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ORIGINAL ARTICLE

Falls risk among a very old home-dwelling population

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Abstract
Objective. The aim of this prospective study was to examine risk factors of falling in a very old home-dwelling population. *Design.* A prospective study of home-dwelling elderly people. *Methods.* Baseline data were collected by home-nursing staff through postal questionnaires and clinical tests. Data on falls were recorded in telephone interviews every other month during a follow-up of 11 months constituting 494 person years (PY). Negative binomial modeling was used to assess fall risk. *Setting.* General community. *Subjects.* A population sample of home-dwelling subjects aged 85 years or older (n = 555). *Main outcome measures.* Fall rate and risk factors of falls. *Results.* Altogether 512 falls occurred in 273 (49%) subjects, incidence rate 1.03/PY. According to a multivariate model, history of recurrent falling, trouble with vision when moving, use of antipsychotic drug, and feelings of anxiety, nervousness, or fear were independent risk factors for subsequent falls. *Conclusion.* Appropriate care of poor vision and feelings of anxiety, nervousness, or fear, and avoidance of use of antipsychotic drugs might be useful in the prevention of falls among the most elderly home-dwellers.

Key Words: *Accidental falls, ageing, home-dwelling, medications, population studies, risk factors*

Up to half of home-dwelling people aged 85 years or older fall each year. At this age, fractures seem to increase at the expense of major soft tissue injuries [1], and there is a peak incidence of hip fractures [2].

Those at risk of falling typically suffer from gait and balance impairments [3,9]. More specifically, prospective community-based studies have identified major risk factors of falling including female gender [4], high age [5], history of falling [4,6–9], reduced lower extremity strength [5,7,9], impaired vision [5,6,9], cognitive impairment [9,10], dizziness [4], depressive symptoms [5,9], fear of falling, incontinence [4], peripheral sensory deficit [7], high and low physical activity [11], malnutrition [12], use of assistive device, poor abilities in activities of daily living [8], chronic diseases such as stroke, arthritis, and Parkinsonism [5,6], and high number of drugs [5]. Meta-analyses conclude that persons with vitamin D deficiency [13] and those using psychotropic, anti-arrhythmic, digoxin, or diuretic drugs [14,15] are at increased risk of falling. A recent review [3] presents additional risk factors for falling, such as arrhythmias, epilepsy, orthostatic hypotension, rheumatoid arthritis, use of alcohol, diabetes, and environmental hazards, but these risk factors have not been verified in prospective studies among the home-dwelling elderly.

Risk factors of falling among very old home-dwelling populations are poorly described, although hip fracture risk increases up to the highest ages.

- Risk factors among a very old home-dwelling population do not differ, at large, from those presented in younger old populations.
- Feelings of anxiety, nervousness, and fear predict subsequent falls and may be a more important risk factor for falls than drugs used in care.

Although high age is a distinguished risk factor for falling [5], risk factors of falling among very old home-dwelling populations remain poorly described. Generally, data on risk factors of falling are based on observations made in populations aged 65–75 years

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or older, including a minority of subjects aged 85 years or older [4–12]. In order to elucidate these research needs, we sought to determine risk factors of falls among home-dwelling seniors aged 85 years or older.

Material and methods

The target population comprised all persons aged 85 years or more living at home or in sheltered housing in the city of Oulu, Northern Finland (n = 827). Only those persons living in long-term institutional care were excluded from the population of this age living in Oulu. Baseline measurements for the 555 (67%) subjects who agreed to participate were conducted through a postal questionnaire [16] helped by home-nursing staff and close relatives. The clinical examinations were made during home visits by the trained district geriatric nurses of the city of Oulu (n = 40) during the period 16 October 2000 to 26 March 2001 after receiving informed consent from the participants or their guardians. The sample and recording of falls have been described in detail in our previous papers [1,17].

The following data were gathered by the questionnaire: number of previous falls in 12 months, disease history, self-rated health (very good, rather good, average, rather poor, very poor), change in mental agility during the past year (clearly better, somewhat better, no change, somewhat worse, clearly worse), trouble with vision when moving (yes/no), difficulty in urination, feelings of anxiety, nervousness, or fear, sleeping problems, and breathlessness (no, yes but not disturbed, disturbed a little, disturbed a lot) during the previous two weeks [16]. The assessment of habitual physical activity was based on a standardized question taken with modifications from the classification of physical activity among elderly people [18]. The question included seven alternative responses: mainly resting or only minimal physical activity, most activities performed sitting down, light physical activity, moderate physical activity about 3 h a week, moderate physical activity at least 4 h a week or heavy physical activity >4 h a week, physical exercise several times a week or heavy leisure-time working at least 3 h a week, and competitive sports several times a week. Depression was assessed according the short version of the Geriatric Depression Scale and was defined as a test score of less than 7 [19]. Medication was recorded from all available data present at home (drug packages, drug prescriptions), and characterized according to the ATC Index.

Home-nursing staff measured cognition according to the Mini Mental State Examination test (MMSE, 0–30) [20] and poor cognitive status was defined as a test score of 20 or less [21]. Body mass index was calculated from measured weight versus squared height (kg/m^2) in light clothing, by categorizing the values in a standard way, according to the WHO criteria into <18.5, $18.5<25$, $25<30$, >30. Standing balance was assessed with the feet in tandem, semi-tandem, and side-by-side positions. Those unable to hold a semi-tandem position for 10 seconds were evaluated with the feet in a side-by-side position. Those able to hold the semi-tandem position were further assessed with the feet in a tandem position, and the time up to 10 seconds maintained in this position was recorded. Walking speed was based on seconds to cover a 2.4-meter distance, irrespective of whether or not a walking device was being used. Ability to rise from a chair included five iterations without using one's arms, and the time required to do this was recorded. Categories of performance were set up for each of the three performance measures and, finally, a sum score of all three performances (0–12) was calculated according to Guralnik et al. [22].

Briefly, the occurrence of falls was monitored via telephone bimonthly from a day of baseline examinations for the following two years (nine phone calls) by the nurse examiner working at the university [1]. The follow-up of the present study was restricted to a period of about 11 months, until the start of an exercise-based intervention, move to long-term institutional care (n = 30), death (n = 48), or refusal to participate in recordings (n = 5) [23,24].

Incidence rate of falls was calculated from the day of baseline examinations until the end of follow-up. Univariate and multivariate analyses were based on negative binomial regressions, with falls as a dependent variable. We initially explored a Poisson model for the data, but based on the likelihood ratio tests, which indicated that our data were significantly over dispersed, a negative binomial model was utilized. An over-dispersed Poisson model produces incorrect variance estimates which are biased downwards (underestimating); in that case, a negative binomial model is more appropriate than the Poisson.

Incidence rate ratios (IRR) with 95% confidence intervals (CI) for each individual predictor variable were determined. The variables statistically significantly associated with falls (95% CI not crossing one) in univariate analyses were identified in multivariate models, which were done with stepwise backward elimination, in order of least significance. Statistical analyses were performed using SAS version 9.1.3.

Table I. Characteristics of the population studied (n = 555) according to presence of falls (yes/no) during the 11 months of follow-up.

Characteristic	Yes (n = 273)	No (n = 282)	p[1]
Demographics			
Baseline age, years, mean ± SD	88 ± 3	88 ± 2	0.15
Female, n (%)	218 (80)	211 (74)	0.16
Home-nursing care, n (%)	93 (34)	68 (24)	0.01
Less than grade school education, n (%)	29 (11)	28 (10)	0.77
Living alone, n (%)	195 (72)	195 (71)	0.63
Recurrent falls in previous year, n (%)	88 (33)	39 (15)	<.01
Lifestyle			
Sedentary physical activity in previous year, n (%)	81 (30)	63 (23)	0.06
Self-rated health and mental functioning			
Rather or very poor self-rated health, n (%)	49 (18)	40 (14)	0.22
Somewhat or clearly worsening mental agility past year, n (%)	101 (38)	77 (28)	0.01
Symptoms[2]			
Anxiety, nervousness, or fear, n (%)	62 (23)	43 (15)	0.02
Sleeping problem, n (%)	42 (16)	40 (14)	0.70
Difficulty in urination, n (%)	30 (11)	15 (5)	0.01
Breathlessness, n (%)	29 (11)	28 (10)	0.77
Trouble with vision when moving, n (%)	63 (24)	46 (17)	0.05
Clinical tests			
Short Geriatric Depression Scale score (0–15) ≥7, n (%)	71 (26)	41 (15)	<.01
Mini Mental State Examination test score (0–30), mean ± SD	23 ± 4	24 ± 4	0.43
Sum score of lower extremity performance score (0–12)[3], mean ± SD	7.0 ± 3.1	6.1 ± 3.4	<.01
Medication			
Use of psychotropic drug[4], n (%)	118 (43)	95 (34)	0.02
Number of used drugs, mean ± SD	6.4 ± 3.8	5.3 ± 3.2	<.01

Notes: [1]p is from chi-square (categorized) or t-test (continuous) statistics; [2]feelings of anxiety, nervousness, or fear, sleeping problem, difficulty in urination or breathlessness disturbing life a little or a lot during the previous two weeks; [3]lower extremity performance score (0–12) formed from balance (0–4), walking speed (0–4), and chair stand (0–4) scores [22]; [4]ATC group N05 and N06.

Results

The background data of the study population according to fall (yes/no) during the 11 months of follow-up are presented in Table I. Altogether, 273 (49%) subjects experienced at least one fall. They more often than non-fallers received home-nursing care and had experienced recurrent falls during the previous year. They more often than non-fallers were depressed, had somewhat or clearly worsening mental agility during the previous year, feelings of anxiety, nervousness, or fear, difficulty in urination during the last two weeks, had trouble with vision when moving, and used a psychotropic drug. They scored less in the lower extremity performance test and used a higher number of drugs than non-fallers.

In univariate negative binomial regression analyses (Table II), recurrent falls during the past year, lower body mass index, rather or very poor self-rated health, somewhat or clearly worsening mental agility during the previous year, sedentary physical activity in the past year, feelings of anxiety, nervousness, or fear, and difficulty in urination during the last two weeks, depression, trouble with vision when moving, use of an antipsychotic, hypnotic, or antidepressant drug, and higher number of used drugs were associated with falls, whereas a higher score of lower extremity function was negatively associated with falls.

In multivariate analysis (see Table II), after stepwise backward elimination of the non-significant variables, recurrent falling during the past year, trouble with vision when moving, feelings of anxiety, nervousness, or fear during the last two weeks, and use of an antipsychotic drug predicted subsequent falls. An adjustment for age and sex did not change the significance of the result.

Discussion

In general, our results derived from a very old home-dwelling population do not differ from those presented in younger old populations. The strongest predictive variables, fall history [4,6–9], poor vision [5,6,9], and use of an antipsychotic drug [25] are well-established risk factors among younger and also

Table II. Univariate and multivariate incidence rate ratios (IRR, 95% CI) of falls; negative binomial models

Risk factor; unit for IRR change	IRR (95% CI) Univariate (n = 555)	IRR (95% CI) Multivariate[1] (n = 526)
Baseline age; one year	1.03 (0.99–1.08)	
Female; yes/no	1.04 (0.80–1.29)	
≥2 falls past year; yes/no	2.15 (1.68–2.76)	1.91 (1.49–2.44)
Sedentary physical activity past year; yes/no	1.51 (1.17–1.95)	
Rather or very poor self-rated health; yes/no	1.55 (1.15–2.09)	
Somewhat or clearly worsening mental agility past year; yes/no	1.53 (1.20–1.96)	
Anxiety, nervousness, or fear[2]; yes/no	1.73 (1.31–2.28)	1.56 (1.19–2.03)
Sleeping problem[2]; yes/no	1.18 (0.86–1.63)	
Urination problem[2]; yes/no	1.79 (1.22–2.64)	
Breathlessness[2]; yes/no	1.20 (0.94–1.54)	
Trouble with vision when moving; yes/no	1.69 (1.28–2.22)	1.46 (1.13–1.90)
Body mass index; <18.5/18.5 <25/25 <30/ ≥30 kg/m^2	1.44 (1.02–2.02)	
Short Geriatric Depression scale ≥7; yes/no	1.59 (1.21–2.08)	
Mini Mental State Examination test ≤20; yes/no	1.25 (0.90–1.76)	
Sum score of lower extremity function[3]; one point	0.93 (0.90–0.97)	
Number of used drugs; one drug	1.06 (1.03–1.10)	
Use of antipsychotic[4] drug; yes/no	2.15 (1.36–3.40)	1.66 (1.07–2.58)
Use of anxiolytic[5]; yes/no	0.92 (0.63–1.37)	
Use of hypnotic[6]; yes/no	1.40 (1.10–1.79)	
Use of antidepressant[7]; yes/no	1.82 (1.32–2.50)	
Use of diuretic[8]; yes/no	1.16 (0.92–1.47)	
Use of digitalis[9]; yes/no	1.11 (0.82–1.49)	
Use of beta blocker[10]; yes/no	1.23 (0.97–1.56)	
Use of calcium channel blocker[11]; yes/no	0.92 (0.64–1.33)	
Use of drug affecting rennin-angiotensin system[12]; yes/no	0.97 (0.72–1.31)	

Notes: [1]Adjusted for all the significant variables in univariate analyses (≥2 falls past year; rather or very poor self-rated health; somewhat or clearly worsening mental agility past year; anxiety, nervousness, or fear; urination problem last two weeks; trouble with vision when moving; body mass index; Short Geriatric Depression scale ≥7; number of drugs used; use of an antipsychotic drug; use of a hypnotic drug; use of an antidepressant drug); stepwise backward elimination of the non-significant variables; [2]feelings of anxiety, nervousness, or fear, sleeping problem, difficulty in urination or breathlessness disturbing life a little or a lot during the previous two weeks; [3]lower extremity performance score (0–12) formed from balance (0–4), walking speed (0–4), and chair stand (0–4) scores [22]; ATC group [4]N05A, [5]N05B, [6]N05C, [7]N06A, [8]C03, [9]C01A, [10]C07, [11]C08, [12]C09.

among older old populations. Several risk factors established in younger populations, such as sedentary physical activity, poor self-rated health, depression, urination problem, high number of drugs used, use of a hypnotic and anti-depressant drug were also associated with subsequent falls in univariate analyses but did not withstand the multivariate adjustments.

Obviously, much of the effect of past falls on future fall risk may depend on the same baseline risk factors presented in the univariate analyses. Accordingly, risk factors such as poor self-rated health, worsening mental agility, depression, restricted physical activity, use of psychotropic drugs, and poor lower extremity function might have increased fall risk already at the time the past falls occurred. On the other hand, falls may increase the effect of such risk factors. Notably, falls increase the risk of extreme events, such as admission to long-term care or death [26]. Therefore, the relationship between previous falls and future falls is complex, and new prospective studies on risk factors of falls should be done, separately, among subjects with a history of previous falls and those without.

A meta-analysis of studies examining psychotropic drugs as risk factors of falling revealed most such drugs to be associated with falling [15]. In the present multivariate analysis, antipsychotic drugs appeared to be the most powerful predictors of falling among the psychotropic drugs. It is possible that, in addition to the extrapyramidal effects, anticholinergic effects and blockade of α-adrenergic receptors [25] may also affect fall risk particularly among the most elderly subjects such as ours. On the other hand, feelings of anxiety, nervousness, and fear were an independent risk factor for subsequent falls, irrespective of the effect of drugs used in care. Another study recently found that insomnia but not hypnotic use is a risk factor for falling [27]. These observations suggest that, in some cases, diseases may increase fall risk even more strongly than drugs. Nonetheless, quality of drug prescriptions among frail elderly subjects needs improvement. One study undertaken in southern Sweden

found that the majority of nursing home residents have inappropriate prescriptions [28].

Interestingly, we did not find cognitive impairment to be significantly associated with falls, although cognitive impairment [9,10] is a distinguished risk factor for falls. Selection bias may partly explain this. Dementia is overrepresented among non-participants of studies among the most elderly subjects [29]. Moreover, dementia is a major reason for admission to long-term care, which restricted follow-up time for falls of some demented persons in the present study.

A major strength of the present study is a modestly representative population sample of home-dwelling oldest adults. Falls were recorded by phone every other month, but no fall diaries were used [30]. Although significant others and home-nursing staff helped to record the falls, some falls may have been lost. The same doubts exist concerning the reliability of collection of baseline risk factor data by questionnaires. Although this was a fairly comprehensive assessment of the study population, there may be factors outside this study that increase fall risk, such as chronic diseases, use of alcohol, disabilities in daily living and locomotion, and environmental hazards.

In conclusion, this study found that a history of recurrent falling, trouble with vision when moving, use of antipsychotic drug, and feelings of anxiety, nervousness, or fear were independent risk factors for subsequent falls.

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Conflict of interest: None declared.

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