Recurrent Falls Predicts Injurious Falls Better than Single Falls in Community-dwelling Older People - A Prospective long-term follow-up on injurious falls

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Abstract

Background

Fall-related injuries in older people are a leading cause of morbidity and mortality. A history of falls is often used to predict increased risk of subsequent falling, but it has not been determined if having fallen just once during the previous year predicts severe cases of injurious falls in the long term, or if two or more falls are required. The objective with this study was to investigate if a history of 1 non-injurious fall, ≥2 non-injurious falls, or ≥1 injurious fall within a period of 12 months may predict the long-term risk of suffering an injurious fall in the future.

Methods

Community-dwelling individuals 75–93 years of age (n = 230) were initially followed prospectively with monthly calendars reporting falls over a period of 12 months. The participants were classified into four groups based on the number and type of falls. The participants were then followed for several years (mean time 4.9 years ± 0.9) regarding injurious falls requiring a visit to a hospital emergency department. The Andersen–Gill method of Cox regression for multiple events was used to estimate the risk of injurious falls.

Results

Thirty-two per cent of the participants had ≥1 injurious falls during the long-term follow-up period that required treatment from a hospital emergency department. Those with a previous history of ≥2 non-injurious falls had higher risk for injurious
falls in the long term (hazard ratio 2.31; 95% CI, 1.27–4.18) than those with no falls.
None of the other groups had a significantly increased risk.

Conclusions

Two non-injurious falls within 12 months predicts a greater risk for subsequent injurious fall than no falls, one non-injurious fall, or one injurious fall in the past 12 months.

Keywords
Accidental falls, Older adults, Risk factors, Community-dwelling, Fall prediction

Background
Falls are a major health concern among older adults, and fall-related injuries are a leading cause of morbidity and mortality a. About 10% of all fall events result in serious injuries such as fractures, subdural hematomas, or soft-tissue injuries, and falls account for almost 10% of visits to a hospital emergency department (ED) [2, 3]. The risk of falling and sustaining fall-related injuries increases exponentially with age [1, 4-6]. After the age of 80 years 50% of community-dwelling people are expected to experience at least one fall each year [5, 7, 8]. Older women are generally believed to be more likely to fall than men [5, 9] and to sustain non-fatal fall-related injuries [6, 10], but in very old people (older than 85 years) men have a greater risk of falls and fall-related mortality compared to women [11, 12].
Based on evidence that the rate of falling and the prevalence of risk factors for falling increase steeply after the age of 70 years, it has been recommended that all patients ≥75 years old be asked about falls and balance or gait difficulties and that they be encouraged to participate in an exercise program of balance and strength training [13]. The American and British Geriatrics Societies (AGS/BGS) have similar recommendations in their clinical guidelines from 2010 but recommend that screening of all patients begin from the age of 65 years [14].

There are indications that older people who have fallen within the past year are more likely to fall again, especially if they have fallen more than once [5, 9]. The estimated odds ratio of falling has been shown to be generally higher after recurrent falls (twice or more within a period of 12 months) than after one fall for community-dwelling people over 65 years [9]. It has been questioned if one single non-injurious fall within 12 months should really be seen as an elevated risk of renewed falls, but instead should be equated with no falls [15, 16]. Proponents for this opinion argue that recurrent falls might indicate an underlying high-risk state that predisposes to falling, and that one fall might happen by chance alone [9, 17, 18]. This approach has become increasingly common in prospective studies on falls [19].

Observational data suggest that the risk factors for falls and for serious fall-related injuries are similar [2, 3]. Furthermore, seeking emergency medical care because of a fall-related injury (no fracture) for the first time seems to be associated with an increased risk of later fractures [10]. It has been less well investigated how the severity of falls relates to the risk of injurious falls in the future. Our hypothesis was...
that it is more likely to visit an ED in the future due to fall-related injuries after
experiencing either recurrent non-injurious falls, or at least one injurious fall requiring
treatment at an ED than after only one non-injurious fall. To our knowledge, this is
the first study to investigate these associations based on a prospective data collection
on falls.

The objective of this study was to determine which fall type (single non-injurious fall,
recurrent non-injurious falls, or an injurious fall) implies an increased long term risk
of experiencing injurious falls.

Methods

Participants

A total of 230 community-dwelling people (64 men and 166 women) from Umeå,
Sweden, between the ages of 75 years and 93 years (mean 79.4 years ± 3.7 years)
were recruited through senior citizen organisations, physiotherapists, occupational
therapists in primary care, and advertisements in the local press between October
2004 and December 2005. As previously reported [20], inclusion criteria were ≥75
years of age, the ability to walk at least 10 meters without a walking aid, and a
cognitive function of 24 points or more on the Mini-Mental State Examination [21] in
order to be able to follow instructions regarding follow-up on falls. The study was
approved by the Regional Ethical Review Board in Umeå (Dnr 2011-191-31M and
04-071M), and all participants gave their written consent.
This study is based on the following three data collections of the same sample: 1) a cross-sectional baseline assessment, 2) a detailed follow-up on falls and fall-related injuries over the course of one year, and 3) a long-term follow-up on individuals presenting to the ED due to injurious falls, including those that occurred during a hospital stay.

**Cross-sectional baseline assessment**

The baseline assessment of the 230 participants included self-reported medical conditions and socio-demographic indicators regarding age, marital status, years of education, history of falls and fractures, fear of falling, and medication use. The Barthel Index score of activities of daily living questionnaire [22] and the 15-item Geriatric Depression Scale [23] were filled out. Performance-based tests were completed, including the Short Physical Performance Battery (SPPB) [24] and self-selected walking speed [25] with a flying start and stop using GAITRite® [26], an instrumented walkway system.

**One-year follow-up on falls and fall-related injuries**

Participants were prospectively followed for one year with monthly fall calendars. If the calendar was not returned on time, the participant was contacted by telephone. A fall was defined as an event in which the participant unintentionally came to rest on the floor or ground regardless of the cause or the consequences of the fall [27]. We
defined a fall-related injury as one that was severe enough for the participant to visit the ED. We thus included all fall-related injuries and not only radiologically confirmed peripheral fractures as recommended [27]. The rate of falls and observation time were recorded from the day of inclusion until voluntary dropout, death or the end of the follow-up period 365 days later [27].

Long term follow-up on injurious falls

Data from the 230 participants were matched with data from the Umeå University Hospital’s on-going injury registration – the Umeå Injury Database (IDB) – up to the end of the data collection period on 31st December 2010. The IDB includes a total data set of injuries due to accidents and trauma from the well-defined geographic area of Umeå, Sweden. When visiting the ED at Umeå University Hospital, the injured, or an accompanying person filled out a form describing the situation causing the injury. When needed, the data set was supplemented with data from ambulance and police records. Injury severity for up to three injuries per patient was registered. Fall-related injuries were classified by a blinded independent employee. The IDB is compared annually with the general hospital register, and all falls causing severe injuries that occurred at the hospital were, therefore, included [28]. Dates of death were obtained from the Swedish Tax Agency’s register.

Statistical methods

Data are reported as rates and proportions and as mean values ± standard deviations. The total observation time during the follow-up period was counted as the number of
days at risk for falls and the incidence rate of injurious falls was presented as the number of falls per 100 person years (PY). The time to the injury event was calculated as the time from inclusion in the long-term follow-up until censoring or any event. An event was defined as a fall requiring a visit to the ED, and participants were censored at the end of the follow-up or at death. The starting time for the long-term follow-up differed for the groups. Those with no falls were included at their date of inclusion in the study, those with one non-injurious fall were included at the date of the actual fall, those with at least two non-injurious falls were included at the date of the second fall, and those with one injurious fall causing a visit to the ED were included at the date of the actual fall. The time to injury event was analysed using a Cox proportional hazards model, employing the Andersen–Gill extension to allow for multiple events per subject [29]. The independent variable of primary interest was fall categories based on the follow-up year. Potential confounders included in the model were age, sex, SPPB, and use of potential risk medications. The proportional hazards assumption was tested for each covariate using Schoenfeld residuals [30]. Analyses were performed using Stata (version 12, StataCorp, College Station, TX, USA). Results were considered significant if the associated \( p \)-value was below 0.05.

**Results**

Overall, 320 incidents were recorded during the prospective monitoring period with an incidence rate of 95 falls/100 PY. One hundred nine of the 230 participants (47%) fell at least once, and 54 (23%) fell at least twice. There was no significant difference between women and men. According to the results of their falls during the monitoring period, participants were classified as no falls \( (n = 119; 53\%) \); one fall without
injuries severe enough to cause a visit to the ED \((n = 50; 21\%)\); two or more falls without injuries \((n = 44; 19\%)\); or one injurious fall \((n = 17; 7\%)\). Baseline characteristics of the four groups are summarised in Table 1.

The total observation time in the long-term follow-up was 1112 PY, and the mean follow-up time was 4.8 years per participant. Seventy-two individuals (32%) were treated in the ED for 95 unintentional injurious falls for an incidence rate of 8.2 injurious falls per 100 PY. Of the 95 events, 20 involved men (31%) and 75 involved women (45%) \((p = 0.030)\). An event could result in more than one injury. Fractures, contusions, abrasions, and lacerations resulted in more than 83% of injury diagnoses (Table 2). Fractures accounted for 29 (39%) of women’s and 4 (20%) of men’s injuries. During the long-term follow-up, 27 individuals (11%) died – 12 (19%) men and 15 (9%) women – but none died as direct consequence of an injurious fall.

None of the potential confounders were significantly related to fall categories based on the follow-up year. The hazard regression of injurious falls for each of the four groups during the long-term follow-up showed that of the considered covariates only the fall category based on the follow-up year was associated with the fall hazard (Figure 1). For the group with at least two non-injurious falls, the hazard ratio compared to the reference group (no falls) was estimated to be 2.31 (95% CI: 1.27–4.18, \(p = 0.006\)). For comparison, the group with one single fall with no injuries, had an estimated hazard ratio of 1.11 (95% CI: 0.66–1.90, \(p = 0.69\)) and for the group with one injurious fall the hazard ratio was 1.44 (95% CI: 0.59–3.51, \(p = 0.42\)). All covariates in the model passed the proportional hazards assumption test, i.e., there were no significant violations of the proportional hazards assumption.
Discussion

The results from the long-term follow-up supports our hypothesis that a history of two or more non-injurious falls – but not one non-injurious fall – predicts an increased risk for future injurious falls in community-dwelling people 75 years of age and older. In contrast to others [11], our results did not confirm that at least one injurious fall predicts an increased long-term risk for subsequent injurious falls. It should be noted, however, that our results are based on a small sample size; there were only 15 individuals (7%) in the injurious falls group. In addition, people who sustained a fall-related injury might subsequently have adopted more cautious behaviours and increased the number of actions taken to prevent future falls based on an increased awareness about the consequences of falls [31].

Based on the results of this study we suggest that researchers who plan to conduct a prospective study on injurious falls in community-dwelling people from 75 years of age consider focusing primarily on recurrent falls within a year instead of one single fall. An alternative is to follow up with three separate groups: one fall, recurrent falls, and one injurious fall. Furthermore, all community-dwelling people 75 years or older who come into contact with any health care staff for any reason should be asked whether they have fallen in the previous year. If they have sustained two or more non-injurious falls, they should be asked about the circumstances surrounding the falls. The answers might provide guidance in commencing with multifactorial risk assessments to look for possible underlying health problems.
The recommendation to screen older people with two or more falls for gait and balance impairments might not be necessary because our results indicate that they are already at high risk for sustaining future injurious falls. Instead, we strongly recommend that the patients be referred to targeted fall prevention interventions.

Discussion groups in the form of workshops with peers and experts in the field of fall prevention are an efficient way to increase awareness of fall risks and the kinds of actions that can be taken to prevent falls in everyday life (Pohl et al, manuscript). In contrast, it can be questioned if all patients 65 years of age and older with a history of only one fall and without gait or balance disturbances who seek out health care for any reason should be annually reassessed. Counselling them about taking part in fall-prevention exercise groups, checking up on their medications, performing annual vision tests, and providing advice regarding a safe environment [14] is resource consuming for public health services and can sometimes be seen as a violation of the person’s integrity, and this can reduce adherence to preventive interventions.

Our study had strengths and limitations. Our prospective design followed recommendations for collecting self-reported data on falls [32]. All participants sent us monthly reports, and if a fall had occurred a telephone interview was conducted to collect details on the fall. Our findings are in agreement with population-based studies showing that about 25% of people over 75 years fall at least twice every year [3, 15, 33], although lower and higher rates have been found by others [19, 34]. The proportion of falls requiring medical care was in agreement with others [13], and the distribution of injury types during the long-term follow-up also corresponded well with other studies [6]. There is a potential selection bias in using a volunteer sample with no cognitive impairments, because this might not accurately represent the
independent community-dwelling population at large. The IDB is based on a thorough data collection and is a reliable source of injurious falls requiring treatment at an ED, but our results must be interpreted with some caution because older people might have forgotten that they have fallen when they are asked about previous falls and because the group with injurious falls during the monitoring year was small in this study.

Conclusions

In conclusion, this study suggests that two or more non-injurious falls within a year predicts a greater risk for subsequent injurious falls than no falls or one single fall in community-dwelling people older than 75 years of age. The study does not support the hypothesis that one injurious fall indicates a higher risk for subsequent injurious falls.

List of abbreviations

ED = Emergency department
AGS/BGS = The American Geriatric Society and the British Geriatric Society
SPPB = Short Physical Performance Battery
IDB = Injury Data Base
PY = Person years
CI = confidence interval
Competing interests

The authors declare that they have no competing interests.

Authors' contributions

All authors participated in conceiving and designing the study, interpreting data, and drafting the manuscript. E.N. and L.L.O. acquired the participants and the data. P.P, A.L., and L.L.O. performed the statistical analyses. E.N., U.B., A.L., and L.L.O. critically revised the manuscript. All authors read and approved the final manuscript.

Acknowledgements

We thank all the participants and our colleagues who helped with baseline assessments. We thank the staff at the ED and the Injury Surveillance for maintaining the IDB at Umeå University Hospital, and especially Magnus Hellström for extracting and organizing our data. This work was supported by the Swedish Research Council (grant number 521-2011-3250); the Swedish Council for Working Life and Social Research; King Gustav V’s and Queen Victoria’s Freemasons’ Foundation; the Erik and Anne-Marie Detlof Foundation, and Umeå University. The sponsors played no role in the study.
References


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**Figures**

Figure 1 - Estimated probability of avoiding injurious falls.

The estimated probability of avoiding falls requiring a visit to the emergency department (E.D.).
### Table 1 - Baseline characteristics of participants with respect to falls.

Baseline characteristics of participants based on their status with respect to falls during the one-year monitoring period expressed as mean ± standard deviation (SD) or as the number (n) and percentage.

<table>
<thead>
<tr>
<th></th>
<th>Total (n = 230)</th>
<th>No falls (n = 119)</th>
<th>1 fall, no injuries (n = 50)</th>
<th>≥2 falls, no injuries (n = 44)</th>
<th>≥1 fall, injuries (n = 17)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age, mean (SD)</strong></td>
<td>79.4 (3.7)</td>
<td>79.1 (3.1)</td>
<td>79.9 (4.0)</td>
<td>79.6 (4.3)</td>
<td>81.9 (4.8)</td>
</tr>
<tr>
<td><strong>Women, n (%)</strong></td>
<td>166 (72)</td>
<td>89 (75)</td>
<td>37 (74)</td>
<td>26 (59)</td>
<td>14 (82)</td>
</tr>
<tr>
<td><strong>Mini-Mental State Examination, score, mean (SD)</strong></td>
<td>27.7 (1.8)</td>
<td>27.7 (1.8)</td>
<td>28.0 (1.7)</td>
<td>27.6 (1.9)</td>
<td>27.1 (2.3)</td>
</tr>
<tr>
<td><strong>Living alone, n (%)</strong></td>
<td>123 (53)</td>
<td>63 (53)</td>
<td>29 (58)</td>
<td>19 (43)</td>
<td>12 (71)</td>
</tr>
<tr>
<td><strong>Use of walking aid indoors, n (%)</strong></td>
<td>30 (13)</td>
<td>16 (13)</td>
<td>7 (14)</td>
<td>3 (7)</td>
<td>4 (24)</td>
</tr>
<tr>
<td><strong>Fear of falling, n (%)</strong></td>
<td>113 (49)</td>
<td>57 (48)</td>
<td>25 (50)</td>
<td>20 (46)</td>
<td>11 (65)</td>
</tr>
<tr>
<td><strong>15-item Geriatric Depression Scale, 0–15 points, mean (SD)</strong></td>
<td>1.7 (2.0)</td>
<td>1.6 (1.9)</td>
<td>1.4 (1.4)</td>
<td>1.8 (2.3)</td>
<td>3.4 (2.3)</td>
</tr>
<tr>
<td><strong>Diabetes mellitus, n (%)</strong></td>
<td>20 (9)</td>
<td>11 (9)</td>
<td>7 (14)</td>
<td>2 (5)</td>
<td>0 (0)</td>
</tr>
<tr>
<td><strong>Previous stroke, n (%)</strong></td>
<td>28 (12)</td>
<td>13 (11)</td>
<td>7 (14)</td>
<td>6 (14)</td>
<td>2 (12)</td>
</tr>
<tr>
<td><strong>Heart disease, n (%)</strong></td>
<td>53 (23)</td>
<td>27 (23)</td>
<td>10 (20)</td>
<td>11 (25)</td>
<td>5 (29)</td>
</tr>
<tr>
<td><strong>Rheumatism/Arthritis, n (%)</strong></td>
<td>15 (7)</td>
<td>7 (6)</td>
<td>4 (8)</td>
<td>4 (9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td><strong>Prescription drugs a ≥1, n (%)</strong></td>
<td>104 (45)</td>
<td>51 (43)</td>
<td>18 (36)</td>
<td>24 (55)</td>
<td>11 (65)</td>
</tr>
<tr>
<td><strong>Barthel Index score, mean (SD)</strong></td>
<td>19.9 (0.5)</td>
<td>19.8 (0.5)</td>
<td>19.9 (0.3)</td>
<td>19.8 (0.5)</td>
<td>19.7 (0.6)</td>
</tr>
<tr>
<td><strong>Preferred gait speed (m/s) over a distance of 6.1 m, mean (SD)</strong></td>
<td>1.0 (0.3)</td>
<td>1.0 (0.3)</td>
<td>1.1 (0.3)</td>
<td>1.0 (0.2)</td>
<td>0.9 (0.2)</td>
</tr>
<tr>
<td><strong>Short Physical Performance Battery score, mean (SD)</strong></td>
<td>10.1 (2.1)</td>
<td>10.3 (2.1)</td>
<td>10.0 (2.3)</td>
<td>10.3 (1.7)</td>
<td>9.4 (2.4)</td>
</tr>
<tr>
<td><strong>Previous fall before baseline b</strong></td>
<td>80 (35)</td>
<td>46 (39)</td>
<td>19 (38)</td>
<td>11 (25)</td>
<td>4 (24)</td>
</tr>
<tr>
<td><strong>≥2 falls in previous year, n (%)</strong></td>
<td>44 (19)</td>
<td>10 (8)</td>
<td>10 (20)</td>
<td>19 (43)</td>
<td>5 (29)</td>
</tr>
<tr>
<td><strong>Fracture previous 5 years, n (%)</strong></td>
<td>94 (41)</td>
<td>45 (38)</td>
<td>21 (42)</td>
<td>18 (41)</td>
<td>10 (59)</td>
</tr>
</tbody>
</table>

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*a* Medications considered to increase risk fall risk include calcium preparations, potassium-sparing diuretics, oxicams, anilides, anxiolytics and hypnotics (both benzodiazepine derivatives).

*b* Participants were asked about falls that occurred one year prior to inclusion and about fractures that occurred five years prior to inclusion.
Table 2
Distribution of the participant’s most severe fall-related injuries ($n = 95$), shown as the number ($n$) and percentage.

<table>
<thead>
<tr>
<th>Injury diagnosis</th>
<th>Total number of injuries ($n = 95$)</th>
<th>Injuries among men ($n = 20$)</th>
<th>Injuries among women ($n = 75$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concussion</td>
<td>2 (2.1)</td>
<td>1 (5.0)</td>
<td>1 (1.3)</td>
</tr>
<tr>
<td>Internal injury</td>
<td>2 (2.1)</td>
<td>0 (0.0)</td>
<td>2 (2.7)</td>
</tr>
<tr>
<td>Fracture, hip</td>
<td>7 (7.4)</td>
<td>0 (0.0)</td>
<td>7 (9.3)</td>
</tr>
<tr>
<td>Fracture, other</td>
<td>26 (27.4)</td>
<td>4 (20.0)</td>
<td>22 (29.3)</td>
</tr>
<tr>
<td>Laceration</td>
<td>18 (18.9)</td>
<td>7 (35.0)</td>
<td>11 (14.7)</td>
</tr>
<tr>
<td>Contusion/bruise</td>
<td>27 (28.4)</td>
<td>4 (20.0)</td>
<td>23 (30.7)</td>
</tr>
<tr>
<td>Abrasion</td>
<td>1 (1.1)</td>
<td>1 (5.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Luxation</td>
<td>4 (4.2)</td>
<td>1 (5.0)</td>
<td>3 (4.0)</td>
</tr>
<tr>
<td>Strain/sprain</td>
<td>3 (3.2)</td>
<td>0 (0.0)</td>
<td>3 (4.0)</td>
</tr>
<tr>
<td>Other</td>
<td>5 (5.3)</td>
<td>2 (10.0)</td>
<td>3 (4.0)</td>
</tr>
</tbody>
</table>
Figure 1

Cox proportional hazards regression

Est. prob. of avoiding fall requiring E.D. visit vs. Time in days

- No falls
- 1 fall
- 2 or more falls
- 1 or more fall(-s) w injury