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Original Article

Different Risk Profiles for Hip Fractures and Distal Forearm Fractures: A Prospective Study

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Abstract. In a prospective cohort of elderly persons, aged 70 years and over, we examined risk indicators for which data could be easily obtained, to construct risk profiles for hip fractures and distal forearm fractures. Participants lived independently, in apartment houses for the elderly or in homes for the elderly. At baseline, information was obtained in 2578 subjects on age, gender, residence, mobility and the frequency of going outdoors. Mobility was measured using a walking score ranging from 1 (not able to walk independently) to 3 (able to walk independently for a fair distance). During the study period (median duration 3.5 years, maximum 4 years) 106 participants sustained a hip fracture and 60 participants suffered a distal forearm fracture. Women compared with men, adjusted for age, had a higher risk of hip fracture (adjusted relative risk (RR) = 2.4, 95% confidence interval (CI) 1.3–4.3) and distal forearm fracture (RR = 3.7, 95% CI 1.5–9.2). Age, adjusted for gender, was related to hip fractures only: the relative risk of fracture for those in the highest age category (>85 years) was 9.5 (95% CI 4.3–21.2) compared with those in the lowest age category (70–75 years). Moderately impaired walking ability compared with normal walking ability, adjusted for age and gender, was associated with a higher risk of hip fracture (RR = 1.8, 95% CI 1.2–2.7) but with a lower risk of distal forearm fracture (RR = 0.4, 95% CI 0.2–0.8). The outdoor score, adjusted for age and gender, was associated with distal forearm fractures only: going outdoors less than once a week, compared with three times or more, was associated with a lower risk of fractures (RR = 0.3, 95% CI 0.1–0.9). In those living in homes for the elderly the risk of hip fracture was higher compared with those living independently (RR = 2.4, 95% CI 1.4–4.2), adjusted for age and gender. Risk profiles were constructed using stepwise Cox's proportional-hazards regression. The risk profile predicted probabilites of sustaining a hip fracture in a 4-year period ranging from 0.4% to 25.9%, and of distal forearm fractures ranging from 0.2% to 4.5%, depending on the subject's characteristics as defined by the risk indicators. We conclude that easily obtainable risk indicators can be used in the prediction of fractures and can discriminate among fracture types.

Keywords: Elderly people; Fracture prediction; Hip fractures; Risk indicators

Introduction

Fractures of the hip and wrist are among the most common fractures in elderly people. Hip fractures in particular often impose considerable morbidity. The identification of important indicators of fracture risk will guide the development and application of preventive strategies. Fracture risk in the elderly is usually assessed by bone mineral density (BMD) measurements [1]. Low BMD is clearly only one of the prognostic variables for fracture risk. Besides BMD, other variables such as mobility, visual acuity, medication, anthropometric measures and falls have been shown to predict fractures [2–7]. The utility of assessing predictors of fracture risk depends on the strength of the

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relationship. Furthermore, while the diagnosis of osteoporosis informs about the bone-related aspect of fracture risk, other predictors may provide different information and may discriminate among different types of fractures – for example by the type of fall or the reaction to the fall [8]. The fact that age is a predictor of hip fractures but not of wrist fractures [6,9] suggests the usefulness of factors other than osteoporosis in the prediction of fractures. In this study we examined risk profiles for hip fractures and distal forearm fractures, based on some easily obtained risk indicators.

Subjects and Methods

The study comprised 2578 persons (1916 women and 662 men), 70 years of age and older (mean age ± SD, 80 ± 6 years; range 70–97 years). Participants were recruited from general practitioners (1047), from apartment houses for elderly persons (505) and from homes for elderly persons (1026) in Amsterdam and its vicinity. Persons recruited from general practitioners were living independently; those recruited from apartment houses and homes were receiving some care, but less than in a nursing home. Subjects participated in a double-blind clinical trial on the prevention of hip fractures by vitamin D supplementation. Participants received vitamin D (400 IU) daily or placebo during a maximum period of 3.5 years. Exclusion criteria were a history of hip fracture or total hip arthroplasty, known hypercalcemia, sarcoidosis, or recent urolthiasis (<5 years earlier). As vitamin D did not protect against hip fractures and other non-vertebral fractures [10], we assumed an unbiased cohort. Median, maximum and total follow-up duration were 3.5 and 4 years and 8450 person-years, respectively. During the follow-up period, 588 participants died and 14 were lost to follow-up.

The participants were visited every year with a questionnaire on hip fractures and other non-vertebral fractures. The general practitioner or caretaker was asked to report hip fracture or death immediately. Fractures were categorized as hip fractures, distal forearm fractures (wrist, hand and fingers) and other non-vertebral fractures. Vertebral fractures were not registered since spinal radiographs were not taken.

Age, gender, residence, mobility and the frequency of going outdoors were registered at baseline. Mobility was estimated by a questionnaire containing a walking score ranging from 1 to 5 [11]: (1) not able to walk; (2) able to walk with the assistance of two persons or one person and walking aid; (3) able to walk with a walking aid under supervision; (4) able to walk a short distance on a smooth surface with or without the use of a walking aid; (5) able to walk independently for a fair distance on any surface (including stair climbing). The frequency of going outdoors was estimated by an outdoor score for the period April to September in the previous year: going outdoors (1) less than once a week; (2) once or twice a week; (3) three times or more per week.

Data Analysis

The walking score was simplified (1, 2, 3 = 1, 4 = 2, 5 = 3), as the lower scores applied to a few participants only. The resulting mobility score, ranging from 1 to 3, was used for analysis. The variables age, residence, mobility and the outdoor score were analyzed as categorical variables. The relationships between hip fractures, distal forearm fractures and other non-vertebral fractures versus the putative risk indicators were tested using Cox's proportional-hazards regression; participants were included for either the total follow-up period or until death, first hip fracture, first distal forearm fracture or first other non-vertebral fracture. Since few participants suffered more than one type of fracture, they were included as fracture patients in more than one regression model. Analysis on each risk indicator adjusted for age or gender or both was performed in relation to hip fractures, distal forearm fractures and other non-vertebral fractures. Risk profiles were constructed to gain a better insight into the independent relationships between the risk indicators and the fracture types. The risk-profile model was constructed using stepwise Cox's proportional-hazards regression (backwards elimination $p<0.10$). Estimated probabilities of fractures over a 4-year period were calculated using beta coefficients and the baseline risk in the risk-profile regression model [12].

Results

The numbers of participants who sustained a hip, distal forearm or another non-vertebral fracture during the study period are presented in Table 1. A total of 111 hip fractures and 157 non-hip and non-vertebral fractures occurred. Five participants sustained a hip fracture on both sides and 11 sustained a hip fracture as well as another fracture. Two participants sustained a wrist and a hand fracture, resulting in 60 patients with a distal forearm fracture. The incidence density per 1000 person-years (ID) for hip fractures was 14.9 for women and 6.2 for men and 25.5 for women living in homes for the elderly. The IDs for distal forearm fractures and other non-vertebral fractures were 8.5 and 12.9 for

Table 1. Number of men and women who sustained a hip fracture or other non-vertebral fracture during follow-up

Fractures	No. of participants	
	Women	Men
Hip fracture	93	13
Other non-vertebral fractures (total)*	135	16
Wrist	40	2
Hand/fingers	16	4
Other	80	11

*Two particpants suffered more than one other non-vertebral fracture.

Table 2. Risk indicators and the adjusted[a] relative risk (RR) and 95% confidence interval (95% CI) for hip fractures, distal forearm fractures and other non-vertebral fractures according Cox's regression analysis

Risk indicator	n	Hip fractures			Distal forearm fractures			Other fractures		
		p value[b]	RR	95% CI	p value	RR	95% CI	p value	RR	95% CI
Age (years)		$p<0.0001$			$p=0.62$			$p=0.55$		
70–75	631		1.0			1.0			1.0	
>75–80	688		2.4	1.0–5.8		1.2	0.6–2.6		0.8	0.5–1.4
>80–85	728		5.4	2.4–12.2		1.0	0.5–2.1		0.7	0.4–1.2
>85	531		9.5	4.3–21.2		1.5	0.7–3.2		0.8	0.4–1.5
Gender		$p=0.02$			$p=0.005$			$p=0.004$		
male	662		1.0			1.0			1.0	
female	1916		2.4	1.3–4.3		3.7	1.5–9.2		2.5	1.4–4.8
Mobility[c]		$p=0.03$			$p=0.01$			$p=0.61$		
3 (normal walking)	1699		1.0			1.0			1.0	
2 (moderately impaired)	691		1.8	1.2–2.7		0.4	0.2–0.8		0.8	0.5–1.3
1 (severely impaired)	188		1.5	0.8–2.9		0.2	0.0–1.1		0.7	0.3–1.9
Outdoor score[a]		$p=0.24$			$p=0.02$			$p=0.50$		
3 (≥3 times/week)	1974		1.0			1.0			1.0	
2 (1 or 2 times/week)	297		1.4	0.9–2.4		0.2	0.1–0.9		1.4	0.8–2.7
1 (<1 time/week)	305		0.8	0.5–1.5		0.3	0.1–0.9		1.1	0.5–2.2
Residence		$p=0.006$			$p=0.16$			$p=0.008$		
Independent	1047		1.0			1.0			1.0	
Apartment for elderly	505		1.4	0.7–2.8		1.1	0.6–2.1		1.8	1.0–3.1
Home for elderly	1026		2.4	1.4–4.2		0.6	0.3–1.1		1.7	1.0–3.0

[a] Age is adjusted for gender and vice versa; the other risk indicators are adjusted for age and gender.
[b] Chi-square test for the contribution of the risk indicator.
[c] Adapted from the 5-point walking score.
[d] Outdoor score not obtained in two participants.

Table 3. Risk indicators and the adjusted relative risk (RR) and 95% confidence interval (95% CI) for hip fractures, distal forearm fractures and other non-vertebral fractures after stepwise Cox's regression analysis[a]

Indictors in profile	Hip fractures		Distal forearm fractures		Other fractures	
	RR	95% CI	RR	95% CI	RR	95% CI
Age (years)						
70–75	1.0					
>75–80	1.9	0.8–4.7				
>80–85	3.5	1.5–8.2				
>85	5.3	2.2–12.8				
Gender						
male	1.0		1.0		1.0	
female	1.9	1.0–3.4	4.1	1.6–10.2	2.5	1.4–4.8
Mobility						
3 (normal walking)	1.0		1.0			
2 (moderately impaired)	1.8	1.1–2.8	0.4	0.2–0.9		
1 (severely impaired)	1.7	0.9–3.5	0.2	0.0–1.3		
Outdoor score						
3 (≥3 times/weekly)	1.0					
2 (1 or 2 times/week)	1.0	0.6–1.7				
1 (<1 time/week)	0.5	0.3–0.9				
Residence						
Independent	1.0					
Apartment for elderly	1.4	0.7–2.8				
Home for elderly	2.1	1.2–3.8				

[a] All risk indicators are adjusted for the other risk indicators. Those risk indicators which did not significantly contribute to the prediction of fractures were eliminated from the model.

women, and 2.4 and 5.3 for men, respectively. Most hip fractures occurred indoors (92%), usually as a result of a fall from standing height or less (94%).

Results of the risk indicator analysis of age, gender, mobility, outdoor score and residence for the fracture types are shown in Table 2. No significant interaction was found among the risk indicators in their relation with fracture risk. Subsequently, age, gender, mobility score, outdoor score and residence were included in the risk-profile model for hip fractures (Table 3). Excluding men from the analyses did not change the results. While the observed risk of hip fracture in a 4-year period was 5.0% in the total population, it ranged from 0.4% to 25.9% depending on the subject characteristics as defined by the risk indicators in the model. The 25th and 75th percentiles of the estimated risk of hip fracture were 1.8% and 9.2%, respectively, and the estimated risk was 15% or higher for 233 persons (9% of the population). Independently living men in the lowest age category with normal mobility, going outdoors less than once a week, showed the lowest risk. The highest risk of hip fracture was estimated for institutionalized women in the highest age group with impaired mobility going outdoors once or twice a week. In those who suffered a hip fracture the estimated risk of fracture based on the subject characteristics as defined by the risk indicators in the model was 9.0%, range 1.2–25.9% (25th and 75th percentiles: 5.1% and 14.1%). The risk-profile model for distal forearm fractures contained gender and mobility score (Table 3). While the observed risk of distal forearm fracture in a 4-year period in the total population was 2.8%, it ranged from 0.2% to 4.5%, depending on gender and the mobility score. The lowest risk was estimated for men with impaired mobility and the highest for women with normal mobility. Only gender remained in the risk-profile model for other non-vertebral fractures after stepwise Cox's regression (Table 3). The estimated risk of other non-vertebral fractures in the total population was 4.4%, ranging from 2.0% for men to 5.0% for women.

Discussion

Hip fractures and distal forearm fractures were differently related to some simple prognostic variables. Age was related to hip fractures only. The mobility score was inversely related to distal forearm fractures compared with hip fractures. Gender appeared to be a common risk indicator for both fracture types, which is probably caused by the loss of bone after menopause. The findings with respect to age and gender have also been reported in previous studies [6,9,13]. The high incidence of hip fractures in residents of homes for the elderly (25.5 per 1000 person-years) compared with the total population confirms previous results in the population of Amsterdam [14]. Other fractures, not of the hip or distal forearm, were related to gender only.

The risk-profile model gives insight into the range of fracture risks based on the information supplied by significantly contributing indicators. However, the risk profile cannot automatically be applied to other populations. Furthermore, some patient characteristics expressed as combinations of risk indicators in the model, apply to a few participants only. Within the range of the predicted risk of fracture (e.g. 0.4–25.9% for hip fractures), especially the higher risk should be regarded as an extrapolation of the results. Comparison of the observed versus the expected risk is only possible when enough participants are available. The observed risk of hip fracture in a 4-year period for women with impaired mobility living in homes for the elderly was 9.8%, while the predicted risk was 10.3%. Comparison of the prediction of fractures by the risk profiles used in this study with the prediction by BMD measurements is difficult since it requires a similar study design and study population. BMD measurements have been shown to predict hip fracture probability in the range 17–43% in a 6-year period [7]. Although the prediction of fractures by simple risk indicators may be not as effective as by BMD measurements, other risk factors, not related to bone, have been shown to supply additional information to BMD in the prediction of hip fractures [4,15,16]. Other easily obtainable risk indicators, not included in this study (e.g. body weight and height), may improve the prediction and differentiation of fracture types. Other fractures, not of the hip or distal forearm, showed the smallest range of estimated risks, being determined by gender only. This is probably due to the heterogeneity in this fracture category.

From an etiological point of view, falls are of crucial importance in explaining these results. The majority of fractures result from falls and the circumstances of a fall determine the type and extent of injury that will ensue [17]. Falls to the side were more common in patients with hip fractures compared with other types of fractures [15]. It has been suggested that wrist fractures are more common in a younger population compared with hip fractures, due to the type of falls involved [18,19]. The occurrence of falls and the type of fall are related to numerous factors, such as physical capacity and physical activity, which were assessed by the mobility score and the outdoor score, respectively. Despite the lower risk of hip fracture for those going outdoors less than once a week, most hip fractures occurred indoors. However, the outdoor score probably reflects a measure of activity level outdoors as well as indoors. The risk for falls has been shown to be higher for mobile unstable persons compared with the very immobile and very mobile persons [20]. This suggests a conflict between physical capacity and high-risk activity or environmental threats, especially in this category with moderate impairment of mobility. The present study also demonstrated a higher risk of hip fracture in those with moderately impaired mobility. Physical inactivity has been shown to be an independent risk factor for hip fractures [21,22]. However, going outdoors less than once a week was protective for hip fractures, which is probably due to the low exposure to environmental threats. This contradiction may be caused by the close linkage of physical capacity and activity. Since physical capacity generally dictates the level of activity, it is difficult to analyze their independent relationships with fractures. The risk of distal forearm fractures was higher in the more active and mobile persons. Physically capable people will respond to a fall with an adequate reaction (e.g. stretching out the hands) to diminish the impact. Physically impaired people, however, will react slower and fall on the hip. Furthermore, a higher speed of gait corresponds with falls forwards, while low gait speed corresponds with falls to the side with impact on the hip [18]. We may assume that the more mobile elderly are exposed more to environmental hazards and that they respond to a fall by an adequate physical reaction, suffering more non-hip fractures such as Colles' fracture. The elderly with impaired mobility are less exposed to hazardous situations, but when they fall they are more likely to fall on the hip and subsequently fracture it.

In this study it has been shown that different risk profiles apply to different fracture types. Information obtained on simple risk indicators combined with BMD measurements may provide a more detailed analysis of the risk of different fracture types.

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