ORIGINAL ARTICLE

Risk factors for serious fall related injury in elderly women living at home

A Bergland, T B Wyller

Injury Prevention 2004;10:308–313. doi: 10.1136/ip.2003.004721

See end of article for
authors' affiliations

Correspondence to:
Professor A Bergland,
Faculty of Health Sciences,
Oslo University College,
Oslo, Norway; Astrid.
Bergland@hf.hio.no

Objectives: To study whether balance, function, and other health status indicators can predict serious fall related injury in elderly women living at home.

Methods: In this prospective study, the authors took a random sample of 307 women aged 75 years and over (mean 80.8 years, response rate 74.5%), living in the community. Serious fall injuries which occurred over a period of during one year were recorded, together with baseline registrations of health, function, and tests of walking and balance.

Results: In all, 155 women (50.5%) fell one or more times. One hundred and fifty six (51%) of the 308 falls resulted in a fall related injury, 74 (24%) in a serious fall related injury, and 40 falls (13%) resulted in fractures. The presence of rheumatic disorders, inability to rise from the floor, arthrosis of the hip, having had more than one fall during the one year follow up period, and an increased tendency to sway in the frontal plane when doing a calculation task were independent and significant predictors for serious fall related injury (fractures included). The independent predictors of fall induced fractures were experiencing more than one fall in the follow up period, cognitive impairment, and receiving care from professional or other.

Conclusion: The study suggests that rheumatic disorders and the inability to get up from lying on the floor were the strongest independent risk factors for serious fall related injury. Experiencing more than one fall in the follow up period and cognitive impairment are the strongest independent predictors for fall induced fractures. Age was not a significant predictor of serious fall related injury. Assessment of these markers is feasible in a clinical setting and is a useful way of identifying those who are at risk of serious fall related injuries.

Falls are common in old age and frequently result in fall related injury^{1–4} and delayed recovery.³ This represents a huge burden on the individual and the community.⁴ Injuries are the sixth leading cause of death in adults of 65 years of age or more and falls are the leading cause of such injuries.⁵ Although many studies have identified risk factors for falls among the elderly in the general population,^{6–7} few have focused on risk factors for fall related injury.

Depending on the population under study, between 20% and 60% of the elderly suffer injuries from falls in any one year.⁸ Among elderly people living at home, almost half of the falls lead to a fall related injury.^{9–10} About one tenth lead to a major soft tissue injury, and about one in 20 to a fall induced fracture,^{10–12} but the estimates vary widely.^{10–15} Falling is a condition that meets all the criteria for prevention: high frequency, evidence of preventability, and a high rate of morbidity.¹ Despite this, there is little information from prospective studies regarding the possible reasons why some falls result in injuries and others do not. Vellas *et al*¹⁶ and Davis *et al*¹³ suggested that risk factors for falls resulting in injuries may differ substantially from those for falls that do not. However, Grisso *et al*¹⁴ state that predictors of fall related injuries, including fall induced fractures are, to a large extent, the same as those of falls without injury.

In a previous study, we found that approximately 50% of the elderly living at home fall during the period of a year. Risk factors for falling were previous falls, osteoporosis, feeling depressed, impaired vision, a slow comfortable walking speed, not managing steps higher than 30 cm, and hypertension.² The aim of this work was to study the impact of balance, function, and other health status indicators (including medication and illnesses) upon the risk of serious fall related injury or fall induced fracture in elderly women

living at home. To our knowledge, no earlier studies have addressed both fall related serious injury and fall induced fracture as the main outcome of the study. Moreover, no study has addressed so many potentially relevant intrinsic predictors for serious fall related injuries and fall induced fractures.

SUBJECTS AND METHODS

A random sample of 650 women aged 75 years and above was drawn from the census files of one of the 25 local authorities in Oslo. We decided in advance that subjects should be referred to the hospital's geriatric outpatient clinic if health problems were discovered that they could not reasonably handle on their own, and for practical reasons the local authority area surrounding our hospital was chosen.

By the time of the survey, 130 individuals of those sampled were dead, had moved, or were living in an institution, and 133 refused to participate, giving a response rate of 74.5%. Those who had to be excluded were 36 women unable to reach the research office alone (by taxi if necessary), eight unable to stand for at least 60 seconds, and 15 with major cognitive impairment (score ≤ 8 on a short version of the Mini-Mental State Examination (MMSE)).¹⁷ Six (2%) died or moved to an institution during the follow up year, and data from 15 subjects could not be further analysed because of technical problems with recordings of the data, leaving data from 307 subjects available for analysis. The mean age of the participants was 80.8 years (range 75–93 years). Attendance for testing was not related to age. The study was approved by

Abbreviations: ADL, activities of daily living; CI, confidence interval; MMSE, Mini-Mental State Examination; OR, odds ratio

the Regional Committee for Ethics in Medical Research, but the committee did not allow us to contact non-attendants.

Power calculation

Suppose that the true rate of serious fall related injury in the population studied is 15% among subjects with one legged stance less than median, and 30% among those with one legged stance above median. It may then be shown that a sample size of 300 implies a probability of 88% to detect a statistically significant difference in serious fall related injury prevalence between these two groups.

Tests

Clinical tests of balance and walking were carried out in the research laboratory. The research leader instructed the subjects and demonstrated how the tests should be performed. The subjects were allowed to practise each test once, and only one try was allowed. This limitation was set up in order not to tire the participants and also to make the test situation clinically relevant. All the participants managed sufficiently well after one trial. The tests were always performed in the same order.

Standing on one leg, eyes open

The subject was asked to stand on the preferred foot, to flex the opposite knee to allow the foot to rise from the floor, and to stand as long as possible with the arms hanging down.^{16 18} The foot being used was not allowed to move from the base position, but compensatory movements of the arms and of the lifted leg were allowed. The time (in seconds) before the subject touched the floor with the other foot was recorded. The validity and reliability of this test have been demonstrated.^{16 18 19}

Tandem stance, eyes open

The heel of one foot was placed in front of and touching the toes of the other, the arms hanging down. The subject was not allowed to move the feet from the base position, but compensatory movements of the arms were allowed. Whether the subject could maintain this position for at least 30 seconds was recorded. This test is also found to be reliable and valid.^{19 20}

Ability to climb stairs

This was a test of ability to mount boxes of increasing heights (10, 20, 30, 40, 50, 60, and 70 cm) without using a handrail.¹⁸ The test has been evaluated for validity, though not for reliability.^{18 20} The height of the highest box mounted was recorded. The results were dichotomised at the median; 30 cm or less versus 40 cm or higher.

Getting up from lying on the floor

This was scored according to whether the subject managed without assistance or not and is a validated measurement.²⁰

Functional reach

Functional reach is the maximum distance (cm) one can reach forward in the standing position while maintaining a fixed base of support. This measure is reliable, valid, and sensitive to change.^{18–21}

Timed up and go

The subject was instructed to rise from a chair, walk 3 m as fast as possible, turn around, return, and sit down again, wearing regular footwear and using customary walking aids if necessary. No assistance was given.²² The outcome was the time from when the subject's back left the back of the chair until the buttock touched the seat again. The test is a reliable, sensitive, and specific indicator of increased risk of falling.^{23 24}

Maximum and comfortable walking speed

The subject was asked to walk at a comfortable speed for 29 m along a corridor, and then to walk the same distance as fast as possible.¹⁸ The test has been evaluated for validity and reliability.^{20 25}

Force plate tests

A calibrated Kistler (Switzerland) force plate (40 × 60 cm) was used to measure displacement of centre of pressure with gain set at 1000. The vertical forces were recorded on a computer and expressed as position and movements in the sagittal and frontal planes. The force plate signals were sampled for one second, for a total of 15 times, with a sampling frequency of 1000 Hz. Software from PEAK (Englewood, CO, USA) was used to calculate the position and the movement of the centre of pressure, called "sway". Before testing, the test position was demonstrated for the subjects who stood barefoot on the force plate with their feet in a fixed position (heels together, each foot toeing out at a 30° angle from the sagittal plane).

For further analyses, the force plate test data were exported to a computer program (M Guttormsen, Norwegian University of Sports and Physical Education, University of Oslo) and filtered with a second order Butterworth filter at 20 Hz, and the length (mm) of the sway path in the anterior-posterior and the mediolateral directions were then calculated. Analyses of variance showed that the variance over time was small compared with the between-subject variance, and we therefore decided to use the accumulated data from the full 15 second registration period for further analyses.

The subjects had to stand as still and as symmetrically as possible, with their hands clasped behind their backs. Spontaneous sway was measured under four different conditions with at least one minute's rest in between: (1) with eyes open and looking at a target 4 m straight ahead; (2) blindfolded in the same position; (3) as in (1) while checking whether simple calculations presented by the research leader were correct or not; (4) with a version of Stroop's test, where 25 coloured words representing the names of colours are shown on a white screen, but where the name of the colour does not correspond to the colour in which the word is written, and where the subject is asked to name the colour.²⁶ Best subset regression showed that the test situation where subjects performed calculations gave the best prediction of falling, and the data from this test situation were therefore used in the further analyses.

Indicators of health status and function

Activities of daily living (ADL) were scored according to whether or not the subject needed assistance with indoor mobility, outdoor mobility, grooming, dressing, eating, shopping, preparing meals, heavy housework, light housework, and medication. The participants were asked to bring all current medications for verification. The drugs were coded according to the ATC coding system,²⁷ and the number of drugs taken on a regular basis was used as a global indicator of use of medication. Factor analyses of the ADL data gave two factors with Eigenvalues over 1.0, named "personal ADL" (PADL) and "instrumental ADL" (IADL), respectively. The factor PADL contained the items grooming, dressing, toileting, and eating, and the factor IADL contained the items shopping, preparing one's own meal, doing heavy housework, and doing light housework. Disability in PADL and IADL was defined as a dependency on at least one item within the respective factor.² Cognitive disability was defined as less than a full score on the MMSE short version.¹⁷ Body mass index (weight (kg)/(height (m))²)²⁸ was also calculated.

The participants were asked if they had ever had any of the following diseases: stroke, Parkinson's disease, heart disease,

Table 1 Bivariate relations between baseline characteristics and one year occurrence of serious fall injury (fractures included) and fractures*

	Percentage with poor score	Injurious falls		Fracture	
		OR	95% CI	OR	95% CI
Inability to get up from lying on the floor	21.8	3.7	1.6 to 8.5	2.1	1.4 to 4.2
Rheumatic disorders†	9.8	3.6	1.3 to 10.3	2.4	1.0 to 6.1
Centre of pressure travel path in the frontal plane (cutpoint between 1st and 2nd quartile) when doing a calculation task		2.6	1.2 to 5.5	2.0	0.9 to 4.0
Arthrosis of the hip†	30.9	2.6	1.3 to 5.3	1.2	0.6 to 2.4
Inability to climb steps higher than 30 cm (cutpoint = median)		2.6	1.2 to 5.4	2.9	1.4 to 6.1
Suffering from more than three diseases (cutpoint = median)†		2.5	1.3 to 5.0	2.9	1.4 to 6.1
Use of antihypertensive drugs†	13	2.4	1.1 to 6.5	2.0	0.8 to 4.7
One legged stance (cutpoint = median)		2.4	1.1 to 5.2	2.4	0.9 to 6.3
Needs care from health professional or somebody else†	43.3	2.3	1.2 to 4.5	2.2	1.2 to 5.1
Osteoporosis†	22.1	1.9	0.9 to 3.8	2.7	1.3 to 5.5
Cognitive impairment	56.1	2.1	1.0 to 4.0	2.5	1.2 to 5.0
Impaired vision†	23.0	1.8	0.9 to 3.6	2.1	1.2 to 4.8
Maximum walking speed (cutpoint = median)		2.0	1.0 to 3.8	0.8	0.3 to 2.3
Disability in instrumental activity of daily living†	46.4	2.0	1.0 to 3.9	1.9	0.9 to 3.8

OR, odds ratio; CI, confidence interval.

*Dependent variable serious injury (fracture included): one serious fall injury or more = 0, no serious injury = 1 or dependent variable fracture: one fracture or more = 0, no fracture = 1.

†Self reported measure.

Logistic regression analyses (n = 307).

any eye disorder, high blood pressure, low blood pressure, chest disease, diabetes, rheumatic disorders, osteoporosis, arthritis/arthrosis of the lower limbs, insomnia, depression, anxiety, or other diseases. They were also asked if they had had a lower limb amputated. The participants provided information about if they needed care from health professionals or somebody else, and whether they lived alone or not.

Registration of falls and serious fall related injury

In this study a fall was defined as "an event which results in a person coming to rest inadvertently on the ground or other lower level, and other than as a consequence of the following: sustaining a violent blow, loss of consciousness, sudden onset of paralysis (as a stroke), an epileptic seizure".⁸ Falls were registered by means of a "fall calendar"²⁹ issued to each participant for a full year. Every third month, the calendar was returned to the project leader. The subjects were asked to fill it in daily and to mark the date and place of falling (indoors or outdoors) if a fall had occurred. Subjects who did not return the calendar were contacted. The participants were also encouraged to phone the study office when a fall had occurred. Fractures, dislocations, head injuries resulting in loss of consciousness, and other injuries resulting in medical care were defined as serious fall related injuries.²⁹⁻³⁰ Multiple fractures resulting from the same event were treated as a single case. All the calendars were returned; though six women had to be contacted. All the fall induced fractures were confirmed by the hospitals the women had been referred to.

Statistics

Statistical analyses were carried out using the BMDP statistical package.³¹ Logistic regression analyses were applied in order to test associations between falls resulting in serious fall related injury and the baseline characteristics. The dependent variable, serious fall related injury or fracture, was coded 0 = experiencing one serious fall related injury or more and 1 = experiencing no fall related injury or 0 = experiencing one fracture or more and 1 = experiencing no fracture, respectively. Explanatory variables showing statistically significant associations with the outcome in

bivariate analyses were finally included in a multivariate logistic regression model in order to identify independent risk factors for injurious falls. A value of $p < 0.05$ on the χ^2 goodness of fit test was used as an indicator of a poor fit of the model to the data.

RESULTS

Eighty seven women experienced only one fall, and 68 women had two or more falls (range 2–11). More than half of the falls occurred outdoors (57.5%, 95% confidence interval (CI) 51.9 to 63.0). The number of indoor falls ranged between one and six, and for outdoors between one and eight. Most of the indoor falls occurred at home except for two falls in a theatre and one at a holiday home. In all, 308 falls were reported, of which 156 (50.6%, 95% CI 45.1 to 56.2) resulted in a fall related injury. In 74 cases (24.0%) the injury was categorised as serious. Forty falls (13.0%) resulted in fractures; 15 of the upper and 13 of the lower extremities, and 12 of ribs. An additional 34 falls (11.0%) resulted in injuries that required medical treatment. There was no significant relation between place of falling (indoor or outdoor) and whether the fall caused a serious injury or a fracture.

Explanatory variables for serious fall related injury and fractures, reaching statistical significance in bivariate analyses, are shown in table 1. The occurrence of falls resulting in injury was not related to age (grouped 75–79, 80+, odds ratio (OR) 1.9, 95% CI 0.9 to 3.9) or whether the person lived alone (OR 1.4, 95% CI 0.6 to 3.1). The corresponding odds ratios for fractures were 1.5 (95% CI 0.67 to 3.3) for age and 0.85 (95% CI 0.4 to 2.0) for living alone.

The risk for serious fall related injury and fracture was significantly associated with number of falls during the follow up period, OR = 2.2 (95% CI 1.2 to 4.3) for injury and OR = 13.6 (95% CI 1.2 to 30.7) for fracture. But the experience of one or more falls during the six months before the study was a significant risk factor neither for serious fall related injury nor for fracture. Regarding the balance platform measurements, the travel distance of the centre of pressure was dichotomised between the first and the second quartile. A value in the second quartile or higher was associated with a threefold increase in the probability of a

serious fall related injury during the follow up period. Four of the clinical tests were significant predictors of a serious fall related injury, namely: inability to rise from the floor, to climb steps and to stand on one leg, and the maximum walking speed. The strongest predictor was inability to rise from the floor. Women suffering from rheumatic disorders demonstrated an almost fourfold greater risk of serious fall related injury, and those suffering from arthrosis of the hip had a threefold greater risk (table 1).

The use of antihypertensive drugs was significantly related to serious fall related injury, but not the use of any other classes of drugs. A significant relation was observed between a submaximal score on the MMSE and a serious fall related injury. Needing care or suffering from a disability on primary or instrumental activities of daily living also predicted future falls resulting in injury (table 1).

The final models of the multivariate analyses regarding serious fall related injury are shown in table 2. The presence of rheumatic disorders or arthrosis of the hip, inability to rise from the floor, and a long centre of pressure travel path when standing still were significant and independent predictors of serious fall injuries. Having more than one fall during the follow up period, needing care, and cognitive impairment were all significant predictors of fracture (table 3).

DISCUSSION

This study confirms that falls may have serious consequences even for relative healthy and mobile elderly Norwegian women aged 75 years or older. The primary purpose of the work was to explore the relation between health, function, and balance on the one hand, and a serious fall related injury (including fractures) on the other. Our observation that 24% of falls resulted in serious fall related injury fits in with the Cochrane report by Gillespie *et al*,¹ which found that 10%–20% of older people who fall present themselves for medical attention. We found a high frequency of falls resulting in a fracture, mostly hip fracture. This fits in well with the finding that Oslo had the highest incidence of hip fracture ever reported.³² Earlier studies (some of these including only women; others both men and women) have shown that fractures occur in 4%–16% of falls,^{1 10 33–37} which fits well with our 13%.

Most fractures in the elderly, if not almost all, are caused by falls.^{38 39} Controlling for the other variables shown in table 1, the women who fell more than once had an almost 14-fold increased fracture risk (table 3) and a two and a half times greater risk of serious fall injury (table 2) compared with those with one fall or less. Roy *et al* suggest that variation in fall rates could explain a significant variation in the incidence of limb fractures across Europe.⁴⁰ In his study, falls were recorded retrospectively and fractures prospec-

Table 2 Independent risk factors for serious fall injury: multivariate logistic regression analyses, final model (n=307) (dependent variable: one serious fall injury or more=0, no serious fall injury=1)

	OR	95% CI
Rheumatic disorders*	3.8	1.2 to 11.7
Inability to get up from lying on the floor	3.0	1.3 to 7.2
Centre of pressure travel path in the frontal plane (cutpoint between 1st and 2nd quartile) when doing a calculation task	2.4	1.1 to 5.3
Arthrosis of the hip*	2.4	1.1 to 6.5
More than one fall during the follow up period*	2.4	1.2 to 5.0

In none of these analyses did the χ^2 goodness of fit test indicate a poor model fit.

OR, odds ratio; CI, confidence interval.

*Self reported measure.

Table 3 Independent risk factors for fracture: multivariate logistic regression analyses, final model (n=307) (dependent variable: one fracture or more=0, no fracture=1)

	OR	95% CI
More than one fall during the follow up period*	13.8	1.2 to 30.7
Cognitive impairment	2.4	1.1 to 5.4
Needs care from health professional or somebody else*	2.2	1.0 to 4.9

In none of these analyses did the χ^2 goodness of fit test indicate a poor model fit.

OR, odds ratio; CI, confidence interval.

*Self reported measure.

tively. In our study, falls that had occurred before inclusion did not predict fall related serious injury or fracture.

One reason for the high frequency of fall and fall related injury in our study may be the careful recording of falls, where the participants were encouraged to phone the research leader whenever a fall had occurred. This may to some extent have counteracted the effect of forgetting the incidence of falls, a phenomenon believed to have a definite impact on this kind of research.^{1 41}

“Inability to rise from the floor”, “rheumatic disorders”, “centre of pressure travel path in the frontal plane”, “arthrosis of the hip”, and “inability to climb steps higher than 30 cm” were the variables that increased the risk of serious fall injury (table 1) with a factor of 2.5 or more. This corresponds well with the findings of others.^{29 33 42 40 43–45} Schwartz *et al* found that a history of arthritis or rheumatism was associated with a higher risk of falling,⁴⁵ but an association with serious fall injury has, to our knowledge, not been reported. Corticosteroid therapy is widely used in the treatment of rheumatic disorders⁴⁶ and corticosteroid induced osteoporosis could explain the association between rheumatic disorders and falls resulting in injury.⁴⁷ Considering the wide confidence intervals in tables 2 and 3, the estimates should be interpreted cautiously.

Performance based measurements of physical capacity, particularly measurements of balance and gait impairments, are strong predictors of the risk of falling among elderly people.^{2 9 11} Our results and those of Cummings *et al*⁴⁸ show that such measurements are also important for prediction of the most damaging falls—that is, those that lead to hip fractures and other serious injuries. Inability to rise from the floor appears to be a promising predictive marker for falls resulting in injury. In our population, this clinical marker could identify those who had a greater risk of serious fall related injury and who were possibly more likely to benefit from intervention. Inability to rise from the floor may serve as a simple proxy measure for some of the balance, function, and health variables used in this study, and also as a marker of frailty.⁴⁹ Cognitive impairment, the presence of at least two chronic conditions, and impaired balance and gait are associated with serious fall injury.²⁹ This fits in with our results both regarding serious fall injury, including fracture, and when looking at predictors of fracture separately.²⁹ In the present study, approximately 15% had to be excluded owing to poor general function and major cognitive impairment, and presumably these subjects had a higher risk of fall related injury.⁵⁰ There was also some attrition to the study in the sense that 2% died or moved to an institution. This may have been related to injuries resulting from falls. Thus, our incidence estimates may be too low.

The significance of the centre of pressure travel path is supported by a case-control study identifying the degree of displacement of the body at waist level as a risk factor for

Key points

- 50.5% of the women fell one or more times.
- 24% of the falls resulted in fall related injuries.
- 13% of the falls resulted in fall induced fractures.
- Rheumatic disorders, inability to rise from the floor, arthrosis of the hip, having had more than one fall during the one year follow up period (fractures included).
- Increased tendency to sway in the frontal plane when doing a calculation task were independent and significant predictors for serious fall related injury (fractures included).

injurious falls.⁴⁶ The association between abnormal balance registered by the travel path in the frontal plane and fall injuries may be explained by an increased tendency of people with balance problems to fall to the side, and falls to the side are more likely to result in fall related injury than falls in other directions.⁵¹ There is accumulating evidence that the effects of aging on balance is more attenuated in the medial-lateral direction. Lord *et al.*⁵² Maki *et al.*⁵³ and Bergland *et al.*² found that the amplitude of movement of the centre of pressure in the medial-lateral direction is an independent and significant predictor of falls.

Physiotherapists often treat people with impaired balance in order to improve overall function and prevent further falls and fall related injury, and they use simple clinical tests to evaluate and predict function. Typical examples of performance based tests used in clinical practice are the one legged stance,¹⁶ stair climbing,¹⁸ functional reach,²¹ the timed up and go,²² and the ability to get up from lying on the floor.⁴⁹ The force plate balance test is, however, not often used.⁵⁴ According to our results, tests of the ability to get up from lying on the floor, stair climbing, the one legged stance, and walking speed could be useful in a clinical setting.

A limitation of this study is the use of self reports for some of the clinical variables. Registrations based upon self reported functioning and actual performances are assumed to complement each other.⁵⁵ In self reports, recall bias can be a problem when respondents have been asked to remember past events, especially if they are of a sensitive nature or have had severe consequences for the individual. However, self reported measures are generally considered reliable and valid,⁵⁶ in the elderly as well as the general population.⁵⁷

During the tests, the surroundings were fixed and the motor activities were carried out at the person's preferred speed. The walking tests were performed in an empty corridor. If the corridor had been crowded, the information processing demand would have increased markedly. Unless a test can incorporate open and challenging environments, clinicians should be aware that the balance assessments currently in use have definite limitations for predicting falls.⁵⁴ A clinical balance test where attention demanding or situational factors⁵⁸ are also included might, at least theoretically, give a better prediction of fall related serious injury or fall induced fracture.

Authors' affiliations

A Bergland, Faculty of Health Sciences, Oslo University College, Oslo, Norway
T B Wyller, University of Oslo, Department of Geriatric Medicine, Ullevaal University Hospital, Oslo, Norway

REFERENCES

- 1 Gillespie LD, Gillespie WJ, Robertson MC, *et al.* Interventions for preventing falls in elderly people. (Cochrane Review). In: The Cochrane Library Issue 1, 2003, Oxford: Update Software.
- 2 Bergland A, Jarnlo G-B, Laake K. Predictors of falls in the elderly by location. *Aging Clin Exp Res* 2003;**15**:43–50.
- 3 Horan MA, Clague JE. Injury in the aging: recovery and rehabilitation. *Br Med Bull* 1999;**55**:895–909.
- 4 Scaf-Klomp W, Sanderman R, Ormel J, *et al.* Depression in older people after fall-related injuries: a prospective study. *Age Ageing* 2003;**32**:88–94.
- 5 Sattin RW. Falls among older persons: a public health perspective. *Ann Rev Public Health* 1992;**13**:489–508.
- 6 Luukinen H, Koski K, Kivela SL, *et al.* Social status, life changes, housing conditions, health, functional abilities and life-style as risk factors for recurrent falls among the home-dwelling elderly. *Public Health* 1996;**110**:115–18.
- 7 Tinetti ME, Williams CS. Falls, injuries due to falls, and the risk of admission to a nursing home. *N Engl J Med* 1997;**337**:1279–84.
- 8 Lord SR, Sherrington C, Menz HB. *Falls in older people. Risk factors and strategies for prevention.* Cambridge: University Press, 2001.
- 9 Nevitt MC, Cummings SR, Kidd S, *et al.* Risk factors for recurrent nonsyncopal falls. A prospective study. *JAMA* 1989;**261**:2663–8.
- 10 O'Loughlin JL, Robitaille Y, Boivin JF, *et al.* Incidence of and risk factors for falls and injurious falls among the community-dwelling elderly. *Am J Epidemiol* 1993;**137**:342–54.
- 11 Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. *N Engl J Med* 1988;**319**:1701–7.
- 12 Luukinen H, Koski K, Laippala P, *et al.* Predictors for recurrent falls among the home-dwelling elderly. *Scand J Prim Health Care* 1995;**13**:294–9.
- 13 Davis JW, Ross PD, Nevitt MC, *et al.* Risk factors for falls and for serious injuries on falling among older Japanese women in Hawaii. *J Am Geriatr Soc* 1999;**47**:792–8.
- 14 Grisso JA, Kelsey JL, Strom BL, *et al.* Risk factors for falls as a cause of hip fracture in women. *N Engl J Med* 1991;**324**:1326–31.
- 15 Robertson MC, Campbell AJ, Gardner MM, *et al.* Preventing injuries in older people by preventing falls: a meta-analysis of individual-level data. *J Am Geriatr Soc* 2002;**50**:905–11.
- 16 Vellas BJ, Wayne SJ, Garry PJ, *et al.* A two-year longitudinal study of falls in 482 community-dwelling elderly adults. *J Gerontol A Biol Sci Med Sci* 1998;**53A**:M264–74.
- 17 Braekhus A, Laake K, Engedal K. The Mini-Mental State Examination: identifying the most efficient variables for detecting cognitive impairment in the elderly. *J Am Geriatr Soc* 1992;**40**:1139–45.
- 18 Frändin K, Sonn U, Svantesson U, *et al.* Functional balance tests in 76-year-olds in relation to performance, activities of daily living and platform tests. *Scand J Rehabil Med* 1995;**27**:231–41.
- 19 Franchignoni F, Tesio L, Martino MT, *et al.* Reliability of four simple, quantitative tests of balance and mobility in healthy elderly females. *Aging (Milano)* 1998;**10**:26–31.
- 20 Bergland A. Validity of an index of self-reported walking for balance and falls in elderly women. *Adv Physiother* 2002;**4**:65–73.
- 21 Duncan PW, Weiner DK, Chandler J, *et al.* Functional reach: a new clinical measure of balance. *J Gerontol* 1990;**45**:M192–7.
- 22 Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc* 1991;**39**:142–8.
- 23 Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the timed Up & Go test. *Phys Ther* 2000;**80**:896–903.
- 24 Lohman Lohman H, Givens D. Balance and falls with elders: application of clinical reasoning. *Phys Occup Ther Geriatr* 1999;**16**:17–32.
- 25 Buchner DM, Cress ME, Esselman PC, *et al.* Factors associated with changes in gait speed in older adults. *J Gerontol A Biol Sci Med Sci* 1996;**51**:M297–M302.
- 26 Mulder T, Nienhuis B, Pauwels J. The assessment of motor recovery: a new look at an old problem. *J Electromyogr Kinesiol* 1996;**6**:137–45.
- 27 WHO Collaborating Centre for Drug Statistics. *Methodology* 2000. Norway, 2000: ATC-index with DDs, Oslo, Norway.
- 28 Galanos AN, Pieper CF, Cornoni-Huntley JC, *et al.* Nutrition and function: is there a relationship between body mass index and the functional capabilities of community-dwelling elderly? *J Am Geriatr Soc* 1994;**42**:368–73.
- 29 Tinetti ME, Doucette J, Claus E, *et al.* Risk factors for serious injury during falls by older persons in the community. *J Am Geriatr Soc* 1995;**43**:1214–21.
- 30 Buchner DM, Hornbrook MC, Kutner NG, *et al.* Development of the common data base for the FICSIT trials. *J Am Geriatr Soc* 1993;**41**:297–308.
- 31 Dixon WJ. *BMDP statistical software.* Berkeley: University of California Press, 1992.
- 32 Kaastad TS, Meyer HE, Falch JA. Incidence of hip fracture in Oslo, Norway: differences within the city. *Bone* 1998;**22**:175–8.
- 33 Koski K, Luukinen H, Laippala P, *et al.* Risk factors for major injurious falls among the home-dwelling elderly by functional abilities: a prospective population-based study. *Gerontology* 1998;**44**:232–8.
- 34 Campbell AJ, Borrie MJ, Spears GF, *et al.* Circumstances and consequences of falls experienced by a community population 70 years and over during a prospective study. *Age Ageing* 1990;**19**:136–41.
- 35 Graafmans WC, Ooms ME, Bezemer PD, *et al.* Different risk profiles for hip fractures and distal forearm fractures: a prospective study. *Osteoporos Int* 1996;**6**:427–31.
- 36 Hill K, Schwarz J, Flicker L, *et al.* Falls among healthy, community-dwelling, older women: a prospective study of frequency, circumstances, consequences and prediction accuracy. *Aust N Z J Public Health* 1999;**23**:41–8.

- 37 **Nurmi I**, Luthje P. Incidence and costs of falls and fall injuries among elderly in institutional care. *Scand J Prim Health Care* 2002;**20**:118–22.
- 38 **Ytterstad B**. The Harstad injury prevention study: the characteristics and distribution of fractures amongst elders—an eight year study. *Int J Circumpolar Health* 1999;**58**:84–95.
- 39 **Boonen Boonen S**, Dequeker J, Pelemans W. Risk factors for falls as a cause of hip fracture in the elderly. *Acta Clin Belg* 1993;**48**:190–4.
- 40 **Roy DK**, Pye SR, Lunt M, *et al*. Falls explain between-center differences in the incidence of limb fracture across Europe. *Bone* 2002;**31**:712–17.
- 41 **Peel N**. Validating recall of falls by older people. *Accid Anal Prev* 2000;**32**:371–2.
- 42 **Lord SR**, McLean D, Stathers G. Physiological factors associated with injurious falls in older people living in the community. *Gerontology* 1992;**38**:338–46.
- 43 **Dargent-Molina P**, Favier F, Grandjean H, *et al*. Fall-related factors and risk of hip fracture: the EPIDOS prospective study. *Lancet* 1996;**348**:145–9.
- 44 **Mahoney JE**, Palta M, Johnson J, *et al*. Temporal association between hospitalization and rate of falls after discharge. *Arch Intern Med* 2000;**160**:2788–95.
- 45 **Schwartz AV**, Villa ML, Prill M, *et al*. Falls in older Mexican-American women. *J Am Geriatr Soc* 1999;**47**:1371–8.
- 46 **Yeap SS**, Hosking DJ. Management of corticosteroid-induced osteoporosis. *Rheumatology* 2002;**41**:1088–94.
- 47 **Sambrook P**, Birmingham J, Kelly P, *et al*. Prevention of corticosteroid osteoporosis: A comparison of calcium, calcitriol, and calcitonin. *N Engl J Med* 1993;**328**:1747–52.
- 48 **Cummings SR**, Nevitt MC, Browner WS, *et al*. Risk factors for hip fracture in white women. *N Engl J Med* 1995;**332**:767–73.
- 49 **Alexander NB**, Ulbrich J, Raheja A, *et al*. Rising from the floor in older adults. *Am Geriatr Soc* 1997;**45**:564–9.
- 50 **Stevens JA**, Poweell KE, Smith SM, *et al*. Physical activity, functional limitations, and the risk of fall-related fracture in community-dwelling elderly. *Ann Epidemiol* 1997;**7**:54–61.
- 51 **Nevitt MC**, Cummings SR. Type of fall and risk of hip and wrist fractures: the study of osteoporotic fractures. The Study of Osteoporotic Fractures Research Group. *J Am Geriatr Soc* 1993;**41**:1226–34.
- 52 **Lord SR**, Ward JA, Williams P, *et al*. An epidemiological study of falls in older community-dwelling women: the Randwick falls and fractures study. *Aust J Public Health* 1993;**17**:240–5.
- 53 **Maki BE**, Holliday PJ, Topper AK. A prospective study of postural balance and risk of falling in an ambulatory and independent elderly population. *J Gerontol* 1994;**49**:M72–84.
- 54 **Hudges MA**, Duncan PW, Rose DK, *et al*. The relationship of postural sway to sensorimotor function, functional performance, and disability in the elderly. *Arch Phys Med Rehabil* 1996;**77**:567–72.
- 55 **Guo X**, Matousek M, Sonn U, *et al*. Self-reported and performance-based mobility related to instrumental activities of daily living in women aged 62 years and older: a population study. *Aging (Milano)* 2000;**12**:295–300.
- 56 **Portney L**, Watkins M. *Foundations of clinical research: applications to practice*. Connecticut: Appleton and Lange, 1999.
- 57 **Simonsick EM**, Kasper JD, Guralnik JM, *et al*. Severity of upper and lower extremity functional limitation: scale development and validation with self-report and performance-based measures of physical function. WHAS Research Group. Women's Health and Aging Study. *J Gerontol B Psychol Sci Soc Sci* 2001;**56**:S10–19.
- 58 **Huxham FE**, Goldie PA, Patla AE. Theoretical considerations in balance assessment. *Aust J Physiother* 2001;**47**:89–100.

Call for papers

10th European Forum on Quality Improvement in Health Care
13–15 April 2005, ExCel, Docklands, London
For further information on how to submit your paper please go to:
<http://www.quality.bmjpg.com>