How well can a previous fracture indicate a new fracture?

A questionnaire study of 29,802 postmenopausal women

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In a population-based, retrospective study, we investigated the effect of a previous fracture on the risk of a later fracture. A questionnaire was mailed to 46,353 postmenopausal women aged 50–80 years and 29,802 (64%) responded. Questions were asked about fractures after age 25 and in what year they had occurred. The fractures were grouped according to whether they occurred within 5 and 10 years before answering the questionnaire. The occurrence of a fracture preceding these time intervals increased the odds ratio (OR) of having sustained a hip fracture to 1.6 (95% CI 1.1–2.3) for a previous ankle fracture and to 3.5 (95% CI 2.4–5.0) for a previous humerus fracture. Corresponding figures for having sustained a spine fracture were 1.5 (95% CI 1.1–2.1) for a previous ankle fracture and 4.5 (95% CI 3.4–5.9) for a previous spine fracture.

It seems possible to select women for evaluation and intervention against osteoporosis by using information on previous fragility fractures.

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Submitted 97-09-07. Accepted 98-05-14

Bone mass has been shown to predict fracture well (Hui et al. 1988, Wasnich et al. 1989, Cummings et al. 1990, Gärdsell et al.1991). A 1 SD decline in bone mass has been estimated to correspond to an increase of 50–300% in fracture risk (Hui et al. 1989, Gärdsell et al 1991). In a meta-analysis, Marshall et al. (1996) found that bone mineral density could predict future fractures in the same way, or slightly better than blood pressure could predict stroke. To predict hip fractures, the best site to measure was at the hip and the relative risk of a 1 SD decrease in bone mass was 2.6. Search for predictors of fracture risk other than bone mass is of particular interest in a global health care perspective, as bone mass measurement presently is available only for small populations. Although previous attempts to find historical risk factors to predict fracture risk have not been successful (Wasnich et al. 1987, Kleerekoper et al. 1989, Slemenda et al. 1990), it has been demonstrated that a pre-existing fracture can predict a new fracture, independently of bone mass (Gärdsell et al.1989, Ross et al. 1991, 1993, Lauritzen et al. 1993, Mallmin et al. 1993, Cummings et al. 1995, Johnell 1998). These findings suggest that previous fractures are indicators of new fractures independently of densitometry. There are several possible mechanisms for an increased postfracture risk. Irreversible bone loss after a fracture, mechanical deformity and an increased propensity to fall are possible explanations of the increased risk due to osteoporosis. A fracture can thus reflect reduced bone mass and reduced bone quality not detected by densitometry.

We investigated whether a previous fracture is a good predictor of a new fracture, adjusted for possible confounders.

Subjects and methods

In 1993, a postal enquiry was sent to the total female population between 60–80 years of age, living in the cities of Haugesund, Bergen and Trondheim and to all women between 50 and 60 years of age living in 8 municipalities near Haugesund. Altogether, 46,353 women were invited to answer the questionnaire and 29,802 did so (64%).

They were asked whether they had sustained a wrist fracture, ankle fracture, lower leg fracture, hip fracture, humerus fracture and spine fracture after the age of 25 years and in what year the fracture occurred. Multiple fractures at the same site were recorded as well. Fractures of the hip, wrist, spine and humerus were considered fragility fractures.

From the fracture variables, new variables were created; whether they had a hip or spine fracture within 5 years and within 10 years before the date of the questionnaire. Another variable was constructed if a fracture had occurred more than 5 years and more than 10 years, respectively, before the date of the questionnaire.

A case-control design was used, comparing those who had had a fracture within 5 years to those who had had a fracture prior to the 5 years. Similarly, comparisons were made between those who had had a fracture within 10 years of the questionnaire and those who had had a fracture before that time.

To validate the enquiry, a follow-up questionnaire, identical with the one sent at the first occasion, was sent 6 months later to a randomly chosen sample of 300 respondents. Events that had occurred between the first and the follow-up enquiry were accounted for in the statistics. The response rate was 61%. The reliability of the enquiry was estimated from the agreement between recalled fractures reported at the first enquiry, and the follow-up. 40 subjects reported having had at least 1 fracture at the first enquiry. These were confirmed in 37/40 cases when, asked about the second time, 6 months later. Only 1 of the 29 fractures of the distal end of the radius was missed in the follow-up enquiry. Calculation of agreement between the year when a radius fracture had occurred was possible in 23 cases. The same year of fracture was reported in 16 of the 23 cases. In 6 cases, the year of the fracture differed by 1 year and in 1 case by 4 years. There was 100% agreement between the enquiries in the 5 cases of hip fracture reported in the first enquiry. For the other fractures, the figures of agreement were virtually the same. Age did not significantly influence agreements.

The study was approved by the regional ethics committee and by the national population register, which provided names, dates of birth and addresses of the investigated population.

The statistical analyses (logistic regression adjusted for age) were performed on SAS.

Table 1. Anthropometric variables and prevalence of self-reported fractures among 29,802 respondents. Percentages in brackets

	Age: 50–59		60–69		70–80	
Respondents	1865	(78)	15454	(71)	12483	(56)
Age [a] (years)	54.9	3.2	64.9	2.9	74.4	3.1
Height [a] (cm)	164.8	5.4	163.8	5.4	162.2	5.9
Weight [a] (kg)	67.3	12	66.3	11	64.5	11
No. with fracture [b]	254	(14)	4585	(30)	5121	(41)
Radius [c]	122	(6.5)	2760	(18)	3162	(25)
Hip [c]	12	(0.6)	351	(2.3)	742	(5.9)
Spine [c]	32	(1.7)	596	(3.9)	808	(6.4)
Humerus [c]	18	(1.0)	498	(3.2)	691	(5.5)
Lower limb [c]	22	(1.2)	281	(1.8)	306	(2.5)
Ankle [c]	78	(4.1)	1110	(7.2)	1112	(8.9)
Fragility fractures [d]	171	(9.1)	3671	(24)	4345	(35)

[a] mean, 1 SD.
[b] number of respondents with one or more fractures.
[c] number of respondents with one or more fractures according to various sites.
[d] number of respondents with one or more fractures of the hip, radius, humerus or spine.

Table 2. Distribution of 14,481 fractures reported in 9,960 respondents

Fracture site	Right	Left	Unspecified	Total [a]	
Radius	3098	3819	247	7164	(50)
Hip	518	641	37	1196	(8.2)
Spine	–	–	1703	1703	(12)
Humerus	588	649	48	1285	(8.9)
Lower limb	294	330	15	639	(4.4)
Ankle	1099	1306	89	2494	(17)

[a] number of fractures (percent of all fractures reported)

Results

Characteristics of the population and fracture prevalence for various fracture types among respondents in different age groups are shown in Table 1. The response rate was significantly lower in the oldest age group compared to the intermediate and youngest age groups. When considering fractures altogether, fracture prevalence increased by about 27% from the youngest through the oldest age group. A 10-fold increase in hip fracture prevalence was observed between the youngest and the oldest age groups. The prevalence of other fracture types increased significantly less with age.

Altogether, 14,481 fractures were reported by the 9,960 individuals who had sustained one or more fractures. Wrist fractures constituted approximately half of all fractures reported (Table 2).

Table 3 shows the odds ratio (OR) of sustaining a hip fracture or a spine fracture within 5 years and within 10 years from the questionnaire, in case of a preceding fracture. In hip fractures that had occurred within 5 years from the questionnaire, all types of fractures, including fragility fracture, were significantly related to a hip fracture—OR: 1.6–3.4 for various previous fracture types. If the same statistics were used with hip fractures that had occurred within 10 years, a fracture previous to that time had almost the same significance as within 5 years. In spine fractures, the same relationship was found as in hip fractures. A previous spine fracture predicted a spine fracture with a very high OR: 3.9–4.5 (Table 3).

Table 3. Odds ratio (95% confidence interval) of having sustained a hip or spine fracture within 5 and 10 years prior to answering the questionnaire in presence of a preceding fracture

Prior fracture	Hip < 5 yrs	Hip < 10 yrs	Spine < 5 yrs	Spine < 10 yrs
Radius	1.80 (1.44–2.25)	1.85 (1.51–2.27)	1.61 (1.31–1.96)	1.71 (1.41–2.07)
Ankle	1.59 (1.12–2.25)	1.38 (0.99–1.92)	1.53 (1.13–2.07)	1.51 (1.12–2.02)
Hip	2.26 (1.46–3.52)	2.30 (1.45–3.68)	2.53 (1.73–3.70)	2.54 (1.66–3.89)
Lower limb	3.37 (2.14–5.29)	2.61 (1.64–4.15)	2.21 (1.38–3.52)	2.40 (1.55–3.73)
Humerus	2.45 (1.63–3.69)	3.51 (2.44–5.03)	2.87 (2.05–4.03)	2.44 (1.66–3.61)
Spine	1.72 (1.12–2.67)	2.35 (1.60–3.46)	4.46 (3.41–5.85)	3.89 (2.88–5.24)
Fragility [a]	1.98 (1.61–2.42)	2.17 (1.81–2.59)	2.38 (2.01–2.82)	2.30 (1.95–2.70)

[a] a fracture of the hip, radius, humerus or spine

Table 4. Odds ratio (95% confidence interval) of having sustained a hip or spine fracture within 5 years prior to answering the questionnaire, in the presence of a preceding fracture, in women < 70 and > 70 years of age

Prior fracture	Hip < 5 yrs ≤ 70 yrs	Hip < 5 yrs > 70 yrs	Spine < 5 yrs ≤ 70 yrs	Spine <5 yrs >70 yrs
Radius	1.51 (0.99–2.29)	1.95 (1.49–2.54)	1.67 (1.19–2.34)	1.57 (1.23–2.02)
Ankle	1.81 (1.02–3.19)	1.48 (0.96–2.28)	1.60 (0.97–2.63)	1.49 (1.01–2.19)
Hip	3.17 (1.38–7.30)	2.04 (1.22–3.44)	1.85 (0.75–4.55)	2.75 (1.80–4.18)
Lower limb	2.86 (1.25–6.53)	3.66 (2.13–6.33)	0.96 (0.30–3.02)	2.93 (1.74–4.95)
Humerus	3.40 (1.71–6.71)	2.12 (1.26–3.52)	2.84 (1.53–5.29)	2.89 (1.92–4.34)
Spine	2.60 (1.32–5.15)	1.38 (0.78–2.44)	5.92 (3.88–9.01)	3.79 (2.68–5.38)
Fragility [a]	1.78 (1.24–2.54)	2.09 (1.63–2.67)	2.54 (1.94–3.36)	2.28 (1.83–2.82)

[a] a fracture of the hip, wrist, humerus or spine

To study whether age effected the predictive ability of a previous fracture, two groups were constructed, one with an age at enquiry < 70 years and another with an age > 70 years (Table 4). Although not significantly different, the ability of some of the previous fractures to predict a hip fracture seemed better before the age of 70. For example, a previous humerus fracture had an OR of 3.4 to have a later hip fracture before the age of 70. After the age of 70, the corresponding figure was 2.1. Concerning spine fractures there was a tendency for previous spine fractures, to be more predictive of a new fracture before the age of 70. A wrist fracture and a fracture of the lower limb tended to be more predictive of a later hip or spine fracture after the age of 70.

Overall, a previous spine fracture appeared to be the best predictor of sustaining a fragility fracture within 5 years from the questionnaire. Its predictive value was significantly better than that of a previous fracture of the wrist or the ankle (data not shown). Of all the fractures studied, ankle fractures appeared to be the least predictive.

The absolute percentage of previous fractures is also important to obtain an impression of the importance of selecting previous fractures (Table 5), for example, hip fractures within 5 years, prior to that time, 23% had had a fracture of the wrist and 32% any fragility fracture. The corresponding figures for spine fractures within 5 years were 20% and 34%, respectively. This indicates that about one third of the patients had had a previous fracture of any of the fragility fracture types. However, of all fractures of the wrist that occurred before 1987, only 3% had a hip fracture during the 5 years before the inquiry, a similar figure for all fragility fractures. If fractures of the wrist before 1982 were compared with hip fractures during the last 10 years, 5% of the fractures of the wrist radius occurred in those who had a fracture during the time, which implies a rather high frequency of previous fractures in a relatively short time interval.

Table 5. Percentage of patients within 5 years who had had a previous fracture

Previous fracture	Hip < 5 years	Spine < 5 years
Wrist radius	23	20
Ankle	7.9	7.2
Humerus	5.7	6.0
Hip	4.8	4.7
Spine	4.8	10
Any fragility fracture	32	34

Discussion

Our findings show that a previous fracture can predict a subsequent fracture of the hip and the spine and that this postfracture risk is independent of age. This is consistent with previous reports suggesting that osteoporotic fractures tend to cluster (Hutchinson et al. 1979, Jensen et al. 1982) and that the occurrence of a fracture usually indicates an increased risk of a subsequent fracture at other sites (Gallagher et al. 1980, Melton et al. 1982, Finsen and Benum 1986, Gärdsell et al. 1989, Ross et al. 1991, 1993, Lauritzen et al. 1993a, b, Mallmin et al. 1993, Johnell 1998).

Of particular importance are risk factors associated with hip fractures, since they entail a high mortality and morbidity compared to other fracture types (Sernbo and Johnell 1993). All types of fractures studied predicted significantly a future hip fracture and could thus be more or less useful when assessing fracture risk. This is consistent with findings made by Cummings et al. (1995). In our study, a previous hip fracture signalled a later hip fracture. The risk was slightly more than doubled compared to controls, this being similar to a report by Melton et. al. (1982).

Although a previous fracture of the spine, hip, humerus and lower limb appeared to be somewhat superior to a wrist fracture in predicting a new hip fracture, the latter would probably be important as a risk factor, due to its higher prevalence and its occurrence at a younger age in the population at risk.

Sustaining a symptomatic spine fracture is considered less dramatic than sustaining a hip fracture, but it is frequently associated with high morbidity. Spine fracture predicted a future spine fracture significantly better than a fracture of the wrist or ankle and with a high odds ratio (3.9–4.5), which is consistent with the fivefold increased risk reported by Ross et al. (1991). A previous spine fracture was also associated with a later hip fracture with an odds ratio of 1.7–2.4, which is similar to findings by Kotowicz et al. (1994), who reported a hip fracture risk of 2.3 among those with previous symptomatic spine fractures. In the current study, we reported the prevalence of symptomatic spinal fractures. According to previous findings (Kotowicz et al. 1994), symptomatic spine fractures constitute about 50% of spine fractures, the rest being asymptomatic fractures. Consequently, the prevalence of spine fractures in the current population could be estimated to be twice as great as reported and was the commonest fracture type next to fracture of the wrist. Although detection of asymptomatic spine fracture would require radiograms, the spine fracture appears to be the most useful indicator of future fracture risk due to its frequency, its occurrence at a relatively young age and its overall great ability to predict both new hip and spine fractures.

The predictive ability of a fracture to indicate a new fracture has previously been suggested to be age-dependent. However, results have not been consistent. While Gärdsell et al. (1989) and Finsen and Benum (1986) found an association only before the age of 70 years, results reported by Kotowicz et al. (1994) corroborate findings in the current study, where age had no significant impact. There was a trend, however, for some of the fracture types (fracture of the hip, spine and humerus) to be more predictive before the age of 70 years, while other fracture types tended to be more predictive after the age of 70 years (fracture of the wrist and the lower leg). Although not significant, this indicates that a possible effect of age concerning predictability of a previous fracture to foretell a new fracture could vary according to fracture type. It also indicates that recall errors were not more frequent in women over 70 years of age, which previously has been suggested as an explanation for missing an association between previous and future fractures in this age group (Finsen and Benum 1986).

The high predictive ability of lower leg fracture was unexpected and has not previously been reported to be typically osteoporotic. A possible explanation is that some of the hip fractures may have mistakenly been reported as lower leg fractures and many of the lower leg fractures were probably osteoporotic fractures of the tibia condyles as ankle fractures were asked for separately in the enquiry. Of the fractures studied, ankle fractures appeared to be least predictive of a new fracture in agreement with results from a Danish study (Lauritzen and Lund 1993).

The major source of bias in our study was the use of subject recall to include fractures that occurred many decades in the past. It has previously been documented that the accuracy of questionnaire responses varies with disease. Compared to other diseases, fractures appear to be less associated with recall errors, since agreement between hospital records and self-reported hip and forearm fractures ranges from 80–100%, according to earlier studies (Colditz et al. 1986, Paganini-Hill and Chao 1993). Our study cannot rule out bias due to old spine fracture being mistakenly reported as a new spine fracture. This would exaggregate the association between old spine fracture and new spine fracture. Another limitation is that our study is not prospective. The response rate was fairly good (64%), but there may have been a selection bias, particularly in the oldest age group where the response rate was low compared with the younger agegroups (Table 1). The validation of the questionnaire showed that the respondents could reproduce their answers about previous fractures fairly well after 6 months. Although no hospital fracture records were consulted for verification, this indicates that they recalled fractures well and even in what year they had occurred.

Prospective studies of bone mass have shown that a 1 SD decrease in bone mass increases the odds ratio of having a later osteoporotic fracture to about 1.6 (Cummings et al. 1990). A 1 SD decrease measured at the proximal femur increases the risk of a subsequent hip fracture to about 2.6 (Cummings et al. 1993). These figures are very similar to the odds ratio we found of having a new hip or spine fracture in the presence of a previous fracture. The implication of these findings is that a previous fracture, with the possible exception of ankle fractures, can be used to select persons for bone densitometry, since they will be in a high-risk group. Probably bone mass and a previous fracture together can substantially increase the prediction of a future fracture. Another possibility would be that the predictive ability of a new hip or spine fracture is so high that this by itself could be an indication for intervention.

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