Fracture rate in a population-based sample of men in Reykjavik

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ABSTRACT **The population-based Reykjavik Heart Study, started in 1967, aims at finding and evaluating risk factors for cardiovascular diseases. It included 4,137 men born between 1907 and 1934 and we examined all fractures recorded in these subjects from January 1977 until the end of December 2000, or death. Their mean age at the start of this study was 54 (42–69) years and the mean follow-up time 19 years.**

We examined the patients' records, including those from the Radiological Departments in all Reykjavik hospitals and the only out-patient accident clinic in Reykjavik. Old fractures and those caused by a malignancy were excluded. The intensity of the trauma was estimated from E-numbers.

Altogether 1,531 fractures were recorded in 939 (23%) persons. A low-energy trauma caused 53% of all fractures. 612 had a single fracture during this period. 323 had two or more fractures—a 53% risk of sustaining additional fractures. The fracture incidence increased by 40% in each 10-year period. Fractures of the ribs were commonest (246), followed by those of the hand (241). 135 were hip fractures, 75% caused by low-energy trauma. The fracture rate was 20 per 1000 persons year—i.e., similar to that in other studies.

The incidence of fractures in both genders is fairly well known (Buhr and Cooke 1959, Johansen et al. 1997, van Staa et al. 2001). To study external causes of fractures, men may serve as a useful model. However, one drawback in analyzing life-style and other exogenous effects, as risk factors is that men have fewer fractures than women. Therefore, it is usually necessary to analyze a large population of men for a long period to reach conclusions, and obtain more information about the fracture, not only the incidence.

We determined the number of fractures in a large population-based sample of men with a long follow-up period. Our interest was twofold: first, to record fractures in a large prospective study as the basis for a later search for risk factors, and secondly, to understand better the fracture pattern in men, by correlating the trauma with the type of fracture and studying the sequence of the fractures during a long follow-up.

Population and methods

The cohort

The outline of the Reykjavik Heart Study, which started in 1967, has been reported elsewhere (Hardarson et al. 2001). The population-based study used the computerized national register. Persons residing in Reykjavik and nearby communities on 1 December 1966 were invited to participate in all stages of the study—i.e., 13,134 men born between 1907 and 1934 and 13,315 women born between 1908 and 1935. 9,328 men and 10,062 women responded. The total cohort selected comprised 45% of the Icelandic population born during the period.

Table 1. Number of participants in the first two stages of the Reykjavik Study. Of the 5525 probands invited to stage II, only 2191 attended for the first time. The rest were re-examined probands from stage I who were invited again

Stage	Year of examination	Invited	Attended, first time	Response rate (%)	Alive 1 Jan 1977
Stage I	1967–1968	2929	2203	75.2	2056
Stage II	1970–1971	5525	2191	73.4	2081

Table 2. Age distribution of participants at the start of the follow-up study (1977) (N = 4137)

Age groups	Number of men studied
40–44	280
45–49	666
50–54	907
55–59	1330
60–64	636
65–69	318

A randomized procedure with the day and year of birth for the probands was used to divide the cohort into six sub-cohorts. These were then invited to undergo examination in six stages during 1967 and 1996. The first sub-cohort of men was invited to the first stage of the study in 1967–1969. Another sub-cohort of men, together with the first one, was invited to the second stage in 1970–1972.

This study includes only men invited to the first two stages. They had been born in 1907, 1910, 1912, 1914, 1916–1922, 1924, 1926, 1928, 1931 and 1934. Those born on the 1st, 4th, 7th, etc., of each month were invited to the first stage. Those born on the 2nd, 5th, 8th, etc. of each month were invited to the second stage together with all those invited to the first stage (Table 1).

The 4,137 participants from the first two stages, alive on 1 January 1977, were followed until 31 December 2000 or death by use of their unique personal identification number. 25 (0.6%) were lost to follow-up because of emigration. The sub-cohort invited to the first stage was asked to participate in all six stages together with a new sub-cohort. Thus of the 5,525 probands invited to stage II, only 2,191 attended for the first time. The rest had been seen in stage I.

We examined the records of men who participated. Their total response rate in the first two stages was 74%. The distribution of participants in this study, according to age groups, is shown in Table 2.

Fracture history

In Reykjavik, all fractures treated on an out-patient basis have been referred to the only out-patient trauma clinic in Reykjavik City Hospital since the early 1960s. Fractures requiring in-patient treatment had been diagnosed in this hospital and then referred to the hospital on call. From 1967 to 1993, three hospitals in Reykjavik admitted patients for treatment of fractures. All three treated fractures on a rotating call scheme. Since 1993, even the in-patient treatment of fractures has gradually been centralized to Reykjavik City Hospital.

We examined all hospital files of the study group in all three hospitals, those in the Departments of Radiology, and the charts from the out-patient trauma clinic. The records of fractures in Akureyri Hospital, the largest rural hospital in the country (situated in northern Iceland), were also examined.

The retrieval of patient records, especially those of out-patients in the period 1967–1976, was not deemed complete enough for this study and the data were therefore excluded. For this reason, the study comprises the period from 1 January 1977 until death or 31 December 2000.

At first when treating an out-patient fracture both the type of fracture and the intensity of the trauma according to the ICD code, were recorded by the attending physician, who made a mark in a box about the nature of the trauma and the fracture type. The nature of the trauma was also noted in the in-patient records. All doubtful information about the fractures and trauma was reviewed by the same persons in our study group and corrected, if necessary.

On 1 January 1997, a new diagnosis coding system (ICD 10) was implemented. This new alpha numerical system provides the clinician with more alternatives in coding for fracture diagnoses than the older numerical ICD 9. To obtain comparable data, all newer codes (ICD 10) for fractures sustained during 1997–2000 were converted into ICD 9. Since the newer code alternatives were more numerous, it was easier to convert the data into the system with fewer alternatives. For example, cervical hip fractures with the newer ICD 10 code S72.00 was changed to ICD9 number 820.0. The same applied to the trauma classification, the more numerous V and W codes of ICD 10 were converted into the E-codes of ICD 9.

Falling from a standing height (E-885 and W-00) was regarded as a low-energy trauma, the rest as high-energy.

Statistics

Age and calendar year were stratified into 5-year groups, 13 age groups and 6 calendar year periods (78 strata). Person years for all fractures were calculated as the time elapsed from 1 January 1977 until death or 31 December 2000. Person years for the first fracture were calculated as the time elapsed from 1 January 1977 until the first fracture, death or 31 December 2000. In each of these strata, the total number of fractures, number of first fractures and both types of person years were determined. The fracture rate was computed as the total number of fractures divided by the former number of person years and the rate of first fractures as their number divided by the latter number of person years. Poisson regression was applied to the stratified fracture rates to assess their dependence on age and period. Age was treated as a continuous variable and non-linearity of its effect tested by including age squared. Since age squared was found not to be a significant predictor it was excluded. The period was treated as a categorical variable (5 dummy variables). To test for a time trend, it was treated as a continuous variable.

Results

The mean follow-up time in this study was 18.5 years (SD 6.5 (0.02–24.0) years).

Of the 4,137 men in the study group, 939 (23%) sustained at least one fracture during the follow-up. 14.9% had a single fracture and 7.8% more than one fracture episode. In total, 1,531 fractures were recorded. Those who sustained one fracture ran a 34% risk of sustaining another. While those who sustained two or more fractures ran a 40% greater risk of sustaining more fractures (Table 3).

Table 3. Frequency of fractures and the cumulative risk of sustaining additional fractures during the follow-up period

Number of fractures per person	Number of men	Cumulative fractures	Risk of additional fracture (%)
0	3198	4137	23
1	616	939	34
2	183	323	43
3	70	140	50
4	41	70	41
5	11	29	41
6	10	18	44
7	5	8	38
8	2	3	33
9	1	1	

Altogether 805 (53%) of the fractures were caused by low-energy trauma.

When the analysis concerned only the first fracture, 51% were low-energy. Fractures of the hip, forearm and humerus were caused by a low-energy trauma in 75%, 77% and 72%, respectively. Fractures of the pelvis were caused by low-energy trauma in 36% of cases and vertebral fractures in only 35%.

Rib fractures were commonest, 246 (16% of all fractures), followed by those of the hand, 241. In 138 cases, we found a fracture of the hip (Table 4).

As a first fracture, hand fractures dominated, followed by the forearm, ribs and foot. 77% of all scapula fractures occurred as a first fracture, followed by the foot with 74%. The lowest percentages for the first fracture were the pelvis (34), femur (46) and the ribs (47) (Table 4).

The age at first fracture after inclusion in the study gives some indication of the distribution of fractures over time. The median age at first fracture was 65 (SD 8.9) years. The median ages for the second, third and fourth fractures were 68, 71 and 73 years, respectively (Table 5). However, it should be noted that fractures occurring earlier in life—i.e., before 1977—were not included in the study.

The average fracture rate was 19.5 per 1000 men year in all age groups over the entire period, increasing from 10.6 in men aged 45–49 years to 52.2 in those aged 85–89 years (too few cases outside this age range were available to be reliable).

Table 4. Types and number of fractures in the study group

Anatomical location	Total number of fractures	First fracture	Second fracture	Third fracture	Later fractures
Ribs	246	115	52	35	44
Hand	241	169	41	18	3
carpal	31	22	6	2	1
metacarpal	66	46	12	8	0
digits	144	107	23	10	4
Forearm	212	138	43	18	13
distal radius alone	187	121	38	16	12
Foot	138	102	17	7	12
Hip	135	80	23	12	20
Spine	110	54	36	13	7
Ankle	106	76	22	5	3
Humerus	97	53	28	5	11
upper	67	39	16	3	9
shaft/lower	30	14	12	2	2
Tibia	59	33	18	5	3
condyle	39	23	11	3	2
shaft	20	10	7	2	1
Skull	68	40	17	9	2
Clavicle	35	25	5	2	3
Pelvis	32	11	13	5	3
Patella	19	16	2	1	0
Femur	13	6	5	1	1
Scapula	13	10	1	2	0
Other	7	5	0	0	2
Total	1531	939	323	140	129

Table 5. The age distribution at the first to fourth fracture

	First fracture	Second fracture	Third fracture	Fourth fracture
Mean	66	69	70	73
St. deviation	8.9	8.7	8.9	8.7
Minimum	43	46	47	51
First quartile	60	63	64	68
Median	65	68	71	73
Third quartile	72	75	77	79
Maximum	92	89	92	92

The relative increase in fracture rate was 1.04 (95% CI. 1.03–1.05) per year of age. When only the first fracture was taken into account, the incidence was 13.6 per 1000 men a year (Table 6).

The age-adjusted fracture rate showed no significant increase with time. In 1997–2000, it was 1.08 (95% CI. 0.88–1.32), as compared to 1977–1981 (Table 7).

The rates of the commonest fractures of the ribs were 3.2/1000/year, of the forearm 2.8, of the hip 1.8, humerus and vertebra, the incidences were 1.3 and 1.4 per 1000 person years, respectively.

Discussion

In this study with a long follow-up, over one fifth of the men who were middle-aged at the start sustained a fracture. The incidence of fractures increased by 40% for each 10 years in age. The length of the follow-up period may influence the number of fractures without affecting the age-adjusted incidence since the number of elderly persons is increasing in the population (Huusko et al. 1999). Because of the long follow-up our study may be useful in evaluating the risk of fracture in the latter half of life in men.

In comparisons of the fracture rates in similar studies, we found that about 25% of 55-year-old men in our study sustained a fracture during the following 19 years, as also noted by others in Sweden (Jonsson et al. 1992) and Great Britain (van Staa et al. 2001).

One way of avoiding the effects of different observation times in various studies is to determine the incidence per 10,000 person years. Our incidence of 136 fractures per 10,000 person years was higher than in Great Britain where it was 78 (Staa et al. 2001), but lower than in Australia, where it was 220 in men over 60 with a follow-up of 5 years (Nguyen et al. 1996).

In our study the incidence rates per 10,000 person years for all individual fractures were; 28 for forearm fractures, 18 for hip fractures, 14 for vertebral fractures and 13 for humeral fractures. This is to be compared with incidence rate of 23 and 34 respectively for proximal humeral and forearm fractures in Australia (Nguyen et al. 2001). In another Australian study the age-specific incidence for hip fractures in men with a mean age of 55 was 11 per 10,000 per year. For vertebral, Colles' and humeral fractures, the incidence was 7, 4 and 3

Table 6. Distribution of fractures, person years and fracture rate/1000 men/ year according to age and period

	All fractures			First fracture		
	Person years	Number of fractures	Fracture rate	Person years	Number of fractures	Fracture rate
Age groups						
40–44	698	3	4.3	693	3	4.3
45–49	3388	36	10.6	3303	29	8.8
50–54	6898	93	13.5	6558	62	9.5
55–59	12243	153	12.5	11472	122	10.6
60–64	16054	278	17.3	14443	204	14.1
65–69	15928	326	20.5	13747	197	14.3
70–74	12472	272	21.8	10371	153	14.8
75–79	7596	223	29.4	6004	108	18.0
80–84	2692	103	38.3	2070	46	22.2
85–89	670	35	52.2	517	12	23.2
90–	73	9	123	59	3	50.8
Total	78712	1531	19.5	69237	939	13.6
Period						
1977–1981	20044	300	15.0	19446	230	11.8
1982–1986	18493	320	17.3	16859	220	13.0
1987–1991	16527	337	20.4	14174	196	13.8
1992–1996	14204	274	19.3	11493	143	12.4
1997–2000	9444	300	31.8	7265	150	20.6

Table 7. Relative risk (RR) of fractures from age and period. Results from multivariate Poisson regression

	All fractures		First fracture	
Risk factor	RR	95% C.I.	RR	95% C.I.
Age, years	1.04	1.03–1.05	1.02	1.01–1.03
Period				
1977–1981[a]	1		1	
1982–1986	0.96	0.82–1.13	1.02	0.84–1.23
1987–1991	0.95	0.80–1.13	1.00	0.81–1.23
1992–1996	0.76	0.63–0.92	0.84	0.66–1.07
1997–2000	1.08	0.88–1.32	1.30	1.01–1.69

[a]The period 1977–1981 was used as a reference

respectively (Sanders et al. 1999). In England and Wales the standardized incidence rates were 11 for hip fractures as well as for radius fractures (van Staa et al. 2001). In a study in Malmö, Sweden, the incidence of forearm fractures was 20 per 10,000 (Jonsson et al. 1999), which was slightly higher than in our study.

In agreement with other studies we found that as the first fracture, hand fractures outnumbered fractures of the distal forearm among men (Buhr and Cooke 1959, Garraway et al. 1979, Johansen et al. 1997). Surprisingly these two fractures were not the most common when including all fractures as both were outnumbered by rib fractures in our study. This may be caused by different clinical approaches. Icelandic physicians may have been more likely to obtain radiographs in order to confirm a rib fracture than colleagues abroad. The third and fourth most common fracture varies in different studies. In women, fractures of the distal forearm are usually most common.

About half of all fractures were caused by a low-energy trauma. An interesting observation is that of fractures commonly associated with bone fragility, only hip, humerus and forearm fractures were caused by low-energy trauma in approximately 3 out of 4 cases. Pelvic and spinal fractures were caused by low energy trauma in less than half of the cases and may therefore not necessarily be associated with osteoporosis in men as in women. This must, however, be confirmed in a larger study of both gender. Nevertheless, most of the low-energy fractures are probably associated with senile osteoporosis, which partly explains the increase in the fracture rate among the older men.

If we had widened our definition of low-energy trauma to include falls downstairs, we would probably have found a higher rate of low-energy fractures. In our study, only falling from a standing height was regarded as a low-energy trauma which seems to be the most widely used definition.

Our study is confined to a large cohort and does not take into account all fractures among all residents in the city. In a study of five cities from different countries in 1990–1992, Reykjavik had the highest incidence of hip fractures with 141 fractures per 100,000 in men (Schwartz et al. 1999), which is close to ours, 180 per 100,000. Our observation period is longer and therefore more fractures are likely to have occurred in the aging population. The incidence of distal radius fractures in Reykjavik was 14 per 10,000 men—i.e., the apparent overall incidence during one year in the middle of the 1980s (Robertsson et al. 1990). This should be compared with the rate in our study of 24 per 10,000, which encourages us to conclude that we are probably not missing fractures.

Several problems are encountered in a study like ours. One is the fact that information on fractures before inclusion is scarce or non-existent. In our case, it was impossible to obtain information prior to enrolment since most of the probands were born and raised in another part of the country before moving to Reykjavik during and after the Second World War. Therefore we have only limited information about fractures in the cohort before 1969. A questionnaire was deemed unreliable for obtaining information about fractures since it has been shown that such information is far from accurate in detecting all fractures (Jonsson et al. 1994) especially if a long time has elapsed since the fracture (Akeson et al. 1992) or if the fracture is regarded as minor (Honkanen et al. 1999). This problem is common in studies like ours and therefore unlikely to cause difficulties in comparisons made with similar studies

Another problem encountered in comparing various longitudinal studies is caused by differences in the age of the probands when including the studies and the variations in the length of the observation periods. More fractures can be expected in studies with a long follow-up and in older persons.

The present study provides some insight into how and when fractures occur in middle-aged and elderly men in Reykjavik at 64° N, an area with limited sunlight for several months during winter, but where the daily intake of cod liver oil is common and the mean intake of calcium is high (Sigurdsson et al. 2000).

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