3.4

Predictors of Fractures

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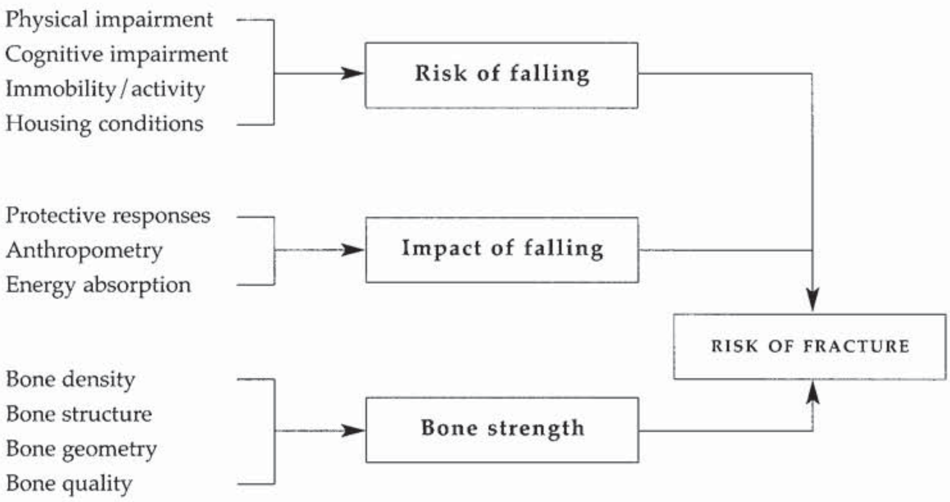
Introduction

Osteoporotic fractures constitute an increasing problem in the elderly population. Osteoporosis has been defined as a disease characterized by low bone mass and micro-architectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fractures (Consensus Development Conference 1993). Typical osteoporotic fractures are fractures of the hip, the vertebrae, the wrist and the humerus, and most fractures in the elderly result from falls. Approximately 5% of all falls result in fractures, and 90% of hip fractures are caused by a fall (Grisso et al. 1991, Nevitt et al. 1991). Falls may be caused by intrinsic factors (e.g., advanced age, specific diseases, gait disorders) or by extrinsic factors (e.g., environmental and housing conditions), but usually a combination of factors is responsible for a fall. However, not only falls play a dominant role in the risk of fractures, but also the impact of the fall and bone strength, as shown in Figure 3.4. The impact of a fall depends on protective responses (e.g. stretching out the hands) and the quantity of adipose tissue around the hip which might reduce the impact on the upper femur during a fall. Bone strength, the third conceptual determinant for fractures, depends on the maximal quantity and strength of bone achieved during a person's lifetime, and the rate at which the bone subsequently deteriorates (Consensus Development Statement 1997). Bone strength can be assessed by measuring the bone density by means of dual X-ray absorptiometry or by ultrasound transmission through the bone tissue.

This chapter presents the results of a prospective study on the predictors of fractures in an elderly cohort of the Longitudinal Aging Study Amsterdam (LASA). The following potential predictors for each of the three determinants of fractures were examined: physical impairments, cognitive impairments, inactivity, immobility and housing conditions (for risk of falling); muscle strength and anthropometry (for impact of falling); ultrasound bone density (for bone strength). The objective of the study was to determine easily measurable predictors of fractures in elderly people.

Autonomy and Well-being in the Aging Population II, edited by Dorly J.H. Deeg et al.
Amsterdam: VU University Press, 1998



Methods

Study sample

The study involved a sub-sample of the LASA cohort, comprised of LASA participants who were born in or before 1930 (aged 65 years and older on the reference date of 1st January 1996). The baseline data-collection took place during the first LASA interview (1992) and the outcome of the occurrence of fractures over a period of three years was registered during the second LASA interview (1995). 1720 subjects were eligible for participation in the follow-up study. 1509 subjects, 781 women and 728 men, participated in the follow-up study. The response rate was 87.7%.

Study variables

In the baseline LASA interview, an assessment was made of physical function, cognitive function, level of physical activity and mobility, and housing conditions (risk of falling), muscle strength and anthropometry (impact of falling).

The assessment of physical function included questions concerning vision and hearing problems, an expiratory peak flow test and a registration of fractures prior to the baseline LASA interview. Expiratory peak flow was measured as an indicator of general physical capacity. Poor distant vision and hearing problems were determined by asking the participant whether he / she could recognize someone's face at a distance of 4 metres (with glasses or contact lenses if necessary) and whether he / she could follow a conversation in a group of 4 people (with a hearing aid if necessary). In the expiratory peak flow test, the participant was asked to blow as hard and as quickly as possible into the peak flow measurement instrument. Cognitive function was determined by means of the Folstein Mini Mental State Examination (MMSE). Participants were classified as having a cognitive impairment if their MMSE score was 24 or less (Folstein et al. 1975). The level of physical activity was assessed by means of a questionnaire for the elderly, which covered household activities, sports and leisure activities (Caspersen et al. 1991, Voorrips et al. 1991). The participant was asked whether he/she had taken part in any sports activities during the previous two weeks. The scores for leisure and household activities, which included walking outdoors, cycling and doing heavy housework, were combined into a total physical activity score (range: 0–3). Respondents who had participated in none of these activities were given a score of 0, whereas a score of 3 was given for participation in all three activities. The level of mobility was assessed by means of a walking test, in which the time needed to walk three metres back and forth beside a rope was measured (Deeg 1994). Housing conditions were assessed by asking whether the participant's house had been specially adapted, i.e. lowered doorstep, special handrails or supports, adapted toilet and anti-slip in the bathroom. Muscle strength was assessed by means of a chair stand test, in which the time needed to stand up and sit down five times with arms crossed was measured (Deeg 1994). Anthropometry included measurements of body weight and body height from which body mass index (BMI) was calculated.

In the second LASA interview, ultrasound measurements of the bone tissue of the heel were performed with the CUBA clinical instrument (McCue Ultrasonics Limited, Winchester, UK). Two ultrasound parameters were measured, the velocity of sound (VOS) through bone and the broad-band ultrasound attenuation in bone (BUA) (for detailed information, see Graafmans et al. 1996, Methods section).

Statistical analysis

The relationship between fractures and their potential predictors was examined by means of bivariate logistic regression analysis. Odds ratios (OR) and 95% confidence intervals (CI) were calculated for each individual predictor of the occurrence of fractures between the first and the second LASA interview.

Results

Occurrence of fractures

The mean follow-up period between the first LASA interview and the registration of fractures was 37.7 months (standard deviation (SD) = 2.2). The mean age and SD at the first LASA interview were 72.3 ± 6.7 years (range 61–85 years). A total of 92 fractures were recorded, which included 14 hip fractures, 25 wrist fractures, 9 fractures of the humerus and 44 other fractures. Nine participants sustained two fractures during the follow-up period. The age-specific rates and incidence density of fractures are shown in Table 3.11. The incidence density per 1000 person years for fractures was 25.8 for women and 8.8 for men, and for hip fractures it was 4.5 for women and 1.3 for men (data not shown).

Predictors of fractures

The odds ratios for predictors of osteoporotic fractures are presented in Table 3.12. Older age and female gender were significantly associated with fractures. Participants with physical impairments, such as vision problems, low peak flow rate and fractures sustained in the past, were at increased risk for the occurence of a fracture. Hearing problems were not related to fractures.

Table 3.11
Age-specific rates and incidence density of fractures in the previous three years for women and men (n=1509)

Age at baseline (y)	Number of respondents	Number of fractures	Person years of follow-up (persons/year)	Incidence density of fractures (per 1000 person/years)
Women				
61–64	121	4	382.5	10.5
65–69	188	13	583.3	22.3
70–74	158	13	496.8	26.2
75–79	168	15	523.7	28.6
≥ 80	146	18	458.0	39.3
Total	781	63	2444.1	25.8
Men				
61–64	116	4	364.3	11.0
65–69	174	4	547.5	7.3
70–74	153	3	483.4	6.2
75–79	158	3	493.6	6.1
≥ 80	127	6	396.1	15.2
Total	728	20	2285.2	8.8

Table 3.12

Prevalence of, odds ratio and 95% confidence interval for predictors of fractures (17.3 per 1000 person years) in the previous three years (n=1509)

Predictors	Prevalence or mean ± SD	Fractures[c]	
		OR[a]	95% CI[a]
General predictors			
Older age (per 1 SD)	72.3 ± 6.7 yrs	1.3	(1.1–1.6)*
Female gender	52 %	3.1	(1.9–5.2)*
Predictors for falls			
Vision problems	16 %	2.4	(1.5–4.0)*
Hearing problems	11 %	1.0	(0.5–2.0)
Low peak flow (per 1 SD)	398 ± 125 ml/sec	1.6	(1.2–2.0)*
Past fractures	28 %	2.2	(1.4–3.4)*
Cognitive impairment[b]	12 %	1.1	(0.6–2.2)
Low level of activity (per 1 SD)[b]	0.8 ± 0.8 pts	1.6	(1.2–1.9)*
Low level of mobility (per 1 SD)[b]	8.5 ± 3.7 sec	1.3	(1.1–1.6)*
Special fall-related adaptations in the home	22 %	1.3	(0.8–2.1)
Predictors modifying impact of fall			
Low muscle strength (per 1 SD)[b]	12.9 ± 4.3 sec	1.3	(1.0–1.5)*
Tall body height (per 1 SD)	1.67 ± 0.09 m	0.8	(0.6–1.0)*
Low body weight (per 1 SD)	75.1 ± 12.5 kg	1.3	(1.0–1.6)*
Low BMI (per 1 SD)[a]	26.9 ± 4.1 kg/m^2	1.1	(0.8–1.3)
Bone strength			
Low VOS (per 1 SD)[a,c]	1622.3 ± 49.7 m/sec	1.4	(1.2–1.5)*
Low BUA (per 1 SD)[a,c]	70.7 ± 20.4 dB/MHz	4.9	(2.6–9.0)*

* $p < 0.05$

a SD, standard deviation; OR, odds ratio; CI, confidence interval; BMI, body mass index; VOS, velocity of sound; BUA, broadband ultrasound attenuation

b See Methods for definition

c Measured retrospectively

Cognitive impairment was not associated with fractures. Although sports activities were performed by 56% of the participants, no significant association was found between this predictor and the incidence of fractures (OR=1.1, 95% CI: 0.7–1.7). The leisure and household activities of walking outdoors, cycling and doing heavy housework were not performed by 11%, 39% and 32% of the participants, respectively. Participants with a lower physical activity score were at increased risk for fractures. A lower level of mobility, i.e. more time needed to perform the walking test, was associated with a higher risk of fractures. Special adaptations in the home were not associated with fractures.

Participants with lower muscle strength, who needed more time to perform the chair stand test, were at increased risk for fractures. Body mass index was not associated with fractures, whereas low body weight and greater body height were significantly associated with fractures. The ultrasound parameters, VOS and BUA, showed a significant association with fractures.

Discussion

This study shows that age, gender, various physical impairments, level of activity and mobility, muscle strength, body height, body weight and bone strength are significantly associated with fractures. In the Netherlands, the incidence of hip fractures in 1987 for women and men between 60 and 84 years of age was 5.2 and 2.7 per 1000 person year, respectively (Boereboom et al. 1992). The incidence of hip fractures found in this study was lower, which gave the impression that the incidence of fractures in general was also lower. This could be due to selective non-response (the most elderly and females were less likely to respond) and to the method of fracture registration (reported by the respondents themselves, retrospectively). The incidence of fractures is higher in women than in men because women have a lower bone density and they are somewhat more likely to fall than men (Campbell et al. 1990).

In recent decades, the incidence of fractures has increased, and a number of possible causes have been postulated for this trend: decreased physical activity, increased body height and changes in nutrition (Cooper 1989). In this study, it was found that low levels of activity and mobility increased the risk of fractures, although no association was found between participation in sport and fractures. Sports activities might have a twofold effect on fracture risk. On the one hand, increased mechanical forces on the bone might increase bone strength and decrease the risk of fractures (Smith et al. 1995), but on the other hand, sports activities might imply increased exposure to environmental threats, and thus increase the risk of fractures.

Physical impairments, such as vision problems, low peak flow rate and history of fractures were predictors of fractures in this study. However, no association between cognitive impairment and fractures was found, probably because the prevalence of cognitive impairment was less frequent in these community dwelling subjects in comparison with a previous study in institutionalized elderly (Graafmans et al. 1996).

The greater length from the hip to ground level in tall people may cause a greater impact of the fall and, consequently, could increase the risk of hip fractures. However, a protective effect of body height on fractures was found, and no association was found between body height and hip fractures. Participants with a high body weight were found to be at a lower risk for fractures in this study. Increased body weight causes higher loading of the skeleton, and might subsequently stimulate bone formation (Ooms et al. 1993). Moreover, fat tissue increases the production of oestrogens after menopause, and thus protects the female skeleton. Fat tissue also decreases the impact of falls on the skeleton (Malmivaara et al. 1993).

In addition to factors related to the risk of falling and the impact of falling, an association was also found between bone strength and osteoporotic fractures. Lower ultrasound values of the VOS and the BUA were found in participants with fractures. However, these results are difficult to interpret, since these measurements were taken at follow-up i.e. after the period during which the incidence of fractures was determined. Fractures often lead to immobilization, and may consequently affect bone density and muscle strength. Therefore, subsequent ultrasound measurements are not related to bone strength at the time of the fracture.

The findings of this study indicate that the three above-mentioned conceptual determinants of fractures are essential in the assessment of the risk of osteoporotic fractures. After assessment of the predictors of fractures, preventive strategies can be developed. A prevention programme for the sub-groups most at risk for fractures includes calcium and vitamin D supplements, bisphosphonates and hormone replacement therapy (Lips 1996)(prevention of rapid bone loss). Non-drug therapy should also be considered, for instance physical exercise to improve balance, strength, and endurance in the prevention of falls, and protective hip-padding to reduce the impact of falls (Lauritzen et al. 1993). In the near future, prospective longitudinal data on fractures will be available from the LASA cohort. It will then be possible to carry out an unconfounded study of possible predictors of fractures.

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