>Analgesics, %</td>
<td>6</td>
<td>13</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drinks alcohol, number of times/mo, mean (SD)</td>
<td>3 (6)</td>
<td>3 (5)</td>
<td>0.9</td>
</tr>
</tbody>
</table>

*Adjusted for age and sex.
confounders were entered in the same model, RR changed only slightly (RR=2.2; 95% CI, 1.1 to 4.3).

Risk of Recurrent Falls
Among the stroke patients, 13 fell twice or more and 12 fell only once. In several studies, elderly people who fall more than once (within a year) are described as true fallers. In our study the risk for a stroke patient to experience 1 fall within 4 months was 3.4 (95% CI, 1.0 to 11.7) times higher than in population controls, when adjusted for potential confounders.

Types and Consequences of Falls
The time, place, and classification of the first fall (intrinsic or extrinsic) are presented in Table 2. Most of the falls happened during daytime, and the stroke patients fell just as frequently outdoors as the control subjects (P=0.2). Intrinsic falls were more frequent among the patients (P=0.001), of whom only 4 reported that they fell because of a slippery surface or obstacles. Most of the falls among both stroke cases and control subjects happened while walking (77% and 81%, respectively). The other falls happened during transfers or while changing position either from sitting to standing or from lying down to sitting.

A total of 62 falls among the cases and 24 falls among the controls were registered. This corresponds to 5 and 1.4 falls per 1000 person-days in the stroke patients and the control subjects, respectively. Nine of the cases and 4 of the controls had injuries due to the falls (P=0.08); 3 were hospitalized because of major injuries (hip fracture, radius fracture, and head injury). The other injuries reported were bruises and a sprained ankle.

Predictors of Falls in Stroke Patients
Within the group of stroke patients, predictors of falls (when entered one by one in the model and adjusted for age and sex) were SSS leg score, MADRS score, and epilepsy (Table 3). However, when these variables were included in the same model, only MADRS was a significant predictor of falling. The patients had a mean MADRS score of 4 (SD 4), and the RR for falls increased by 1.5 per standard deviation increase in the MADRS score.

In our participants with stroke, 20% had a MADRS score ≥7, 36% had a SSS leg score <6, and 7% had epilepsy. Among 17 patients with 0, 65 patients with 1, and 29 patients with >1 of these risk factors, 2, 12, and 11 individuals, respectively, fell at least once. Thus, as shown in Figure 3, the risk of falling increased with the number of these risk factors present (P=0.03 for linear trend, adjusted for age and sex).

Discussion
This study shows that during a 4-month period, long-term stroke survivors have twice the risk of falling compared with population controls. The risk increases to 3.4 when frequent falling (>1 fall) is considered. To our knowledge, this is the

TABLE 2. Time, Place, and Classification of First Fall According to Self-Report

<table>
<thead>
<tr>
<th>Classification</th>
<th>Cases (n=25)</th>
<th>Controls (n=16)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daytime</td>
<td>20</td>
<td>13</td>
<td>0.9</td>
</tr>
<tr>
<td>Evening/night</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Place</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indoors</td>
<td>13</td>
<td>6</td>
<td>0.2</td>
</tr>
<tr>
<td>Outdoors</td>
<td>12</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Classification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrinsic falls</td>
<td>17</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Extrinsic falls</td>
<td>4</td>
<td>12</td>
<td>0.001</td>
</tr>
<tr>
<td>Do not know</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 3. Predictors of Falls Among Stroke Patients**

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Units</th>
<th>RR*</th>
<th>95% CI</th>
<th>RR†</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>MADRS score</td>
<td>4</td>
<td>1.6</td>
<td>1.2–2.3</td>
<td>1.5</td>
<td>1.0–2.2</td>
</tr>
<tr>
<td>SSS leg score</td>
<td>1</td>
<td>0.8</td>
<td>0.6–1.0</td>
<td>0.9</td>
<td>0.7–1.3</td>
</tr>
<tr>
<td>Epilepsy</td>
<td>Yes/no</td>
<td>3.6</td>
<td>1.2–10.7</td>
<td>2.4</td>
<td>0.7–8.1</td>
</tr>
</tbody>
</table>

*Adjusted for age and sex.
†Adjusted for age, sex, and other variables in the table.

Figure 2. Kaplan-Meier curves for the first fall among 111 stroke patients (solid line) and 143 control subjects (dotted line) during 4 months of follow-up.

Figure 3. Occurrence of falls among stroke patients according to number of risk factors. Risk factors were depressive symptoms (MADRS score ≥7), weakness of a leg (SSS score <6), and presence of epilepsy.
first follow-up study examining falls among community-dwelling patients with long-standing stroke. Although the risk of falling among patients in acute and institutional care may be higher,\textsuperscript{1,4} the risk found in the present study is still substantial. At particularly high risk are patients with depressive symptoms and with several risk factors present.

In our study most of the stroke patients fell while walking, half of them outdoors. In contrast, hospitalized stroke patients and those recently discharged to home after acute stroke usually fall indoors, often from their bed or chair and in relation to transfers.\textsuperscript{1,2,5} However, even though outdoor falls were frequent, the majority of our patients related their falls to intrinsic factors. In the population controls, the majority of the falls had extrinsic etiology.

In accordance with 2 other studies, \textsuperscript{1} early after stroke\textsuperscript{1} and \textsuperscript{2} later on,\textsuperscript{24} we found a relationship between depressive symptoms and falls. The latter study was, however, cross-sectional and thus at a larger risk of bias. We probably minimized recall bias because our participants registered falls daily by use of the fall calendars provided.

The high proportion of marked depressive symptoms in our patients with stroke (20\% with MADRS score $\geq 7$) was similar to that found in other community studies of stroke patients.\textsuperscript{25,26} Moreover, we found an interrelationship between impaired mobility (SSS of the legs) and depressive symptoms ($r=-0.3$, $P=0.001$), a result in agreement with other studies (eg, the Sunnybrook Stroke Study\textsuperscript{25}). However, when impairment of the leg and depressive symptoms were entered in the same model, only the latter was a statistically significant independent predictor of falls.

Depression may lead to reduced attention and thereby to an increased risk of falling. A possible alternative explanation, however, is that falls may lead to a decline in mobility, which further increases disability and possibly results in depression. We do not know whether some of our patients had been depressed because of falls that had occurred before we started the fall registration. Whether depressive symptoms were the cause or result of the tendency to fall can therefore not be inferred from our study.

There are other limitations of the present study. The baseline measurements were performed up to 1 year before the registration of falls, and changes in predictor status may have occurred during this period. Moreover, people participating in a survey examination are likely to be healthier than average. Furthermore, not all cases and control subjects were enrolled in the fall registration. However, because the participants and the nonparticipants differed only slightly with respect to the baseline measurements, we assume that our results can be generalized at least to the more healthy, same-aged part of the population.

In our study the mean age of the participants was 67.5 years when the falls were registered. Because both the risk of stroke\textsuperscript{27} and falls\textsuperscript{28} increase with age, the frequency of falls in a general stroke population may be underestimated. Moreover, we followed the subjects for a maximum of 4 months. A longer follow-up period increases the probability of identifying fallers. The difference in the proportion of the subjects who had not fallen among the stroke patients compared with the control subjects was, however, obvious after 1 month (Figure 2).

A final limitation is related to the size of the study. With a larger study sample, more statistically significant risk factors for falls may have been detected.

Our results suggest that fall prevention in stroke survivors should focus on intrinsic factors, particularly mobility and depression, the most prevalent risk factors in long-term stroke survivors. It is nevertheless a paradox that antidepressant medication may increase the risk of falling.\textsuperscript{29} Among elderly people in general, individually prescribed exercise programs have been shown to reduce the number of falls.\textsuperscript{30,31} and because many patients with stroke have problems walking outdoors, it is probably important to emphasize this activity in their program. Studies specifically designed for stroke patients are needed.

Besides falling, low bone mineral density is a major determinant of fracture risk.\textsuperscript{32–34} Several studies show that stroke patients have a large loss of bone mineral, especially on the paretic side, over time\textsuperscript{35–38} and that they are at increased risk of fracture, especially hip fracture.\textsuperscript{7,8} Intervention programs should therefore target both fall-related factors and maintenance of bone mass.

We conclude that falls are more frequent among individuals with stroke than among community controls, and we call for strategies that seek to reduce the frequency of falls.

Acknowledgments

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References


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