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HIP FRACTURES IN THE COUNTY OF FUNEN, DENMARK

Implications of Demographic Aging and Changes in Incidence Rates

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In patients 40 years and above a total of 3096 hip fractures (783 in males and 2313 in females) occurred in the entire county of Funen, Denmark from 1 July 1973 to 30 June 1979. The incidence of hip fractures increased exponentially with age in both sexes. During the survey the number of hip fractures in females showed a marked increase above what could be explained by demographic aging alone, whereas this tendency was not so pronounced in males.

Provided the observed increase in incidence rates prevails, aging of the population in combination with this increase will lead to a threefold increase in the number of hip fractures over a 20-year period. This is substantially more than other Scandinavian authors have reported.

Key words: age standardization; demographic aging; epidemiology; hip fractures; incidence rates

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As the population in most Western industrialized countries is increasing in age, patients with hip fractures can be expected to continue to place a substantial and increasing demand on hospital beds. During the last three decades increasing age and sex specific incidence rates of hip fractures have been reported (Stewart 1955, Bauer 1960, Alffram 1964, Jensen 1980, Zetterberg & Andersson 1982). In a survey from 1971 to 1977 Jensen (1980) did not report any significant changes in the incidence of hip fractures during the period of investigation. However, based on the expected composition of the population Jensen & Tøndevold (1980) estimated the number of hip fractures to double within a period of 17 years. These findings are supported by Nilsson & Obrant (1978) who in a study from Malmö, Sweden found the previously reported rising trend in incidence rates of hip fractures to have ceased. Contrary to these observations Zetterberg & Andersson (1982) in a survey covering a period of 40 years in Gothenburg, Sweden reported a highly significant increase in the age specific incidence of hip fractures in both males and females. Furthermore the incidence of hip fractures would double within the next 20 years, if the present trend continued. This is in accordance with the findings of Alffram (1964) in Malmö, Sweden and Falch & Ilebekk (1978) in Oslo.

The purpose of the present study has been to establish age and sex specific incidence rates of hip fractures in a geographically well-defined area. The study also intended to clarify whether the increasing number of hip fractures can be explained by demographic aging of the population or whether the incidence rates of hip fractures are truly rising; and further to predict the number of hip fractures likely to be encountered over the next decade.

PATIENTS AND METHODS

The study included all hip fractures in patients aged 40 years and above, which occurred in the county of Funen, Denmark from 1 July 1973 to 30 June 1979. A hip fracture was defined as: a fracture of the femoral neck, a pertrochanteric fracture or a subtrochanteric fracture. Isolated fractures of the greater or lesser trochanter were excluded.

From the centralized computerized hospital discharge system in the county of Funen all cases with ICD-N diagnoses 820.00 to 820.99, which include all fractures of the upper end of the femur, were extracted. This amounted to a total of 5578 discharge records. Based on the recorded operative procedures, hospital case histories and, when necessary, radiographic pictures the 5578 discharge records were found to contain 3096 cases of fresh hip fractures, of which 2313 occurred in females and 783 in males.

Included in the study were visitors and tourists who sustained a fresh hip fracture during their stay in the county of Funen. Inhabitants of the county of Funen who sustained a hip fracture elsewhere were excluded from the study.

The county of Funen is a well defined area consisting of one major island (Funen) and several small islands. The population aged 40 years and above rose from 188676 inhabitants (98207 females and 90469 males) on 1 January 1974 to 192345 inhabitants (101220 females and 91125 males) on 1 January 1979. During the period of the survey there was a steady increase of elderly people.

In order to have reliable mid-year populations available for the computation of incidence rates, the investigation period was divided into six registration years (1973–74, 1974–75, etc.), each centered around 1 January, for which official Danish population statistics, based on the Central Person Registration system, are computed and published. The patients have been grouped in sex and age groups, with 5-year increments.

For estimating the future number of hip fractures a methodology of maximum likelihood estimation (developed and programmed by professor Johannes Ipsen, The Institute of Social Medicine, University of Aarhus) using a natural logarithmic model for the odds (of having a hip fracture versus not having a hip fracture) has been applied. The logarithmic linear regression model can be expressed as

$$\ln(\text{odds}) = \alpha + \beta X \qquad (1)$$

where "X" connotates any given year in the model, using the first registration year as $X = 1$.

By taking the antilogarithm of (1) the expected odds are derived. The expected incidence rates are obtained from:

$$\text{Expected incidence rates} = \frac{\text{Expected (Odds)}}{1+\text{Expected (Odds)}} \qquad (2)$$

Finally these incidence rates were applied to the population statistics provided by the Danish Central Bureau of Statistics, so as to arrive at the expected number of cases in any given year.

RESULTS

Apart from the first two age intervals the age specific incidence rates for women were approximately twice as high as for males (Tables 1 and 2). However, the *increase* in age specific incidence rates showed only minor differences between the two sexes in the age interval 55 years to 89 years. During the survey there was an average overall incidence of hip fractures of 3.87 per 1000 females and 1.44 per 1000 males aged 40 years and above.

If only patients aged 50 years and above are considered, the average overall incidence rates of hip fractures were 5.11 per 1000 in females and 1.91 in males.

The number of hip fractures in females increased from 329 fractures per year in 1973–74 to 457 fractures per year in 1978–79 (Table 2) as compared to an increase in males from 107 fractures in 1973–74 to 146 fractures in 1978–79 (Table 1).

In order to analyze to what extent the increase in number of fractures could be explained merely by the demographic aging of the population at risk, sex specific standardized rates were computed for each registration year. For this purpose direct standardization was applied, and the population statistics for each registration year were pooled to form the standard population (Colton 1974). The age adjusted rates for females exhibited a marked increase above what could be explained by demographic aging alone, whereas this tendency was less pronounced in males (Table 3).

The estimation of the future number of hip fractures has been performed by two different methods, applying:

1) The average age and sex specific incidence rates found in this study (Table 1 and Table 2) to the predicted population in the county of Funen provided by the Danish National Bureau of Statistics.

Table 1. The age specific incidence rates of hip fractures per 1000 males in the County of Funen. Number of cases shown in brackets

Age	1973–74	1974–75	1975–76	1976–77	1977–78	1978–79	The average age specific incidence
40–44	0.08 (1)	0.25 (3)	–	–	0.08 (1)	0.08 (1)	0.08
45–49	–	0.41 (5)	0.24 (3)	0.25 (3)	0.33 (4)	0.33 (4)	0.26
50–54	0.23 (3)	0.15 (2)	0.47 (6)	0.64 (8)	0.08 (1)	0.24 (3)	0.30
55–59	0.65 (8)	0.41 (5)	0.40 (5)	0.40 (5)	0.89 (11)	0.73 (9)	0.58
60–64	0.89 (11)	0.66 (8)	0.25 (3)	1.18 (14)	1.03 (12)	0.95 (11)	0.82
65–69	1.36 (14)	0.85 (9)	1.86 (20)	1.86 (20)	2.28 (25)	1.64 (18)	1.65
70–74	1.16 (9)	1.65 (13)	2.24 (18)	1.47 (12)	1.57 (13)	2.61 (22)	1.79
75–79	3.82 (20)	4.18 (22)	4.29 (23)	5.36 (29)	4.00 (22)	3.76 (21)	4.23
80–84	6.31 (19)	5.01 (15)	9.97 (30)	6.49 (20)	6.01 (19)	9.63 (31)	7.25
85–89	13.3 (19)	11.8 (17)	13.8 (20)	14.9 (21)	10.5 (15)	11.1 (16)	12.54
90–94	5.3 (2)	22.1 (9)	35.5 (15)	26.2 (12)	13.3 (6)	19.7 (9)	20.55
95–	15.4 (1)	28.2 (2)	14.9 (1)	–	41.1 (3)	13.9 (1)	19.14
Overall incidence per year	1.18	1.22	1.59	1.59	1.45	1.60	
No. of fractures per year	107	110	144	144	132	146	

Table 2. The age specific incidence rates of hip fractures per 1000 females in the County of Funen. Number of cases shown in brackets

Age	1973–74	1974–75	1975–76	1976–77	1977–78	1978–79	The average age specific incidence
40–44	–	–	0.08 (1)	0.08 (1)	–	0.16 (2)	0.05
45–49	0.23 (3)	0.16 (2)	0.24 (3)	0.08 (1)	0.41 (5)	0.08 (1)	0.20
50–54	0.23 (3)	0.82 (11)	0.61 (8)	0.69 (9)	0.62 (8)	0.79 (10)	0.62
55–59	1.32 (17)	0.95 (12)	0.70 (9)	0.85 (11)	1.47 (19)	1.00 (13)	1.05
60–64	1.88 (24)	1.64 (21)	1.43 (18)	2.14 (27)	2.01 (25)	1.29 (16)	1.73
65–69	2.47 (28)	2.85 (33)	2.78 (33)	2.44 (29)	2.75 (33)	3.09 (37)	2.73
70–74	4.75 (44)	5.69 (54)	5.20 (50)	4.80 (47)	5.40 (54)	6.62 (68)	5.42
75–79	7.67 (53)	9.74 (69)	9.73 (70)	11.5 (85)	10.4 (79)	13.0 (100)	10.38
80–84	17.5 (72)	13.4 (57)	19.0 (85)	17.7 (83)	19.1 (93)	19.2 (96)	17.72
85–89	30.1 (58)	27.6 (55)	29.9 (62)	33.8 (74)	31.1 (70)	34.6 (83)	31.30
90–94	36.6 (20)	45.8 (26)	21.6 (14)	44.9 (30)	37.3 (27)	38.7 (29)	37.40
95–	54.7 (7)	35.1 (4)	80.4 (9)	64.8 (7)	30.1 (4)	14.2 (2)	44.84
Overall incidence per year	3.35	3.48	3.64	4.04	4.14	4.51	
No. of fractures per year	329	344	362	404	417	457	

Table 3. The incidence rates of hip fractures during the survey, adjusted for age (direct standardization)

Years of survey	Age adjusted rates per 1000 Males	Females
1973–74	1.20	3.54
1974–75	1.23	3.61
1975–76	1.60	3.69
1976–77	1.58	4.00
1977–78	1.44	4.01
1978–79	1.57	4.28

2) Age and sex specific incidence rates based on maximum likelihood estimation using a natural logarithmic model for the odds.

The appropriateness of using a logarithmic linear regression model was examined in two ways. First, the model was tested against:

$$\ln (\text{Odds}) = \alpha$$

that is, eliminating the year-effect. The difference can be tested using a likelihood ratio test. The resulting statistic (G^2) is approximately chi^2 distributed. The difference was highly significant ($P < 0.01$) indicating a strong year-effect. Second, the linear regression model was tested against the expression:

$$\ln (\text{Odds}) = \alpha + \beta_1 x + \beta_2 x^2$$

There was no improvement in the goodness of fit when applying the latter model to the observed data from the predominant age groups, – accordingly the results are based on the linear regression model.

A comparison of the results obtained by the two methods is shown in Table 4.

The first method led to more conservative estimates whereas the maximum likelihood method yielded numbers of hip fractures twice as high for prediction years 1990 and 1995.

DISCUSSION

The incidence rates of hip fractures showed no difference between males and females below 50 years of age. This was also observed by Alffram (1964), who reported incidence rates equal to ours.

In females 50 years and older an almost exponential increase in age specific incidence rates of hip fracture has been reported by Stewart (1955),

Table 4. The future number of hip fractures in the county of Funen estimated by two different methods. Method 1: The average observed age and sex specific incidence rates have been applied to the predicted population. Method 2: Maximum likelihood estimates of incidence rates applied to the predicted population

Age	1985				1990				1995			
	Method 1		Method 2		Method 1		Method 2		Method 1		Method 2	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
40–49	5	3	9	6	5	4	15	10	6	4	23	14
50–59	10	20	17	29	10	20	24	36	11	22	37	49
60–69	26	53	59	58	26	53	92	60	24	50	141	59
70–79	42	149	58	259	41	150	67	359	40	148	80	501
80–89	44	196	52	266	48	220	63	359	50	236	71	459
90–	11	46	15	38	11	56	19	40	12	64	23	41
Total	138	467	210	656	141	503	280	864	143	524	375	1123
Total of both sexes	605		866		644		1144		667		1498	

Bauer (1960), Alffram (1964), Jensen (1980) and Zetterberg & Andersson (1982). This was confirmed in the present study. Lucht (1971) showed that the number of falls in the home among the elderly females exhibited a similar exponential increase with increasing age, implying that most of the hip fractures in elderly patients were due to minor trauma.

The crude incidence rates of hip fractures in people 50 years and older, have been reported to have risen from below 2 per 1000 inhabitants in the 1950's to almost 5 per 1000 inhabitants in the late 1970's (Stewart 1955, Bauer 1960, Alffram 1964, Falch & Ilebekk 1978, Jensen 1980, Zetterberg & Andersson 1982).

A similar increase in crude rates was found in the present study. Some of this increase is obviously due to demographic aging, but the application of direct age standardization revealed a true increase in the incidence rate (Table 3).

With regard to secular changes in incidence rates, the present study has confirmed the findings of Zetterberg & Andersson (1982), who expect the incidence of fractures of the proximal end of the femur to double in the next 20 years.

Our conservative estimate of the future number of cases using the average age specific incidence rates from the period 1973–79 applied to the official population prediction yields a somewhat smaller increase than reported by Jensen & Tøndevold (1980). In this respect a possible explanation could be a slightly greater proportion of elderly in the population at risk in the county of Copenhagen. On the other hand, our maximum likelihood estimate taking both the projected demographic aging and the observed increase in incidence (odds) into account, seems to yield a much greater increase in the expected number of cases.

Projecting findings more than a few years ahead calls for close examination of the model used. In the present study the maximum likelihood estimates are based on a multiplicative model (the ratio of incidence rates from adjacent model years is assumed to be constant), and even slight departures from the model may result in considerable differences in the estimated future number of cases. Accordingly the model fit was checked numerically using the likelihood ratio test, which yielded chi^2 distributed test values, which never exceeded 9.18 (4 d.f.) with an average of 3.85 for the 12 age and sex groups. The appropriateness of the model was also controlled by plotting the logarithm of the observed incidences against observation years. No obvious departures from straight lines were found in the 12 plots.

Where Jensen & Tøndevold (1980) expect the number of cases to double over a 17-year period, we expect the number to triple over the period 1975–95.

This expected increase in the number of patients with hip fractures constitutes a major challenge to the planning of orthopaedic services and para-medical care, and to continued efforts to prevent these fractures.

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REFERENCES

Alffram, P. A. (1964) An epidemiologic study of cervical and trochanteric fractures of the femur in an urban population. *Acta Orthop. Scand.*, Suppl. 65.

Bauer, G. (1960) Epidemiology of fracture in aged persons. A preliminary investigation in fracture etiology. *Clin. Orthop.* **17**, 219–225.

Colton, T. (1974) *Statistics in medicine.* Little, Brown and Company, Boston.

Falch, J. & Ilebekk, A. (1978) Fractures of the proximal end of the femur. Prevalence and incidence in Oslo, 1950–1975. *Tidskr. Nor. Lægerforen.* **14**, 738–739.

Jensen, J. S. (1980) Incidence of hip fractures. *Acta Orthop. Scand.* **51**, 511–513.

Jensen, J. S. & Tøndevold, E. (1980) A prognostic evaluation of the hospital resources required for the treatment of hip fractures. *Acta Orthop. Scand.* **51**, 515–522.

Lucht, U. (1971) A prospective study of accidental falls and resulting injuries in the home among elderly people. *Acta Socio-Med. Scand.* **2**, 105–120.

Nilsson, B. E. & Obrant, K. J. (1978) Secular tendencies of the incidence of fracture of the upper end of the femur. *Acta Orthop. Scand.* **49**, 389–391.

Stewart, I. M. (1955) Fractures of neck of femur. Incidence and implications. *Br. Med. J.* **1**, 698–701.

Zetterberg, C. & Andersson, G. B. J. (1982) Fractures of the proximal end of the femur in Göteborg, Sweden, 1940–1979. *Acta Orthop. Scand.* **53**, 419–426.

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