

# A multidisciplinary, multifactorial intervention program reduces postoperative falls and injuries after femoral neck fracture

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## Abstract

**Introduction** This study evaluates whether a postoperative multidisciplinary, intervention program, including systematic assessment and treatment of fall risk factors, active prevention, detection, and treatment of postoperative complications, could reduce inpatient falls and fall-related injuries after a femoral neck fracture.

**Methods** A randomized, controlled trial at the orthopedic and geriatric departments at Umeå University Hospital, Sweden, included 199 patients with femoral neck fracture, aged  $\geq 70$  years.

**Results** Twelve patients fell 18 times in the intervention group compared with 26 patients suffering 60 falls in the control group. Only one patient with dementia fell in the intervention group compared with 11 in the control group. The crude postoperative fall incidence rate was 6.29/1,000 days in the intervention group vs 16.28/1,000 days in the control group. The incidence rate ratio was 0.38 [95% confidence interval (CI): 0.20–0.76,  $p=0.006$ ] for the total sample and 0.07 (95% CI: 0.01–0.57,  $p=0.013$ ) among patients with dementia. There were no new fractures in the intervention group but four in the control group.

**Conclusion** A team applying comprehensive geriatric assessment and rehabilitation, including prevention, detection, and treatment of fall risk factors, can successfully prevent inpatient falls and injuries, even in patients with dementia.

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## Introduction

Nearly all hip fractures occur as a result of a fall [1] and many fall again soon after sustaining the fracture [2]. Osteoporosis with low bone mineral density (BMD) puts older people who fall at high risk of sustaining fractures [3, 4]. A first hip fracture is associated with a 2.5-fold increased risk of a subsequent fracture [5]. A population-based study among people aged 85 years or older showed that 21% of those with a hip fracture had suffered at least two hip fractures [6].

Previous research has identified several fall risk factors such as comorbidity, functional disability, previous falls, and use of drugs [7–11] but also aging [12, 13] and among

the oldest old, male sex [14]. Delirium, which is very common after hip fracture surgery, especially among those with a cognitive decline [15, 16], has been found to be one of the most important risk factors for falls among older people [10].

Multi factorial intervention strategies among community-living older people can prevent falls [17–20] and are the recommendations in fall prevention interventions nowadays [21]. The recommendations in fall prevention programs is that they should include gait training, advice on use of assistive devices, medication reviews, exercise programs including balance training, treatment of hypotension, environmental modification, and treatment of cardiovascular disorders. In long-term care the program recommends also to include staff education [21]. Most fall prevention studies are performed in the community, but multidisciplinary and multifactorial interventions have also been shown to be beneficial in residential care facilities [22].

Few fall prevention studies have been carried out in hospitals; there have been a few studies with single interventions among older patients in rehabilitation units, without any significant effects [23–25]. Recently two studies, one using multiple interventions [26] and one using a multidisciplinary fall prevention approach [27], have demonstrated a reduction in falls. None of these fall prevention studies have focused on hip fracture patients or tried to reduce postoperative complications as a fall prevention measure.

**Fig. 1** Flow chart for the randomized trial

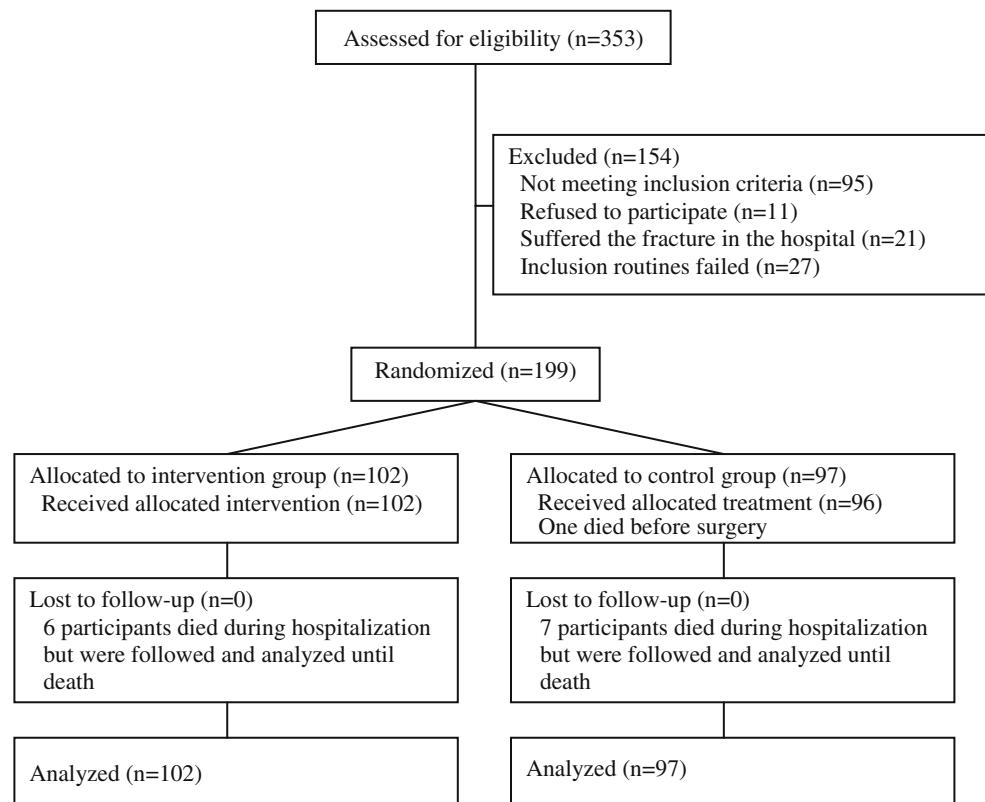
Considering the lack of fall prevention studies in hospitals, especially after recent hip fracture surgery, this is an area of interest for study. The aim of this study was thus to evaluate if a postoperative multidisciplinary, multifactorial intervention program could reduce inpatient falls and fall-related injuries in patients with femoral neck fractures.

## Methods

### Recruitment and randomization

This study included patients with femoral neck fracture aged  $\geq 70$  years, consecutively admitted to the orthopedic department at the Umeå University Hospital, Sweden, between May 2000 and December 2002, and the study was designed according to the CONSORT guidelines [28].

In Sweden different surgery methods are used depending on the displacement of the femoral neck fracture. In the present study patients with undisplaced fracture were operated on using internal fixation (IF) and patients with displaced fracture were operated on using hemiarthroplasty (HAP). If patients had severe rheumatoid arthritis, severe hip osteoarthritis, or pathological fracture they were excluded, by the surgeon on duty, because of the need for a different surgery method, such as total hip arthroplasty



(THA). Patients with severe renal failure were excluded, by the anesthesiologist, because of their morbidity. Patients being bedridden before the fracture occurred were also excluded.

In the emergency room the patients were asked both in writing and orally if they were willing to participate in the study. The next of kin was always asked prior to the inclusion in patients with cognitive impairment. The patients or their next of kin could at any time decline participation. A total of 258 patients met the inclusion criteria; 11 patients declined to participate and 48 patients were not invited to participate because they had sustained the fracture in the hospital or the inclusion routines failed (Fig. 1). These 59 patients were more likely to be men ( $p=0.033$ ) and living in their own house/apartment ( $p=0.009$ ), but there was no difference in age ( $p=0.354$ ) compared to the participating patients. The remaining 199 patients (Table 1) consented to participate. All patients received the same preoperative treatment.

Patients were randomized, to postoperative care in a geriatric ward with a special intervention program or to conventional care in an orthopedic ward, in opaque sealed

envelopes. The lots in the envelopes were sequentially numbered. All participants received this envelope while in the emergency room but the envelope was not opened until immediately before surgery to ensure that all patients received similar preoperative treatment. Persons not involved in the study performed these procedures.

The randomization was stratified according to the operation methods used in the study. Depending on the degree of dislocation, the patients were treated with IF using two hook-pins (Swemac Ortopedica, Linköping, Sweden) ( $n=38$  intervention vs  $n=31$  control) or with bipolar hemiarthroplasty (Link, Hamburg, Germany) ( $n=57$  vs 54). Basocervical fractures ( $n=7$  vs 10) were operated on using a dynamic hip screw (DHS, Stratec Medical, Oberdorf, Switzerland) and one had a resection of the femoral head due to a deterioration in medical status and one died before surgery (both were in the control group).

### Intervention

The intervention ward was a geriatric unit specializing in geriatric orthopedic patients. The staff worked in teams to

**Table 1** Basic characteristics and assessments during hospitalization among participants in the intervention and control groups. SD standard deviation, ADL activity of daily living

	Intervention (n=102)	Control (n=97)	p value
<b>Sociodemographic</b>			
Age, mean±SD	82.3±6.6	82.0±5.9	0.724
Females	74	74	0.546
Independent living before the fracture	66	60	0.677
<b>Health and medical problems</b>			
Stroke (n=102/93)	29	20	0.265
Dementia	28	36	0.145
Previous hip fracture (n=102/96) <sup>a</sup>	16	14	0.829
Depression (n=102/95)	33	45	0.031
Diabetes (n=102/95)	23	17	0.417
Cardiovascular disease (n=101/93)	57	53	0.938
<b>Medications on admission</b>			
Number of drugs, mean±SD	5.8±3.8	5.9±3.6	0.867
Antidepressants	29	45	0.009
<b>Sensory impairments</b>			
Impaired hearing (n=94/82)	42	34	0.667
Impaired vision (n=91/74)	37	27	0.584
<b>Functional performance before fracture</b>			
Use of roller walker (n=101/93)	56	52	0.948
Use of wheelchair (n=101/93)	23	16	0.334
Previous falls, last month (n=99/90) <sup>b</sup>	24	25	0.580
Walking independently, at least indoors (n=101/94)	85	85	0.191
Staircase of ADL, median (Q <sub>1</sub> ,Q <sub>3</sub> ) (n=92/88)	5 (1–7.75)	5 (0.25–7)	0.859
<b>Assessments during hospitalization</b>			
Mini Mental State Examination, mean±SD (n=93/90)	17.4±8.2	15.7±9.1	0.191
Organic Brain Syndrome Scale, mean±SD (n=94/90)	10.1±10.8	12.5±11.4	0.148
Geriatric Depression Scale, mean±SD (n=81/68)	5.2±3.6	4.5±3.5	0.271

<sup>a</sup> Except for the present hip fracture

<sup>b</sup> Except for the fall that caused the hip fracture

**Table 2** Main content of the postoperative program and differences between the two groups

	Intervention group	Control group
Ward layout	Single and double rooms 24-bed ward, extra beds when needed	Single, double, and four-bed rooms 27-bed ward, extra beds when needed The geriatric control ward was similar to the intervention ward
Staffing	1.07 nurses/aides per bed Two full-time physiotherapists Two full-time occupational therapists 0.2 dietician	1.01 nurses per bed Two full-time physiotherapists 0.5 occupational therapist No dietician The geriatric control ward had staffing similar to the intervention ward
Staff education	A 4-day course in caring, rehabilitation, teamwork, and medical knowledge including sessions about how to prevent, detect, and treat various postoperative complications such as postoperative delirium and falls	No specific education before or during the project
Teamwork	Team included registered nurses (RN), licensed practical nurses (LPN), physiotherapists (PT), occupational therapists (OT), dietician, and geriatricians Close cooperation between orthopedic surgeons and geriatricians in the medical care of the patients	No corresponding teamwork at the orthopedic unit
Individual care planning	All team members assessed each patient as soon as possible, usually within 24 h, to be able to start the individual care planning Team planning of the patients' individual rehabilitation process and goals twice a week	The geriatric ward, where some of the control group patients were cared for, used teamwork similar to that in the intervention ward Individual care planning was used in the orthopedic unit but not routinely as in the intervention ward
Prevention and treatment of complications	Investigation as far as possible regarding how and why they sustained the hip fracture, through analyzing external and internal fall risk factors An action to prevent new falls and fractures was implemented including global ratings of the patients' fall risk every week during team meetings Calcium and vitamin D and other pharmacological treatments for osteoporosis were used when indicated Active prevention, detection, and treatment of postoperative complications such as delirium, pain, and decubitus ulcers was systematic	At the geriatric rehabilitation unit there was weekly individual care planning No routine analysis of why the patients had fractured their hips No attempt was made to systematically prevent further falls
Nutrition	Oxygen-enriched air during the 1st postoperative day and longer if necessary until the measured oxygen saturation was stable Urinary tract infections and other infections were screened for and treated If a urinary catheter was used it should be discontinued within 24 h postoperatively Regular screening for urinary retention, and prevention and treatment of constipation Blood transfusion was prescribed if B-hemoglobin <100 g/l and <110 for those at risk of delirium or those already delirious If the patient slept badly, the reason was investigated and the aim was then to treat the cause Food and liquid registration was systematically performed and protein-enriched meals were served to all patients during the first 4 postoperative days and longer if necessary Nutritional and protein drinks were served every day	No routine prescription of calcium and vitamin D Assessments for postoperative complications were made with check-ups for, i.e., saturation, hemoglobin, nutrition, bladder and bowel function, home situation etc., but these check-ups were not carried out systematically as in the intervention group A dietitian was not available at the orthopedic unit No routine nutrition registration or protein-enriched meals were available for the patients

**Table 2** (continued)

	Intervention group	Control group
Rehabilitation	Mobilization within the first 24 h after surgery The training included both specific exercise and other rehabilitation procedures delivered by a PT and OT, as well as basic daily ADL performance training, by caring staff. The patients should always do as much as they could by themselves before they were helped The rehabilitation was based on functional retraining with special focus on fall risk factors	Mobilization usually within the first 24 h The PT on the ward mobilized the patients together with the caring staff. The PT aimed to meet the lucid patients every day. Functional retraining in ADL situations was not always given. The OT at the orthopedic unit only met the patients for consultation The geriatric control ward had both specific exercise and other rehabilitation procedures delivered by a PT and OT, similar to the intervention ward but did not systematically focus on fall risk factors
	Home visit by an OT and/or a PT	No home visits were made by staff from the orthopedic unit

apply comprehensive geriatric assessments, management, and rehabilitation [29, 30]. Active prevention, detection, and treatment of postoperative complications such as falls, delirium, pain, and decubitus ulcers was systematically implemented daily during the hospitalization (Table 2). The staffing at the intervention ward were 1.07 nurses/aides per bed.

The control ward was a specialist orthopedic unit following the conventional postoperative routines. A geriatric unit, specializing in general geriatric patients, was used for those who needed longer rehabilitation ( $n=40$ ). The staffing at the orthopedic unit was 1.01 nurses/aides per bed and 1.07 for the geriatric control ward. The main content of both the intervention program and the conventional care is described in Table 2.

The staffs on the intervention and control wards were not aware of the nature of the present study.

#### Data collection

Two registered nurses were employed and performed the assessments during hospitalization.

Medical, social, and functional data were collected from the patients, relatives, staff, and medical records on admission. Complications during hospitalization, including falls, length of stay, morbidity, and mortality, were systematically registered in the medical and nursing records. Nurses are obliged by law to document any falls in the records [31]. A fall was defined as an incident when the patient unintentionally came to rest on the floor and included syncopal falls. Numbers of falls and time lapse to first fall after admission were calculated. The Abbreviated Injury Scale (AIS) [32] was used to classify the injuries resulting from a fall. The maximum injury (MAIS) connected with each incident was recorded.

A few days after surgery, patients were assessed and interviewed regarding their cognitive status using the Mini

Mental State Examination (MMSE) [33]. The modified Organic Brain Syndrome Scale (OBS Scale) [34] was used to assess cognitive, perceptual, emotional, and personality characteristics as well as fluctuations in clinical states. Mental state changes were also documented from medical records. Depression during hospitalization was diagnosed due to current treatment with antidepressants and depression screened using the Geriatric Depression Scale (GDS-15) [35] in combination with depressive symptoms observed and registered by the OBS Scale. The patients' vision and hearing were assessed by their ability to read 3-mm block letters with or without glasses, and their ability to hear a normal speaking voice from a distance of 1 m. Activities of daily living (ADL) prior to the fracture were measured retrospectively using the Staircase of ADL [36].

A geriatrician, unaware of study group allocation, analyzed all assessments and documentation, after the study was finished, for completion of the final diagnoses according to the same criteria for all patients.

The Ethics Committee of the Faculty of Medicine at Umeå University approved the study (§ 00-137).

#### Statistical analysis

The sample size was calculated to detect a 50% reduction of number of fallers between the intervention and control groups at a significance level of 0.050, based on our previous multifactorial fall intervention study in institutional care [22]. Student's *t*-test, Pearson's  $\chi^2$  test, and the Mann-Whitney U test were performed to analyze group differences regarding basic characteristics and postoperative complications.

We analyzed outcomes on an intention to treat basis. The incidence of falls between intervention and control groups was compared in three ways. First, an unadjusted comparison using Pearson's  $\chi^2$  and Fisher's exact test regarding number of patients who fell and injuries. Second, the fall

incidence rate was compared between intervention and control groups by calculating the fall incidence rate ratio (IRR) using a negative binomial regression, with adjustment for observation time and for overdispersion. Negative binomial regression (Nbreg) is a generalization of the Poisson regression model and is recommended for evaluating the efficacy of fall prevention programs [37]. Third, a Cox regression was used to compare the time lapse to first fall between groups (hazard rate ratio, HRR). The difference in fall risk between groups was further illustrated by a Kaplan-Meier graph.

Basic characteristics that differed between the intervention and the control groups, corresponding to a  $p$  value  $<0.150$  (depression, antidepressants, and dementia, Table 1), were considered as covariates in the Poisson (Nbreg) and the Cox regression models. However, the inclusion of these variables had only marginal effects on the log-likelihood values of the models as well as on the IRR and HRR values and standard errors for the group allocation variable (intervention or control). In addition, none of the variables showed significant effects on the dependent variable and are therefore not included in the Poisson (Nbreg) and Cox regression analyses.

Pearson's  $\chi^2$  test and Fisher's exact test were also used to analyze the associations between falls and days with delirium between the groups.

All calculations were carried out using SPSS v 11.0 and STATA 9 statistical software for Macintosh. A  $p$  value  $<0.050$  was considered statistically significant.

## Results

During hospitalization 12 patients in the intervention group sustained 18 falls (range: 1–3) and in the control group 26 patients sustained 60 falls (30 falls in the orthopedic unit and 30 in the geriatric control unit) (range: 1–11). Among patients with dementia 1 patient sustained a single fall in

the intervention group and 11 patients sustained 34 falls in the control group (Table 3).

The crude postoperative fall incidence rate was 6.29/1,000 days in the intervention group vs 16.28/1,000 days in the control group. Using a negative binomial regression, the fall incidence was significantly lower in the intervention group, IRR 0.38 (95% CI: 0.20–0.76,  $p=0.006$ ), and among patients with dementia, IRR 0.07 (95% CI: 0.01–0.57,  $p=0.013$ ) (Table 3). In Fig. 2, a Kaplan-Meier survival analysis of time lapse to first fall illustrates the difference between the two groups with a significantly reduced fall rate in the intervention group (log rank  $p$  value 0.008).

The difference in fall risk, expressed as time lapse to first fall, was compared between intervention and control groups in a Cox regression (HRR). Including all patients in the calculation, the fall risk was significantly lower in the intervention group, HRR 0.41 (95% CI: 0.20–0.82,  $p=0.012$ ).

There were in total 3 minor or moderate injuries (MAIS 1–2) in the intervention group compared to 15 in the control group according to the AIS. The serious injuries (MAIS 3) were new fractures of which four, two hip fractures, one rib fracture with pneumothorax, and one with multiple skull fractures, occurred in the control group and none in the intervention group (Fisher's exact test:  $p=0.055$ ).

Three of the patients who fell in the intervention group (25%) and 12 in the control group (46%) fell during a day when they were delirious ( $p=0.294$ ). Analyzing the number of falls revealed that 4 of 18 (22%) falls in the intervention group and 27 of 60 (45%) in the control group occurred on a day when the patient was delirious,  $p=0.083$ .

Apart from the falls there were fewer other postoperative complications in the intervention group, such as fewer patients with postoperative delirium ( $p=0.003$ ) and fewer delirious days ( $p\leq 0.001$ ), urinary tract infections ( $p=0.005$ ), sleeping disturbances ( $p=0.009$ ), nutritional problems ( $p=0.038$ ), and decubitus ulcers ( $p=0.010$ ). The postoperative in-hospital stay was shorter in the intervention group,  $28.0\pm 17.9$  days vs  $38.0\pm 40.6$  days,  $p=0.028$ . Among

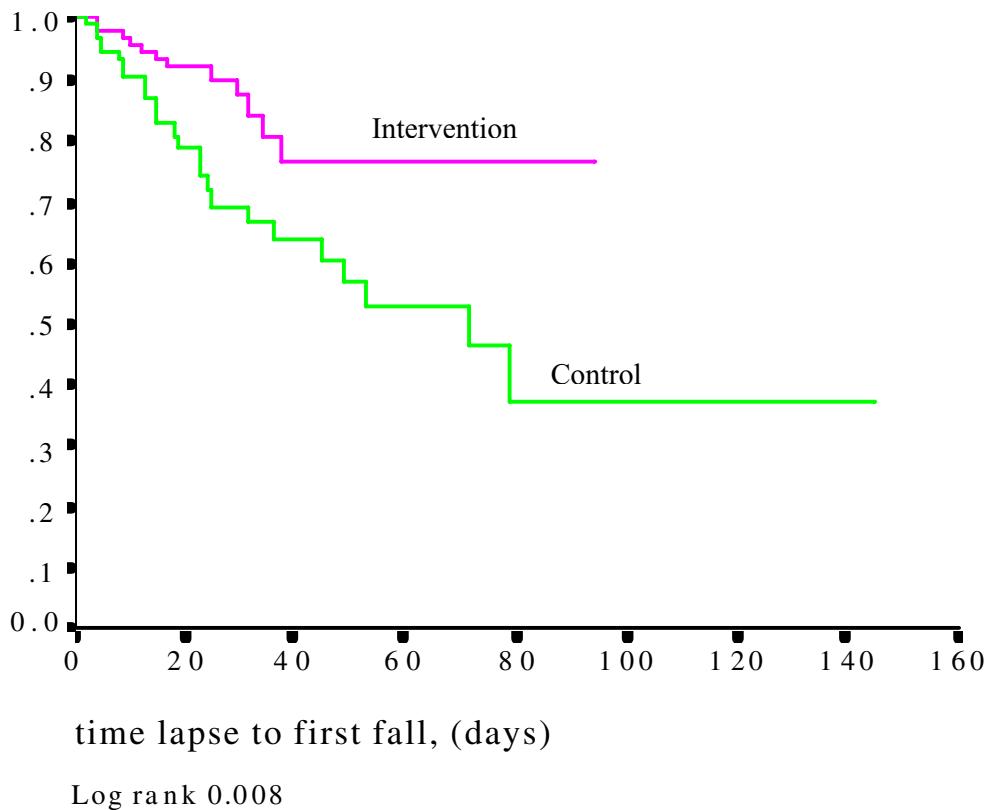
**Table 3** Falls during hospitalization. *CI* confidence interval, *IRR* incidence rate ratio

	Intervention (n=102)	Control (n=97)	<i>p</i> value
Number of falls	18	60	
Postoperative in-hospital days	2,860	3,685	
Crude fall incidence rate (number of falls/1,000 days)	6.29	16.28	
IRR (95% CI)	0.38 (0.20–0.76) <sup>a</sup>	1.00 (Ref.)	0.006
Number of fallers	12	26	0.007
Number of fallers with injuries due to falls	3	15	0.002
Number of fallers with fractures due to falls	0	4	0.055
Number of falls among people with dementia	1	34	
IRR (95% CI) among people with dementia	0.07 (0.01–0.57) <sup>a</sup>	1.00 (Ref.)	0.013
Number of fallers among people with dementia (n=28/36)	1	11	0.006

<sup>a</sup> Negative binomial regression analyses adjusted for overdispersion and controlled for dementia, depression, and use of antidepressants

**Fig. 2** Kaplan-Meier survival graph

## Kaplan-Meier survival graph



those ten with the longest postoperative in-hospital stays in the control group there were eight patients with any fall and two had had new fractures.

### Discussion

The present study shows that the number of falls and time lapse to first fall can be reduced during in-hospital rehabilitation after a femoral neck fracture. A multidisciplinary, multifactorial geriatric care program with systematic assessment and treatment of fall risk factors as well as active prevention, detection, and treatment of other postoperative complications resulted in fewer patients who fell, a lower total number of falls, and fewer injuries.

To our knowledge this is the first fall intervention study in this group of patients, despite the fact that this is a group of patients with a high fall risk. In general there are few fall prevention studies in hospital settings. Two [26, 27] with positive outcomes in other patient groups and on subacute wards have recently been published. The first one [26] reduced falls at three subacute rehabilitation wards, but the differences were most obvious after 45 days of observation. Thus the results were not comparable with those from the present study, which included both the acute and rehabil-

itation hospital stay. The other study [27] resulted in fewer fallers, falls, and injuries on a geriatric ward but the differences disappeared when the results were adjusted for observation time. Those studies used a multidisciplinary approach in their fall intervention similar to that used in the present study, but in the present study we have, in addition, focused on inpatient complications associated with falls such as delirium and urinary tract infections. One of those studies [27] tried to manage the delirious patients using bedrails, alarms, and changing the furniture arrangements for the patients, but no mention was made of any prevention and treatment of the underlying causes of delirium. The use of physical restraints was not included in the intervention program in the present study. The studies above used fall risk assessment tools to recognize those with a high fall risk. In the present study, we used a rehabilitation and care program including assessment of risk factors for falls and global ratings for each patient during team meetings. A critique of fall risk assessment tools is that few have been tested for validity and reliability testing in a new independent sample. When using fall prediction tools in different clinical settings the specificity decreases [38].

A limitation in the present study is that some falls could have been missed, but we presume that there were

very few. For one thing the nurses are obliged to document falls in the records. Also hip fracture surgery patients can hardly get up by themselves after a fall so soon after the surgery and are, therefore, bound to be noticed; but if there were any missing falls there would probably be no difference between the groups. Another limitation is that the fall registration could not be blinded regarding group allocation, but the staffs on each ward were not aware of the comparison with another ward regarding falls and injuries. The study sample is also quite small, but the sample size is calculated according to the results from a previous study [22]. The method of concealment could have been improved, but one strength was that none from the research team performed this procedure and the envelopes were not opened until the intervention was to begin. Other strengths were the intention to treat analyses, the few patients who refused to participate, and that there were no crossover effects due to staff changing wards during the study period.

One may speculate that the successful reduction in number of falls in the present study could be a result of the active prevention, detection, and treatment of postoperative complications after surgery. During the period of hospitalization there were differences between the groups regarding some complications associated with falls among older people in residential care facilities and in hospitals, such as delirium and urinary tract infections. The reduction of postoperative delirium can probably explain much of the difference between the groups regarding the numbers of falls and the number of patients who fell. There are studies that have found that delirium is an important risk factor for falls [10]. Demented patients especially are at high risk of developing delirium when they are treated for femoral neck fractures [15, 16] and these patients seemed to have benefited most in this study from the intervention program regarding prevention of postoperative falls. Our findings support an earlier non-randomized study that fewer injurious falls occur when the incidence and duration of delirium was reduced [39].

The investigation into why the patients had fractured their hip and why they fell may also have influenced the result, as well as the investigation and rehabilitation concerning external fall risk factors such as the use of walking aids, safe transfers, balance, and mobility. It seems that teamwork and individual care planning alone do not have the same effect on falls, as half the falls in the control group occurred in the geriatric control ward, a ward specializing in geriatric patients where teamwork, as well as individual care planning, is applied.

In the community and residential care facilities, interdisciplinary and multifactorial fall prevention studies have shown positive effects on the reduction in the number of falls and injuries [19, 22]. Among those with cognitive

decline or dementia there is no evidence that such strategies prevent falls [40, 41], but the present study allowed the conclusion that at least during the in-hospital stay, this group of patients could benefit from such strategies. The reduced number of falls and injuries also probably contributed to the shorter hospitalization seen in the intervention group. The program seems easy applicable both in the acute postoperative care as well in the post-acute rehabilitation settings and except for the staff education there were no increased costs.

## Conclusion

A team applying comprehensive geriatric assessment and rehabilitation, including prevention, detection, and treatment of fall risk factors, can successfully prevent inpatient falls and injuries, even in patients with dementia.

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## Conflict of Interest

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Author contributions:

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Birgitta Olofsson, acquisition of subjects and data, analysis and interpretation of data, and preparing of the manuscript.

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