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Falls in very old people: The population-based Umeå 85+ Study in Sweden

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ABSTRACT

The aim of this study was to describe incidences of falls and fall-related injuries, and to identify predisposing factors for falls in very old people in a prospective population-based follow-up study for falls. The study is part of the Umeå 85+ Study which includes half of the population aged 85, and the total population aged 90 and $\geq$95 ($-$103), in Umeå, Sweden. Of the 253 people interviewed, 220 (87%) were followed up for falls for 6 months, of whom 109 lived in ordinary and 111 in institutional housing. A comprehensive geriatric baseline assessment was made through interviews and testing during home visits. Forty percent of the participants did fall a total 304 times, corresponding to 2.17 falls per Person Year (PY). It occurred 0.83 injuries per PY, including 0.14 fractures per PY. In a Cox regression analysis, the independent explanatory risk factors for time to first fall were dependency in activities of daily living (ADL), thyroid disorders, treatment with selective serotonin reuptake inhibitors (SSRIs) and occurrence of falls in the preceding year. It could be predicted that every seventh participant and every third of the people who did fall would suffer a fracture within 1 year. ADL, thyroid disorders and treatment with SSRIs should be considered in fall prevention programmes.

1. Introduction

Sustaining falls is a major cause of morbidity and mortality in the older population. Falls increase with age (Tinetti et al., 1988; Nevitt et al., 1989; Campbell et al., 1990; Luukinen et al., 1994; Myers et al., 1996; AGS et al., 2001; Lehtola et al., 2006) and the world's population is growing older. Currently, 10% of the world's population is aged 60 years or older, and the proportion will double within the next 50 years. The very old people, aged 80 years and over, are the fastest growing group of older people today (United Nations, 2005). Among people aged 65 years or older, one third of people living in ordinary housing fall each year (Tinetti et al., 1988; Nevitt et al., 1989; Luukinen et al., 1994), and about two thirds of those living in residential care facilities (Liu et al., 1995; Kallin et al., 2002).

It has been estimated that falls account for one third of the total cost of medical treatment for all injuries (Sjögren and Björnstig, 1989), and they are the most common cause of death due to accidents in older people (Rubenstein et al., 1994; Swedish Rescue Services Agency (Räddningsverket), 2003). Approximately 10% of the falls result in major injuries such as fractures, head injuries and serious soft tissue injuries (Tinetti et al., 1988; Campbell et al., 1990; Rubenstein et al., 1994; Luukinen et al., 1995; Jensen et al., 2002b), and the incidence rate for fractures is twice as high in institutional settings than in ordinary housing (Luukinen et al., 1995). Hip fracture, the most common serious injury caused by falls, considerably increases the risk of institutionalization and mortality (Marottoli et al., 1994). In addition, fear of falling and the resulting self-imposed functional limitations as well as an increased risk of placement in a nursing home, are consequences that clearly reduce feelings of good health in the older population (Rubenstein et al., 1994; Tinetti and Williams, 1997; Cumming et al., 2000).

The cause of falls in older people is largely multifactorial, with combinations of predisposing and precipitating factors (Kallin et al., 2002). These factors can be both intrinsic and extrinsic (related to the individual and the environment) to their nature (AGS et al., 2001). The fall risk also increases as the number of risk factors increases (Tinetti et al., 1988; Nevitt et al., 1989; AGS et al., 2001). Examples of fall risk factors are higher age (Tinetti et al., 1988; Nevitt et al., 1989; Campbell et al., 1990; Luukinen et al., 1994; Myers et al., 1996; AGS et al., 2001; Lehtola et al., 2006), previous falls (Tinetti et al., 1988; Myers et al., 1996; AGS et al., 2001; Kallin et al., 2002, 2004; Bootsma-van der Wiel et al., 2003), gait and balance disorders (Tinetti et al., 1988; Nevitt et al., 1989; Rubenstein et al., 1994; Liu et al., 1995; Myers et al., 1996; AGS et al., 2001; Kallin et al., 2002, 2004; Bootsma-van der Wiel et al., 2003), medical diagnoses (Tinetti et al., 1988; Rubenstein et al., 1994; Myers et al., 1996; AGS et al., 2001), drugs (Tinetti et al., 1988; Rubenstein et al., 1994; Liu et al., 1995; Myers et al., 1996;

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Thapa et al., 1998; AGS et al., 2001; Kallin et al., 2002, 2004) and environmental circumstances (Tinetti et al., 1988; Rubenstein et al., 1994). In a previous study we found surprisingly that treatment with levothyroxin was associated with an increased fall risk (Kallin et al., 2004). Another study has reported that a history of high thyroid (marked by low levels of thyroid-stimulating hormone, TSH), but not levels of TSH itself, was associated with falling (Schwartz et al., 1999).

Little is known about falls in very old people and to our knowledge, only two population-based studies regarding falls and fall risk factors have been published to date (Luukinen et al., 1994; Bootsma-van der Wiel et al., 2003). Very old people are generally frailer than younger old people, and have an increased risk of falling (Luukinen et al., 1994; von Heideken Wågert et al., 2006). Using the same baseline assessment and analyses for people living in both ordinary and institutional housing, increases the possibilities of obtaining a deeper knowledge about falls in very old people, and might contribute to improvement in fall prevention strategies. The aim of this study was therefore to describe incidences of falls and fall-related injuries, and to identify predisposing factors for falls in very old people, living in both ordinary and institutional housing.

2. Methods

This study is part of the Umeå 85+ Study, which is described in detail elsewhere (von Heideken Wågert et al., 2006). In brief, a random sample, comprising half the population born in 1915 (85-year olds), and the total population born in 1910 (90-year olds) and 1905 or earlier ($\geq$95-year olds, range 95–103), living in the municipality of Umeå, Sweden on the 1 January 2000, were selected for participation ($n = 348$). Twenty-nine of the 348 (8%) died before they could be asked to participate. Of the 319 who were asked to participate, 66 (21%) declined home visits either personally or through their next-of-kins, leaving 253 participants of whom 33 (13%) declined assessments or follow-up for falls. The 99 people that refused home visits, assessments and/or follow-up for falls were younger ($p < 0.001$) more often married ($p = 0.004$) and living in ordinary housing ($p < 0.001$) than the study sample of 220 participants. The follow-up for falls was carried out from January 2000 to December 2001. Characteristics of the participants are presented in Tables 1 and 2. The Ethics Committee of the Medical Faculty of Umeå University approved the study (§99-326 and §00-164).

2.1. Follow-up for falls and injuries

Baseline data were collected during two or three home visits and from next-of-kins, caregivers, and medical charts. After baseline assessment, participants ($n = 253$) were asked if they wanted to participate in a follow-up study for falls over a period of 6 months. In total, 220 out of 253 (87%) agreed to do so, of who 109 were living in ordinary housing and 111 in institutional housing. Participants in ordinary housing received a fall calendar to fill in

Table 1
Characteristics of the participants in the total sample, people who did and did not fall. Prevalence in % or mean ± S.D.

	Total 220[a]	Fallers 91[a]	Non-fallers 129[a]	p[b]
Sociodemographic data				
Age, mean ± S.D.	90.3 ± 4.8	91.1 ± 5.1	89.7 ± 4.5	0.046
Female	76	74	78	0.506
Living in ordinary housing	49	38	57	0.006
Independence, ADL level				
I- and P-ADL-independent	18	10	24	0.007
I-ADL-dependent	30	24	35	0.089
P-ADL-dependent but not bedridden	39	62	23	<0.001
P-ADL-dependent and bedridden	12	4	18	0.003
Walked outdoors independently	51	41	58	0.011
Physical ability				
Able to perform gait test 2.4 m ($n = 187$)[c]	86	83	91	0.139
Able to perform chair stands test ($n = 186$)[c]	63	66	59	0.359
BBS scores ($n = 188$)[c]	35.0 ± 19.6	33.5 ± 18.8	35.9 ± 20.2	0.409
Falls				
Fall/s the preceding year ($n = 218$)[b]	47	59	39	0.003
Fear of falling ($n = 172$)[c]	27	36	21	0.036
FES(S) scores ($n = 153$)[c]	93.0 ± 35.6	82.4 ± 34.5	100.1 ± 34.7	0.002
Physical and psychological assessments				
Reading vision ($n = 213$)[c]	71	67	75	0.195
Height ($n = 212$)[c]	1.59 ± 0.10	1.59 ± 0.10	1.59 ± 0.10	0.983
Weight ($n = 215$)[c]	62.4 ± 14.2	61.6 ± 15.7	63.0 ± 13.0	0.483
BMI ($n = 211$)[c]	24.4 ± 4.6	23.9 ± 4.7	24.8 ± 4.5	0.183
MMSE scores ($n = 205$)[c]	20.8 ± 9.0	20.3 ± 7.8	21.2 ± 9.7	0.483
MNA scores ($n = 214$)[c]	22.3 ± 5.2	22.1 ± 4.4	22.4 ± 5.8	0.679
GDS-15 scores ($n = 175$)[c]	3.9 ± 2.5	4.2 ± 2.5	3.7 ± 2.5	0.184
Diagnoses				
Dementia	31	36	27	0.149
Previous stroke	22	23	22	0.810
Depression ($n = 210$)[c]	30	38	22	0.015
Diabetes	13	13	12	0.864
Constipation	45	49	43	0.317
Delirium in preceding month	20	26	16	0.047
Cardiac insufficiency	25	26	24	0.693
Thyroid disorders ($n = 214$)[c]	15	25	8	0.001

[a] Number.
[b] p refers to differences between fallers and non-fallers.
[c] Valid percentages are given for variables with less than 220 valid cases.

Table 2
Prescribed drugs and blood tests in the total sample, people who did and did not fall. Prevalence in % or mean ± S.D.

	Total 220[a]	Fallers 91[a]	Non-fallers 129	p[b]
No. of prescribed drugs	7.1 ± 4.1	7.5 ± 5.0	6.7 ± 4.2	0.187
Analgesics	59	60	57	0.648
ACE inhibitors	11	14	9	0.177
Antidepressants	20	29	14	0.008
SSRIs	19	26	13	0.013
Antiepileptics	2	1	3	0.326
Benzodiazepines	38	43	35	0.231
Beta-blockers	29	27	30	0.657
Calcium entry blockers	10	11	10	0.828
Vitamin B_{12}	27	29	26	0.622
Digitalis	18	18	19	0.846
Diuretics	55	59	53	0.330
Laxatives	42	49	37	0.070
Levodopa	2	3	1	0.168
Levothyroxin	8	14	4	0.006
Neuroleptics	20	19	20	0.786
Blood tests, reference values[c] (S = serum; P = plasma)				
S-hemoglobin, W 125–158 and M 132–168 g/l (n = 197)[d]	126.8 ± 13.6	127.4 ± 13.1	126.4 ± 14.0	0.597
S-sodium, 134–148 mmol/l (n = 194)[d]	140.1 ± 2.2	141.2 ± 2.1	140.8 ± 2.2	0.248
S-potassium, 3.4–5.0 mmol/l (n = 194)[d]	4.2 ± 0.4	4.2 ± 0.4	4.2 ± 0.4	0.680
S-Ca-corr. 2.1–2.6 mmol/l (n = 191)[d]	2.3 ± 0.1	2.3 ± 0.1	2.3 ± 0.1	0.338
S-albumin, W 24–44 and M 35–45 g/l (n = 195)[d]	39.8 ± 3.7	39.5 ± 3.4	40.0 ± 3.9	0.383
S-creatinine, W 48–94 and M 58–109 μmol/l (n = 194)[d]	93.6 ± 34.2	95.4 ± 32.5	92.3 ± 35.5	0.529
S-B_{12}, 96–568 pmol/l (n = 191)[d]	454.4 ± 320.1	497.9 ± 351.5	422.4 ± 292.3	0.107
S-folic acid, 3.4–47 nmol/l (n = 191)[d]	18.8 ± 15.4	21.2 ± 17.1	17.0 ± 13.9	0.068
P-homocysteine, <15 μmol/l (n = 188)[d]	17.1 ± 6.2	17.3 ± 6.3	17.1 ± 6.1	0.825
S-TSH, 0.28–4.5 mU/l (n = 190)[d]	1.7 ± 1.6	1.9 ± 2.1	1.4 ± 1.0	0.045
S-free T_3, 2.5–5.3 pmol/l (n = 189)[d]	3.3 ± 0.7	3.2 ± 0.7	3.3 ± 0.7	0.150
S-free T_4, 11.1–21.4 pmol/l (n = 191)[d]	14.7 ± 3.0	15.0 ± 3.4	14.4 ± 2.5	0.176

[a] Number.
[b] p refers to differences between fallers and non-fallers.
[c] Reference values and units for each blood test are given, in some cases separately for women (W) and men (M).
[d] Valid cases are given in parenthesis for variables with less than 220 valid cases.

daily, on which they noted whether or not they had fallen and circumstances of any fall/s. Every second week the participants received a telephone call from a member of the research team (one medical student, one geriatrician, and five physiotherapists), asking about fall accidents, and the circumstances and consequences of any fall/s. In four cases, next-of-kins were called instead of the participants because of hearing disabilities. For participants in institutional housing, the research team reviewed all fall reports the staff are obliged to complete in institutional settings, in addition to the regular ward charts, with information about the circumstances and consequences of the falls. Institutional housing included residential care, skilled nursing homes and group dwellings for people with dementia. Nineteen participants living in institutional housing did not need very much help from the staff. Because of the risk of them falling and not reporting it to the staff, they also filled in the fall calendar and received telephone calls; seven additional falls in four people were detected this way. In reviewing the ward charts 63 more falls in 36 people were found, of which 19 had no earlier falls registered.

2.2. Definitions

The follow-up period for falls was 6 months or until the participant died or no longer wanted to participate. A fall was defined as an event in which the person unintentionally came to rest on the ground or floor, regardless of whether an injury was sustained or of the cause. Injuries were classified according to Nevitt et al. (1991), where minor injuries included bruises, superficial lacerations, and wounds that did not need suturing. Major injuries included fractures, dislocations, and soft tissue injuries needing suturing. Only the most serious injury resulting from each fall was registered. Actions taken (contacts with nurse, doctor and/or hospital care) after each fall were also registered.

2.3. Baseline assessments

Independence in ADL was assessed using the Staircase of ADL (Sonn, 1996), which is a further development of the Katz Index of ADL (Katz et al., 1963). The scale measures both instrumental ADL (I-ADL), which includes cleaning, grocery shopping, transport and cooking, and personal (P-ADL) which includes bathing, dressing, toileting, transfer, continence and eating. Balance was tested with a Swedish translation (Jensen et al., 1998) of the Berg balance scale (BBS) (Berg et al., 1989). The scale consists of 14 static and dynamic balance tasks that commonly occur in everyday life. The maximum score is 56, indicating good balance for an older person. The ability to rise from a chair without armrests and without using their arms as support, was tested with three self-paced, consecutive chair stands (Thapa et al., 1994), a modified version. The participant was asked how frequently they walked outdoors independently, if they had sustained any falls during the preceding year, and if they were afraid of falling. Fear of falling was also assessed with the modified Swedish version of the falls efficacy scale (FES(S)) (Hellström and Lindmark, 1999). This scale assesses the perceived self-efficacy in avoiding falls during 13 non-hazardous ADL tasks. The maximum score of 130 indicates total confidence.

Reading vision was rated as unimpaired when the participant, with or without glasses, could read a word written in 3 mm capital letters at reading distance. Height and weight were assessed with a folding ruler and a digital bathroom scale. Body mass index (BMI) was calculated (kg/m^2) from these figures. Nutrition was assessed using the mini-nutritional assessment (MNA) (Guigoz et al., 1994), a screening instrument for nutritional status which is valid for use in very old people or residents in institutional care. The MNA has a maximum score of 30, which indicates very good nutritional status. Scores between 23.5 and 17 indicate a risk of malnutrition, and scores below 17 the presence of malnutrition.

Diagnoses were collected from participants, next-of-kins and caregivers, and from medical charts at the hospital, general practitioners and/or the institutional care facility. Prescribed drugs were registered. Cognition was screened for using the mini-mental state examination (MMSE) (Folstein et al., 1975), with a maximum score of 30. A score below 24 indicates impaired cognition (Tombaugh and McIntyre, 1992). Dementia was diagnosed if the participant had had a previous diagnosis of dementia based on an earlier dementia assessment, and/or if the MMSE assessment and the organic brain syndrome scale (OBS scale) (Jensen et al., 1993) revealed cognitive impairment, indicating dementia. When the etiology of the cognitive impairment was uncertain, the participant was referred to the Department of Geriatric Medicine, Norrland University Hospital in Umeå, for a complete dementia assessment. Depressive symptoms were screened for using the geriatric depression scale-15 (GDS-15) (Sheikh and Yesavage, 1986), with 15 yes/no questions and a maximum score of 15. Scores between five and nine indicate mild depression, and a score of ten or more indicates moderate to severe depression. Those who scored 5 or more on the GDS-15 were further assessed using the Montgomery–Åsberg depression rating scale (MADRS) (Montgomery and Åsberg, 1979) by a specialist in geriatric medicine (YG or KK). Depression was diagnosed after evaluation of earlier documented diagnoses in medical charts, current treatment with antidepressants, and depression screened for using the GDS-15 and rated using the MADRS. If participants had an earlier diagnosis of depression with ongoing treatment with antidepressants, despite a GDS score <5, they were diagnosed as having depression, but regarded as having responded to treatment. Participants classified as having thyroid disorder included those who had been treated for hyper/hypothyroidism with or without substitutional therapy and those whose laboratory values indicated a thyroid disorder.

Blood tests were collected during the home visits, and analyzed for serum (S-) hemoglobin, S-sodium, S-potassium, S-calcium corrected, S-albumin, S-creatinine, S-vitamin B_{12}, S-folic acid, plasma (P-) homocysteine, S-TSH, S-free triiodothyronine (T_3), S-free thyroxine (T_4) at Umeå University Hospital laboratory, accredited since 9 May 1995 by SWEDAC (Swedish Board for Accreditation and Conformity Assessment) ref. no. 1397. Sysmex FC 9000 was used for photometric analysis of S-hemoglobin. S-B_{12} and S-folic acid were analyzed using Biorad quantaphase II RIA and P-homocysteine using the immunological method, Abbot IMX. S-sodium, S-potassium, S-calcium, S-albumin and S-creatinine were all analyzed in J&J Vitros, S-sodium and S-potassium using direct ISE, S-calcium using the arsenazio method, S-albumin using BCG and S-creatinine using enzymatic J&J Vitros. S-TSH, S-free T_3 and S-free T_4 were analyzed using Abbot AXSYM, Microparticle Enzym Immunoassay. When data is presented for the blood tests, reference values as well as mean $\pm$ S.D. are given.

A specialist in geriatric medicine (YG) evaluated all diagnostic documentation, drug treatments and assessments, for completion of final diagnoses according to the same criteria for all participants. Participants with assessments indicating undiagnosed conditions were either further assessed by specialists in geriatric medicine or were referred for further assessments and treatments.

2.4. Data analysis

The incidence rates of falls and fall-related injuries were calculated as the number of falls or injuries divided by PY (=total number of observation days divided by 365.25). The observation time and time to first fall was counted in number of days. When the exact dates of the falls were unknown (13 falls in total), dates for each fall was imputed exactly mid-way between the two telephone calls. A new four-level variable was created from the Staircase of ADL, where the item "Transfer" was used to categorize the participants as bedridden or not. The new variable includes the following levels: 1 = independent in both I-ADL and P-ADL ($n = 40$); 2 = dependent in all I-ADL and independent in all P-ADL items ($n = 67$); 3 = dependent in all I-ADL, one or more P-ADL item, but not bedridden ($n = 86$), and 4 = dependent in all I-ADL, most P-ADL items and bedridden ($n = 27$). When presenting data of incidence of falls and fall-related injuries (Table 3), data were weighted by counting every 85-year-old twice. This weighting was done because of the sampling procedure, in which half the 85-year-old population was included in the study in contrast to the 90- and $\geq$95-year olds where the total populations were included, to achieve a more correct interpretation of the results. People who did or did not fall were compared using the χ^2-test and Student's t-test. Variables that differed between people who did or did not fall in the univariate analyses ($p \leq 0.15$) were entered into a Cox regression analysis to find independent factors which would explain the variation of time to first fall. Adjustments were made for age and sex. When validating time to first fall, a significant difference in time to first fall was found between people who did fall once and those who did fall twice or more, 91.0 days vs. 45.4 days, $p < 0.001$, and thus, the Cox regression analysis was considered to be a suitable method to use. For the Cox regression, Hazard Ratio (HR) are given together with a 95% confidence interval (95% CI). A $p \leq 0.05$ was regarded as statistically significant. SPSS® software package 12.0.1 was used for all calculations.

3. Results

Forty percent of the participants did fall a total of 304 times in 6 months, corresponding to a fall incidence rate of 2.17 falls per PY (Table 3). Forty-nine percent did fall more than once, and the highest number of falls for any person was 14. Thirty-four percent

Table 3
Incidences of falls and fall-related injuries for the total sample, people in ordinary and institutional housing, and women and men during 6 months of follow-up. Figures are weighted.

	Total sample 220[a]	Ordinary housing 109[a]	Institutional housing 111[a]	Women 167[a]	Men 53[a]
Number of falls	304	118	186	194	110
People who did fall (%)	40	32	50	38	45
PY	140.36	83.17	57.19	106.39	33.64
Falls/PY	2.17	1.42	3.25	1.82	3.27
Injurious falls/PY	0.83	0.57	1.22	0.84	0.83
Minor injurious falls/PY	0.62	0.38	0.96	0.60	0.68
Major injurious falls/PY[b]	0.21	0.18	0.26	0.23	0.15
Falls resulting in fractures/PY	0.15	0.11	0.19	0.16	0.09
People injured (%)	26	20	34	26	26

[a] Number.
[b] Total major injurious falls, including falls resulting in fractures.

Table 4
Cox regression model of factors associated with time to first fall.

	Total sample 220[a]		Ordinary housing 109[a]		Institutional housing 111[a]	
	HR[b]	95% CI[b]	HR[b]	95% CI[b]	HR[b]	95% CI[b]
ADL						
I- and P-ADL-independent	1.0		1.0		1.0	
I-ADL-dependent (n = 66)	1.392	0.636–3.050	1.381	0.559–3.410	1.580	0.170–14.683
P-ADL-dependent, but not bedridden (n = 82)	**2.882**	**1.340–6.202**	**6.758**	**2.526–18.080**	1.709	0.212–13.759
P-ADL-dependent, and bedridden (n = 24)[c]	0.436	0.170–1.828			0.254	0.025–2.587
Thyroid disorder	**2.421**	**1.432–4.093**	**2.462**	**1.039–5.834**	1.985	0.974–3.934
Treatment with SSRIs	**2.103**	**1.242–3.560**	1.464	0.527–4.070	**2.480**	**1.275–4.824**
Fall/s preceding year	**1.574**	**1.007–2.461**	1.472	0.724–2.994	1.684	0.903–3.009
Male sex	1.622	0.977–2.696	**2.835**	**1.319–6.093**	1.002	0.475–2.113
Age	1.046	0.994–1.101	1.021	0.920–1.134	**1.071**	**1.001–1.147**

Statistically significant results are in bold. Overall χ^2: total sample 61.499, d.f. = 8, $p < 0.001$; ordinary housing 36.928, d.f. = 7, $p < 0.001$; institutional housing 28.138, d.f. = 8, $p < 0.001$.
[a] Number.
[b] Variable.
[c] Only participants living in institutions.

of the falls resulted in contact with a nurse, 7% with a physician, and 13% in hospital care. Injuries occurred in connection with 38% of the falls, and fractures in 7%. In addition, 65% of people who did fall had at least one injurious fall. Seven percent of the participants suffered a fracture. Among people who did fall, there were 2.1 injurious falls per PY (1.56 minor and 0.54 major injurious falls per PY), including 0.36 fractures per PY. No one suffered more than one fracture. In summary, every seventh participant and every third one of the people who did fall would suffer a fracture over a period of 1 year.

For participants living in ordinary housing, the fall incidence rate was 1.42 falls per PY (Table 3), and 40% of the falls were injurious, and 8% resulted in a fracture. For participants living in institutional housing, the corresponding figures were 3.25 falls per PY, 38% of the falls were injurious and 6% resulted in a fracture. Sixty-three percent of people in ordinary housing and 67% of those in institutional housing who did fall had at least one injurious fall. In summary, those living in institutions did fall more than twice as often as those living in ordinary housing, but the proportion of injurious falls did not differ.

Men did fall more than women, with 3.27 falls/PY compared to 1.82. The 85-year olds had a fall incidence rate of 1.75 falls/PY, and the 90- and $\geq$95-year olds had fall incidence rates of 2.38 and 2.62, respectively. Of the falls, 21% were injurious among the 85-year olds, and 29% and 26% among 90- and $\geq$95-year olds, respectively. The mean time to first fall was 71 $\pm$ 56 days, range 1–175. Two hundred and four people (93%) were followed up for the total follow-up period of 6 months. The other 16 people were followed up for 4–120 days, and the most common reason for drop-out was that the participant died (75%) during the follow-up period.

In the univariate analyses the following factors were significantly more common among people who did fall than among those who did not fall: living in institutional housing, being older, dependent in ADL and in walking outdoors, afraid of falling, had fallen in the preceding year, was diagnosed with depression, suffered delirium and thyroid disorders (Table 1). Treatment with SSRIs, antidepressants as a group, levothyroxin and higher levels of S-TSH (Table 2), were also more common among those who did fall.

In a Cox regression analysis P-ADL-dependent but not bedridden, thyroid disorders, treatment with SSRIs and occurrence of fall/s the preceding year were significantly associated with time to first fall (Table 4). The model was adjusted for age and sex. When the Cox regression analysis was compared between ordinary and institutional housing, somewhat different patterns emerged, but thyroid disorders and falls in the preceding year followed similar patterns in both models. In those living in ordinary housing, the highest HR of 6.758 was seen for participants who were dependent in P-ADL but not bedridden. For participants in institutional housing, treatment with SSRIs had the highest HR of 2.480.

As seen in Table 2, S-TSH levels were also higher, and treatment with levothyroxin was more common among people who did fall than among those who did not fall, but those variables did not qualify for the final Cox regression model, as the variable thyroid disorders did. The variable treatment with SSRIs (p = 0.001), was chosen in the Cox regression model instead of the diagnosis of depression, because depression did not reach statistical significance in the Cox regression model even if it replaced SSRIs (data not shown).

4. Discussion

The independent explanatory risk factors for time to first fall in this sample of very old people were P-ADL-dependent but not bedridden, thyroid disorders, treatment with SSRIs and occurrence of falls in the preceding year. We have previously found that treatment with levothyroxin was significantly associated with falls in a sample of older people in geriatric care settings (Kallin et al., 2004). In addition, to our knowledge, thyroid disorders have only been reported as a fall risk factor in one earlier study (Schwartz et al., 1999). That study included 59- to 84-year-old women living in the community, and a history of high thyroid was associated with falls, but not S-TSH levels. In the present study, we therefore wanted to study thyroid disorders as well as treatment with levothyroxin and levels of S-TSH. We found that both treatment with levothyroxin and S-TSH levels were significantly associated with falls in the univariate analyses, which might indicate a possible functional mechanism explaining the association between falls and thyroid disorders. Participants who did fall had significantly higher S-TSH levels which might indicate an under-substitution of their thyroid function. Thyroid hormone levels can influence, e.g., heart rate, blood pressure, blood volume, physical ability and cognition and might thus increase the fall risk (Miller, 2003).

The variable with the highest HR of all risk factors in the total sample, P-ADL-dependent but not bedridden, did also have the highest HR among those living in ordinary housing, but was not significant in those in institutional housing. In institutional housing, the highest HR was seen for treatment with SSRIs, which is in accordance with earlier research (Thapa et al., 1998; Kallin et al., 2002, 2004). One might speculate that the environment is more adjusted in institutional housing and precipitating factors, such as infections and drug side effects, are more important there than in ordinary housing. In addition, the great majority of participants living in institutions were dependent in P-ADL. Fall prevention programs with exercise as a single intervention have not been successful in those living in institutional housing (Mulrow et al., 1994; Nowalk et al., 2001), but have been successful in ordinary housing (Robertson et al., 2002).

In residential care facilities, a multifactorial fall prevention program focusing on both predisposing and precipitating fall risk factors significantly reduced falls and hip fractures (Jensen et al., 2002a).

Only two studies have previously investigated falls in population-based samples of very old people (Luukinen et al., 1994; Bootsma-van der Wiel et al., 2003), and one has studied very old people living in ordinary housing (Lehtola et al., 2006). Bootsma-van der Wiel et al. (2003) studied a group of 85-year olds in Leiden, in the Netherlands, for 1 year, and Luukinen et al. (1994) studied people aged 70+ in northern Finland, with results presented after both 1 and 2 years (Luukinen et al., 1995) of follow-up, for different age groups. Lehtola et al. (2006) studied people living in ordinary housing aged 85+ for 2 years, also in Northern Finland. A proportion of people who did fall similar to that in the present study was found (Bootsma-van der Wiel et al., 2003), although the participants in that study were younger, and one might have expected lower figures. In the present study, the fall incidence rates were almost twice those found earlier in the age group 85+, 2.17 falls/PY compared to 1.17 (Luukinen et al., 1994). The present study also showed higher figures among both those living in ordinary housing, 1.42 falls/PY compared to 0.88 (Luukinen et al., 1994) and 1.04 (Lehtola et al., 2006), as well as those living in institutions aged 85+, 3.25 falls/PY compared to 1.64 (Luukinen et al., 1994).

Among participants living in ordinary housing, men had a fall risk almost three times higher than women in the present study. This was somewhat inconsistent compared to earlier research which reports that women living in ordinary housing fall more than men (Luukinen et al., 1994; Lehtola et al., 2006), but men living in institutions tend to fall more than women (Luukinen et al., 1994). These studies have also reported that sex differences in fall incidence seemed to disappear with advancing age (Luukinen et al., 1994; Lehtola et al., 2006).

Regarding injuries and fractures, the present study showed figures that were more than double those of the 2-year follow-up study by Luukinen et al. (1995), with injury incidence rates (including fractures) for participants living in institutions of 1.22/PY vs. 0.47, and 0.57 vs. 0.22 for participants living in ordinary housing. However, these are figures for the age group 85+ compared to 70+, which might partly explain the large differences. Participants living in ordinary housing aged 85+ in the study by Lehtola et al. (2006) had similar figures for major injuries and fractures, 0.07 major injuries and 0.09 fractures/PY compared to the present study's figures for such participants of 0.07 and 0.11, respectively. A recent 10-year follow-up study of fall-related injuries in initially community-dwelling 75- and 80-year olds, show lower figures of injuries than the present study (Saari et al., 2007). There were also higher fracture rates in the present study than in the study by Bootsma-van der Wiel et al. (2003), 7% and 3%, respectively. The participants in the present study were older and probably frailer, and Sweden has one of the highest figures in the world for osteoporotic fractures, and it also increases with age (Thorngren et al., 2002). The present study confirms earlier findings that fractures are twice as common in institutional than ordinary housing (Luukinen et al., 1995), and that 10% of the falls result in major injuries (Tinetti et al., 1988; Campbell et al., 1990; Rubenstein et al., 1994; Luukinen et al., 1995; Jensen et al., 2002a). The higher fracture rate in institutions in the present study was due to a higher fall incidence rate, because the proportion of injurious falls did not differ between the various types of housing. However, there were high fracture rates in the present study, and studies combining both fall prevention and treatment of osteoporosis should be prioritized in future prevention and intervention studies in very old people.

It is acknowledged that this study has certain limitations. The sample consists of three separate age groups, and not a continuous range of very old people. The drop-outs were younger, more often married and living in ordinary housing. These differences were probably consequences of the procedure for follow-up of falls, where the participants living in ordinary housing had to be active in the follow-up and refused to participate more often than the participants living in institutions. Regarding both the follow-up for falls and the question about falls the preceding year, we had to rely on the ability of participants living in ordinary housing to remember the actual fall event, which is a common problem in fall research (Cummings et al., 1988). The shame of falling and not telling anyone about the fall, and the fact that it is probably easier to remember an injurious fall, and forgetting and not reporting the non-injurious falls might have contributed to the high proportion of injurious falls in the present study. The high proportion could also indicate an underreporting of falls, but we had a very thorough follow-up, which was more frequent than the earlier studies mentioned that included very old people (Luukinen et al., 1994; Bootsma-van der Wiel et al., 2003; Lehtola et al., 2006). There are also a number of strengths in the present study. This is the first study with a follow-up for falls in a population-based sample of three different age groups of very old people, analyzed as one group, regardless of age, sex and housing. The same, and rather comprehensive, geriatric assessment baseline was used for both those in ordinary and in institutional housing, and the follow-up for falls was carried out very carefully for both kinds of housing. The follow-up was only for 6 months, which increases the possibilities of the baseline data being accurate for the total follow-up period, especially for this old and frail population. Another study, including older people in residential care, reported that prediction of falls seemed better for the first 6 months than for 12 months after baseline assessment (Rosendahl et al., 2003). For the participants living in institutions, we both reviewed the fall reports and the regular ward charts. In total only six investigators (two geriatricians, two medical students, one nurse and one physiotherapist) were included in making the baseline assessments and seven investigators (five physiotherapists, one geriatrician, and one medical student) performed the follow-up for falls.

This study suggests that thyroid disorders with disturbed thyroid function might be an important fall risk factor that should be included in future fall prevention programs and in intervention studies. For very old people living in ordinary housing, the focus in fall prevention should be on improving their ADL ability, since the group that were independent regarding P-ADL had a much lower fall risk than those who were P-ADL-dependent but not bedridden. It is also important that both staff and the very old people themselves, who are dependent in P-ADL, become more aware of this increased risk of falling and take fall preventive actions that are individually tailored. Regarding very old people living in institutions, there is probably a more complex combination of fall risk factors, but two possible interventions are going through the medications thoroughly, and finding alternatives to the SSRIs. On the basis of our findings we also suggest that it should be mandatory to register falls as a possible drug side effect in drug-treatment studies in old people.

5. Conclusion

Falls and fractures are major public health problems in very old people. From the results of the present study, every seventh participant and every third one of the people who fell would suffer a fracture over a period of 1 year. The most important independent predisposing factors for falls were being P-ADL-dependent but not bedridden, thyroid disorders and treatment with SSRIs, thus these factors should be considered in fall prevention in very old people.

Conflict of interest statement

None.

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References

AGS (American Geriatrics Society), British Geriatrics Society, American Academy of Orthopaedic Surgeons Panel on Falls Prevention, 2001. Guideline for the prevention of falls in older persons. J. Am. Geriatr. Soc. 49, 664–672.

Berg, K., Wood-Dauphinée, S., Williams, J., Gayton, D., 1989. Measuring balance in the elderly: preliminary development of an instrument. Physiother. Can. 41, 304–311.

Bootsma-van der Wiel, A., Gussekloo, J., De Craen, A.J., Van Exel, E., Bloem, B.R., Westendorp, R.G., 2003. Walking and talking as predictors of falls in the general population: the Leiden 85-Plus Study. J. Am. Geriatr. Soc. 51, 1466–1471.

Campbell, A.J., Borrie, M.J., Spears, G.F., Jackson, S.L., Brown, J.S., Fitzgerald, J.L., 1990. Circumstances and consequences of falls experienced by a community population 70 years and over during a prospective study. Age Ageing 19, 136–141.

Cumming, R.G., Salkeld, G., Thomas, M., Szonyi, G., 2000. Prospective study of the impact of fear of falling on activities of daily living, SF-36 scores, and nursing home admission. J. Gerontol. A: Biol. Sci. Med. Sci. 55, M299–M305.

Cummings, S.R., Nevitt, M.C., Kidd, S., 1988. Forgetting falls. The limited accuracy of recall of falls in the elderly. J. Am. Geriatr. Soc. 36, 613–616.

Folstein, M.F., Folstein, S.E., McHugh, P.R., 1975. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J. Psychiatr. Res. 12, 189–198.

Guigoz, Y., Vellas, B.J., Garry, P.J., 1994. Mini Nutritional Assessment: a practical assessment tool for grading the nutritional state of elderly patients. Facts Res. Gerontol. 4, 15–59.

Hellström, K., Lindmark, B., 1999. Fear of falling in patients with stroke: a reliability study. Clin. Rehabil. 13, 509–517.

Jensen, E., Dehlin, O., Gustafson, L., 1993. A comparison between three psychogeriatric rating scales. Int. J. Geriatr. Psychiatry 8, 215–229.

Jensen, J., Lundin-Olsson, L., Lindmark, B., Nillbrand, A., Gustafson, Y., 1998. Bergs balansskala: Prövning av interbedömarreliabilitet (The Berg Balance Scale: testing interrater reliability). Nordisk Fysioterapi (Nordic Physiotherapy) 2, 3–8 (in Swedish).

Jensen, J., Lundin-Olsson, L., Nyberg, L., Gustafson, Y., 2002a. Fall and injury prevention in older people living in residential care facilities. A cluster randomized trial. Ann. Intern. Med. 136, 733–741.

Jensen, J., Lundin-Olsson, L., Nyberg, L., Gustafson, Y., 2002b. Falls among frail older people in residential care. Scand. J. Public Health 30, 54–61.

Kallin, K., Lundin-Olsson, L., Jensen, J., Nyberg, L., Gustafson, Y., 2002. Predisposing and precipitating factors for falls among older people in residential care. Public Health 116, 263–271.

Kallin, K., Gustafson, Y., Sandman, P.O., Karlsson, S., 2004. Drugs and falls in older people in geriatric care settings. Aging Clin. Exp. Res. 16, 270–276.

Katz, S., Ford, A., Moskowitz, R., 1963. Studies of illness in the aged. The Index of ADL a standardized measure of biological and psychosocial function. J. Am. Med. Assoc. 185, 914–919.

Lehtola, S., Koistinen, P., Luukinen, H., 2006. Falls and injurious falls late in home-dwelling life. Arch. Gerontol. Geriatr. 42, 217–224.

Liu, B.A., Topper, A.K., Reeves, R.A., Gryfe, C., Maki, B.E., 1995. Falls among older people: relationship to medication use and orthostatic hypotension. J. Am. Geriatr. Soc. 43, 1141–1145.

Luukinen, H., Koski, K., Hiltunen, L., Kivelä, S.L., 1994. Incidence rate of falls in an aged population in northern Finland. J. Clin. Epidemiol. 47, 843–850.

Luukinen, H., Koski, K., Honkanen, R., Kivelä, S.L., 1995. Incidence of injury-causing falls among older adults by place of residence: a population-based study. J. Am. Geriatr. Soc. 43, 871–876.

Marottoli, R.A., Berkman, L.F., Leo-Summers, L., Cooney Jr., L.M., 1994. Predictors of mortality and institutionalization after hip fracture: the New Haven EPESE cohort. Established Populations for Epidemiologic Studies of the Elderly. Am. J. Public Health 84, 1807–1812.

Miller, M., 2003. Disorders of the thyroid. In: Tallis, R.C., Fillit, H.M. (Eds.), Brocklehurst's Textbook of Geriatric Medicine and Gerontology. sixth ed. Elsevier Science Limited, London, pp. 1165–1179.

Montgomery, S.A., Åsberg, M., 1979. A new depression scale designed to be sensitive to change. Br. J. Psychiatry 134, 382–389.

Mulrow, C.D., Gerety, M.B., Kanten, D., Cornell, J.E., DeNino, L.A., Chiodo, L., Aguilar, C., O'Neil, M.B., Rosenberg, J., Solis, R.M., 1994. A randomized trial of physical rehabilitation for very frail nursing home residents. J. Am. Med. Assoc. 271, 519–524.

Myers, A.H., Young, Y., Langlois, J.A., 1996. Prevention of falls in the elderly. Bone 18, 87S–101S.

Nevitt, M.C., Cummings, S.R., Kidd, S., Black, D., 1989. Risk factors for recurrent nonsyncopal falls. A prospective study. J. Am. Med. Assoc. 261, 2663–2668.

Nevitt, M.C., Cummings, S.R., Hudes, E.S., 1991. Risk factors for injurious falls: a prospective study. J. Gerontol. 46, M164–M170.

Nowalk, M.P., Prendergast, J.M., Bayles, C.M., D'Amico, F.J., Colvin, G.C., 2001. A randomized trial of exercise programs among older individuals living in two long-term care facilities: the Falls FREE program. J. Am. Geriatr. Soc. 49, 859–865.

Robertson, M.C., Campbell, A.J., Gardner, M.M., Devlin, N., 2002. Preventing injuries in older people by preventing falls: a meta-analysis of individual-level data. J. Am. Geriatr. Soc. 50, 905–911.

Rosendahl, E., Lundin-Olsson, L., Kallin, K., Jensen, J., Gustafson, Y., Nyberg, L., 2003. Prediction of falls among older people in residential care facilities by the Downton index. Aging Clin. Exp. Res. 15, 142–147.

Rubenstein, L.Z., Josephson, K.R., Robbins, A.S., 1994. Falls in the nursing home. Ann. Intern. Med. 121, 442–451.

Saari, P., Heikkinen, E., Sakari-Rantala, R., Rantanen, T., 2007. Fall-related injuries among initially 75- and 80-year old people during a 10-year follow-up. Arch. Gerontol. Geriatr. 45, 207–215.

Schwartz, A.V., Villa, M.L., Prill, M., Kelsey, J.A., Galinus, J.A., Delay, R.R., Nevitt, M.C., Bloch, D.A., Marcus, R., Kelsey, J.L., 1999. Falls in older Mexican-American women. J. Am. Geriatr. Soc. 47, 1371–1378.

Sheikh, J., Yesavage, J., 1986. Geriatric Depression Scale (GDS): recent evidence and development of a shorter version. Clin. Gerontol. 5, 165–172.

Sjögren, H., Björnstig, U., 1989. Unintentional injuries among elderly people: incidence, causes, severity, and costs. Accid. Anal. Prev. 21, 233–242.

Sonn, U., 1996. Longitudinal studies of dependence in daily life activities among elderly persons. Scand. J. Rehabil. Med. Suppl. 34, 1–35.

Swedish Rescue Services Agency (Räddningsverket), 2003. Injuries of Older People in Sweden (Äldres skador i Sverige). , ISBN: 91-7253-203-3 (in Swedish).

Thapa, P.B., Gideon, P., Fought, R.L., Kormicki, M., Ray, W.A., 1994. Comparison of clinical and biomechanical measures of balance and mobility in elderly nursing home residents. J. Am. Geriatr. Soc. 42, 493–500.

Thapa, P.B., Gideon, P., Cost, T.W., Milam, A.B., Ray, W.A., 1998. Antidepressants and the risk of falls among nursing home residents. N. Engl. J. Med. 339, 875–882.

Thorngren, K.G., Hommel, A., Norrman, P.O., Thorngren, J., Wingstrand, H., 2002. Epidemiology of femoral neck fractures. Injury 33, C1–C7.

Tinetti, M.E., Williams, C.S., 1997. Falls, injuries due to falls, and the risk of admission to a nursing home. N. Engl. J. Med. 337, 1279–1284.

Tinetti, M.E., Speechley, M., Ginter, S.F., 1988. Risk factors for falls among elderly persons living in the community. N. Engl. J. Med. 319, 1701–1707.

Tombaugh, T.N., McIntyre, N.J., 1992. The mini-mental state examination: a comprehensive review. J. Am. Geriatr. Soc. 40, 922–935.

United Nations, 2005. World Population Prospects: The 2004 Revision. United Nations Publication, Sales No. E.05.XIII.4.

von Heideken Wågert, P., Gustavsson, J.M.C., Lundin-Olsson, L., Kallin, K., Nygren, B., Lundman, B., Norberg, A., Gustafson, Y., 2006. Health status in the oldest old. Age and sex differences in the Umeå 85+ Study. Aging Clin. Exp. Res. 18, 116–126.