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FRACTURES OF THE PROXIMAL END OF THE FEMUR IN GÖTEBORG, SWEDEN, 1940–1979

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A total of 3475 fractures of the proximal femur occurring in Göteborg, Sweden, in 1965, 1969, 1970, 1975, 1978 and 1979 were reviewed, and the information obtained was compared with earlier published epidemiologic data from Göteborg presented by Mårtensson (1962) for the years 1940–1959. A highly statistically significant age specific increase in fracture incidence was found for trochanteric as well as cervical fractures, and for both women and men. The fracture incidence increased from about 3 per 1000 in 1965 to 5 per 1000 in 1979, and the yearly number of fractures in this city from 104 in 1940 to 788 in 1979. With the present trend the fracture incidence will double over the next 20 years.

Key words: epidemiology; femoral fractures; femoral neck fractures; fracture incidence; hip fractures; osteoporosis

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Patients with fractures of the proximal end of the femur place a constant heavy demand on hospital beds. In spite of improved treatment with early discharge, they remain the most numerous group of patients in most orthopaedic wards. In Sweden, for example, patients with proximal fractures of the femur occupy as many hospital beds as are required for all abdominal surgery excluding cancer patients (Bauer 1977).

Most of these fractures are due to bone fragility (Alffram 1964, Buhr & Cooke 1959, Nilsson & Westlin 1977) and occur particularly in the elderly (Bruns 1882). Hence, the probability of sustaining a fracture of the upper end of the femur increases almost exponentially with age (Alffram 1964, Buhr & Cooke 1959, Gallannaugh et al. 1976, Jensen 1980, Knowelden et al. 1964, Nilsson & Obrant 1978, Stewart 1955, 1958). Some authors, however, have found a greater increase in incidence during certain time intervals than would be expected from the age distribution in the population. Alffram (1964) reported this to occur in Malmö, Sweden, from 1951 to 1960, Mårtensson (1962) in the late 1950s in Göteborg, Nilsson & Obrant (1978) in the early 1960s in Malmö, and Falch & Ilebekk (1978) in the 1960s in Oslo. When the incidence rates of the 1950s (Alffram 1964, Mårtensson 1962, Stewart 1958) are compared with some recently reported incidence rates (Jensen 1980), a continuously rising trend in the fracture incidence is obvious. This trend was not confirmed in 1971–1976 in Gentofte, Denmark, however (Jensen 1980), nor in Malmö, Sweden, from 1967/68 to 1974/75 (Nilsson & Obrant 1978).

This apparent difference inspired the present research to clarify the true incidence of fractures of the proximal end of the femur in Göteborg (Gothenburg), and to relate this to the age change of the population as a whole.

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PATIENTS AND METHODS

The survey includes fractures of the proximal end of the femur which occurred in the city of Göteborg (about 440,000 inhabitants in the 1970s) from 1940 through 1959, and in 1965, 1969, 1970, 1975, 1978 and 1979. The incidence data from 1940 through 1959 were obtained from a previously published report by Mårtensson (1962), based on hospital statistics in the city.

The incidence for the more recent 6 years selected was based on information from three sources: records of all operative procedures in the city, records from the Department of Radiology, and hospital admission records.

All pertrochanteric, subtrochanteric and cervical fractures were included in the survey, but not isolated fractures of the greater or lesser trochanter.

A total of 3475 hip fractures occurred in the 6 years surveyed. They were subdivided according to location (cervical and trochanteric), sex, and age.

STATISTICAL METHODS

Test of time trend

Time trend of probability of fracture was tested using the contingency table (Maxwell 1961) for each age group. The technique of adding the test variables of the different age groups, suggested by Mantel (1963), was used to obtain a test for the material as a whole.

Prognosis

Let V(i), i = 1, ..., 6, denote the year of the study, i.e. V(1) = 1965, ..., V(6) = 1979, and let g (i) be the expected number of fractures during the year V(i) if the risk of fracture equals that estimated during 1965 and the age distribution and number of inhabitants equal those of V(i).

Let

$$t(i) = V(i) - V(i),$$

and

$$r(i) = \log g(i) - \log g(i).$$

The number of fractures during a year follows a Poisson distribution. For the prognosis it was assumed that the expected number for the year V(i) was

$$e^{at\,(i) + c + r(i)},$$

where a and c are constants. The model means that the relative increase of risk per time unit is constant. Let K(1), ..., K(6) denote the number of fractures during the years 1965, ..., 1979 and L be the likelihood function. The parameters (a) and (c) of the model were estimated by the maximum likelihood method. Thus, the equations system

$$\frac{\partial \log L}{\partial a} = \Sigma K(i)t(i) - \Sigma t(i)e^{at\,(i) + c + r(i)} = 0$$

$$\frac{\partial \log L}{\partial c} = \Sigma K(i) - \Sigma e^{at(i) + c + r(i)} = 0$$

was solved using a computer.

Each sex was treated separately.

Let h(t) denote the number of fractures per inhabitant and year for the period 1978–1979 at the age t. For simplicity h(t) was determined as a function which is constant within each 5 year period of age. For a year i, i > 1979, the number h(i,t) of fractures per inhabitant and year was assumed to satisfy the relation

$$h(i,t) = e^{a(i-1979)}\, h(t),$$

where (a) is the previously defined constant describing the risk increase. Let n(t) denote the number of inhabitants in Göteborg in 1979 at the age t. The function h(t) was approximately determined for each year t of age. Mortality rates were obtained from the National Health Bureau of Sweden (Population changes 1978). The yearly mortality rate at the age t is here denoted by d(t). The immigration to Göteborg can be expected to approximately balance the migration from the city. The number of fractures during the year i, i > 1979, was predicted by

$$\sum_t h(t, i)\, n(t,i),$$

where

$$n(t,1979) = n(t),$$
$$n(t,i) = n(t-1, i-1) \times (1-d(t)),$$
$$n(o,i) = n(1,i).$$

A prediction was also performed assuming no time trend of fracture risk, i.e., a prediction obtained by letting the rate of increase a = o.

RESULTS

The number of fractures increased over the time period studied from 104 to 788 per year (Figure 1). As expected more fractures occurred in women than in men, with an overall ratio of 3.7:1 in cervical fractures and 2.4:1 in trochanteric fractures (Figure 2).

The increase in fracture incidence is statistically significantly greater than expected when considering the age change of the population in

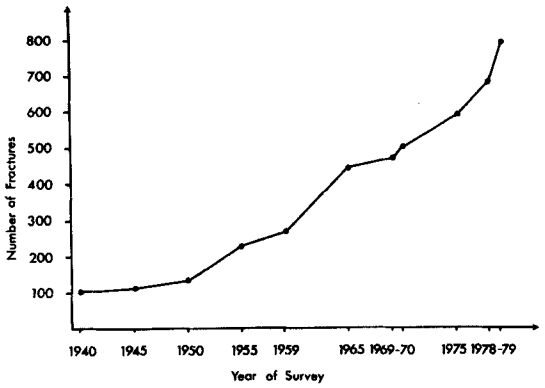

Figure 1. The number of fractures of the proximal end of the femur in Göteborg, Sweden, 1940–1979.

the city. Table 1 shows the results of a statistical test of the time trend when the fractures are divided according to sex and age. A statistically significant incidence increase was found for men 50 to 89 years of age, and for women 70 to 89 years of age, as well as for both types of fractures (Tables 2 and 3). The increase was more pronounced in trochanteric than in cervical fractures. There is no tendency indicating a change in the increase. Thus, the age specific fracture risk was found to increase significantly from 1965 through 1979.

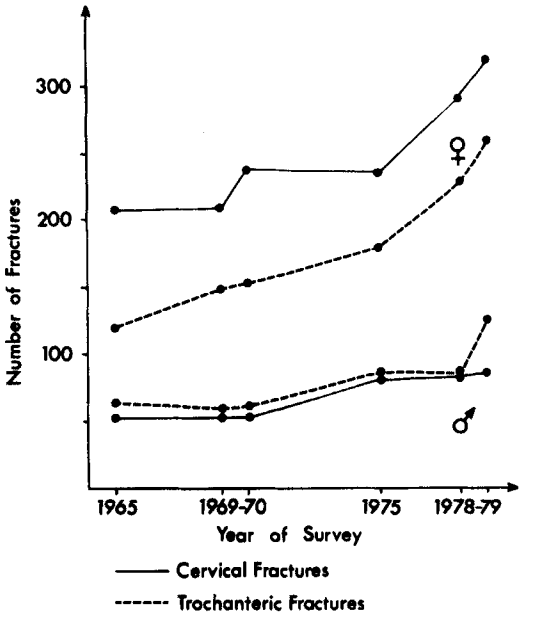

Figure 2. Cervical and trochanteric fractures, subdivided according to sex of the patient, 1965–1979.

Table 1. Statistical test of the time trend. All fractures have been subdivided according to age and sex, and the totals are also shown. Univariate test value of 0.5 means no trend with time, less than 0.5 a decrease and more than 0.5 an increase. 0.995 is significant at the 1 per cent level.

Age	Men	Women
15–49	.5957	.2583
50–69	.9996***	.6039
70–79	.99988***	.99998***
80–89	.999976***	.999998***
90–	.8726	.9435
All ages	1.0***	1.0***

Table 2. Time trend. Cervical fractures are subdivided according to age and sex, and the totals are also shown. Univariate test $P > 0.975$, significant at the 5 per cent level

Age	Men	Women
15–49	.6487	.1181
50–59	.9123	.6116
70–79	.9992**	.9937*
80–89	.9533	.9908*
90–	.9395	.7586
All ages	.999954***	.9983**

Table 3. Time trend. Trochanteric fractures, subdivided according to age and sex, and totals are also shown

Age	Men	Women
15–49	.5033	.6957
50–69	.9994**	.5197
70–79	.9804*	.9998***
80–89	.99996***	.99998***
90–	.2976	.9309
All ages	.9999999652***	.999999904***

The annual incidence rate per 1000 was calculated for three pairs of the years investigated; 1965 and 1969, 1970 and 1975, and 1978 and 1979 (Figure 3).

A further calculation was made of the incidence of fractures in patients with an age over 50 and 80 years, respectively (Tables 4 and 5). A 26

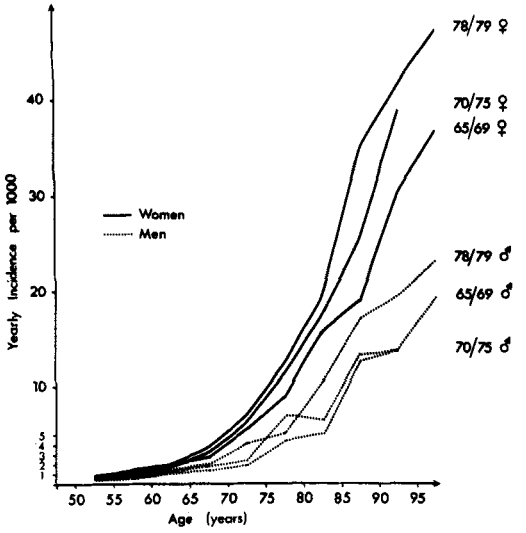

Figure 3. The annual incidence rate of fractures of the proximal end of the femur per 1000 persons. Three pairs of the years investigated, 1965–1979, are plotted separately for women and men.

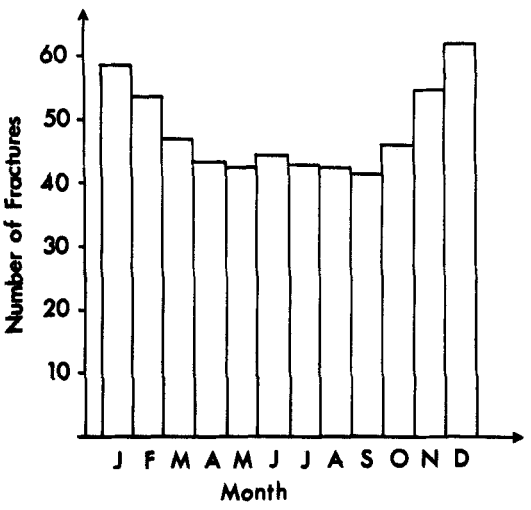

Figure 4. The seasonal variation in fracture rate. Total material, 3475 hip fractures.

per cent increase was found from 1965 to 1979 in patients 50 years and older, and an almost 100 per cent increase in patients over 80 years of age.

Table 6 shows the number of hospital beds and the average period of hospitalization. In spite of a dramatic reduction in the average period of time spent in the hospital, more beds are required each year for these patients. The somewhat surprising figures in 1975 were because of a temporary relative shortage of secondary rehabilitation facilities outside the trauma hospitals.

The mean age of the patients with cervical fractures increased from 72.6 (1965) to 75.6 (1979) in women, and from 71.7 (1965) to 74.4 (1979) in men. Similarly, there was an increase in the mean age of patients with trochanteric fractures from 74.3 to 78.4 in women, from 67.8 to 70.2 in men. When all the fractures were totalled,

Table 4. The incidence per 1000 of fractures of the proximal femur in patients over 50 years of age

Year	Women	Men	Total
1965	4.4	2.3	3.6
1969	4.4	1.6	3.1
1970	4.8	1.6	3.3
1975	4.8	2.3	3.7
1978	5.9	2.3	4.3
1979	6.6	2.8	4.9

Table 5. The incidence per 1000 of fractures of the proximal femur in patients over 80 years of age

Year	Women	Men	Total
1965	15.6	6.0	11.9
1969	20.8	9.4	16.7
1970	21.6	7.0	16.3
1975	21.3	10.5	17.7
1978	26.6	11.9	21.7
1979	26.0	14.4	22.2

Table 6. Average hospitalization time, number of fractures and number of beds per year occupied in the acute ward by hip fracture patients in Göteborg

Year	Beds/year	Average hosp. time	Number of fractures
1959[1]	37[1]	50[1]	269[1]
1965	44	36	443
1969	38	28	471
1970	32	23	503
1975	50	31	584
1978	36	19	686
1979	46	21	788

1. Mårtensson (1962).

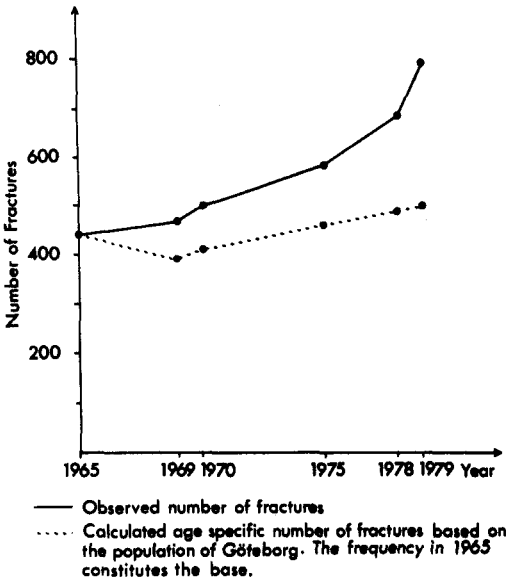

Figure 5. The observed and expected number of fractures of the proximal end of the femur in Göteborg, 1965–1979. The expected number was calculated from the actual population of Göteborg in the investigated years. 1965 constitutes the base.

men were found to be on average 4.5 years younger than women (70.8 and 75.3 years respectively).

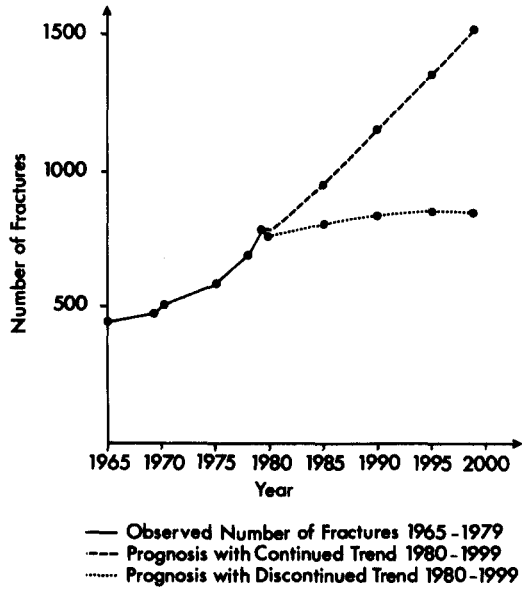

Figure 6. Observed number of fractures 1965–1979 and prognosis for 1980–1999.

Women sustaining a trochanteric fracture were older than women sustaining a cervical fracture, while the reverse was found in the men.

Figure 4 shows the seasonal variation in fracture rate. A moderate increase in fracture incidence was found in the winter months.

The expected incidence of femoral neck fractures in Göteborg was calculated, based on the 1965 data and on the age development of the population from 1965 to 1979 (Figure 5). When the predicted data is compared with the observed incidence a dramatic increase was found above that expected. Thus, with the present trend the incidence will double in 16 years in men and in 30 years in women. Using a function for the fracture risk based on the observed rates in 1978 and 1979 a prognosis was made of the incidence from 1980 to 1999. The mortality rate was estimated using data from the National Bureau of the Statistics in Sweden. Figure 6 shows the predicted data assuming both that the observed trend will continue and that the increased will discontinue. With the present trend the incidence can be predicted to double by the turn of the century.

DISCUSSION

Several authors have demonstrated an increase in the incidence of fractures of the proximal end of the femur over the last 30 years, even when changes in the age and sex of the population were accounted for. This material clearly confirms these reports. Figure 7 shows the age specific fracture incidence per 1000 women based on surveys in Dundee 1952–1957 (Stewart 1958), Malmö 1951–1960 (Alffram 1964), Göteborg 1955–1959 (Mårtensson 1962), and the present material. The slope of the curve based on our material is clearly steeper, indicating a more rapid increase in fracture incidence than that found in the previous surveys. The incidence of hip fractures in Göteborg in patients 50 years and older is similar to that in recent studies on fracture incidence from the beginning of the 1970s (Jensen 1980, Gallanaugh et al. 1976, Gordon 1971) (Table 4). At that time the incidence rate was about 3 per 1000. However, in the late 1970s the incidence rate was found to be between 4 and

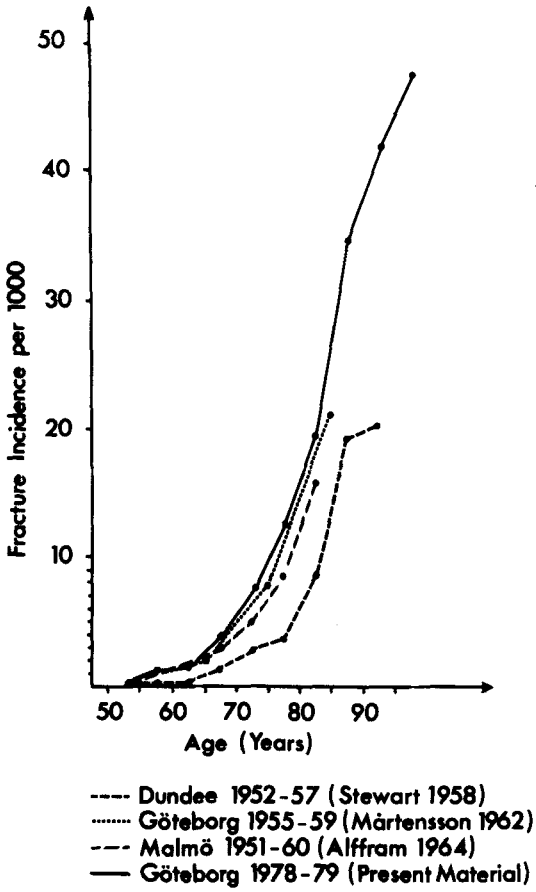

Figure 7. The age specific incidence of fractures of the proximal end of the femur. A comparison between three reported materials and the present study.

5 per 1000. The statistically significant increase in incidence rate was found to prevail for all age groups up to 90 years. Few patients were 90 years or older, however, which may explain this fact.

The increase in fracture rate places significant demands on hospital beds and other services. It is reasonable to speculate that the observed specific incidence increase will continue. If we assume that the patients' mean stay in the orthopaedic wards remains the same as in 1978/79, i.e., 20 days, and base a prognosis on a continued incidence increase, there will be a need for 63 beds for acute care for hip fractures in 1990 and 83 beds in 1999, compared with the 46 used in 1979. The duration of the hospital stay and the place of discharge are largely dependent on the pre-fracture condition of the patient and the aftercare facilities (Dolk & Westerborn 1977, Gylling 1960, Knowelden et al. 1964, Stewart 1958). However, improved treatment methods have been the main factor contributing to a decrease in the hospital stay over the years (Borgquist 1974, Ceder 1980). A continued progress in this respect can obviously alter the prediction.

There are many possible explanations for the increased age-specific incidence in hip fractures. Nilsson & Obrant (1978) suggested that the deficient diet during the first World War, possibly induced a deficient bone mineralization and therefore, could account for more osteoporosis at advanced ages. The patient sustaining a hip fracture belongs to a sicker subset of the population. As a group, they are more osteoporotic (Lender et al. 1976, Hagberg & Nilsson 1977, Nilsson 1970, Stevens et al. 1962, Vose & Lockwood 1965) and factors known to influence the bone mineral content, i.e., gastric resection, certain drugs, osteomalacia (Aaron et al. 1974, Bauer 1960, Nilsson 1970, Nilsson & Westlin 1971, O'Driscoll 1973) are also more frequent. Furthermore, there is an increased proportion of patients with cardiovascular and muscle weakening diseases (Boucher 1959, Dolk & Westerborn 1977), with diabetes mellitus (Alffram 1964, Wong 1966), and with thyrotoxicosis (Gallagher et al. 1980). There are also some ethnic differencies (Pogrund et al. 1977).

It has been shown that osteoporosis and osteomalacia are clearly related to hip fractures. It is therefore reasonable to assume that the observed incidence increase is paralleled by similar increases in osteoporosis and osteomalacia. Evidence is accumulating that the main osteoporosis-inducing factors are age, sex, level of alcohol intake, cigarette smoking and gastric resection. These factors are believed to be more important than nutritional factors and type of work.

Smoking is a rather new concept in this respect and is therefore discussed below. It is known to co-variate with alcohol drinking, which leads to a higher risk for peptic ulcer and gastric resection, thereby increasing the risk for osteoporosis (Mellström et al. 1981). There are other possible effects of smoking, however, which can contribute to the development of osteoporosis (Holló

et al. 1979, Kershbaum et al. 1968, Daniell 1972, 1976). Cadmium is known to interfere with the metabolism of vitamin D (Lorentzon & Larsson 1977). Except for massive exposure (Tsuchiya 1969) the main route for cadmium resorption may be from cigarette smoke via the lungs, because the resorption via the intestine is very low. Thus, one of the reasons for the increased incidince of hip fractures may be a change in the smoking and drinking habits.

CONCLUSIONS

The age specific incidence of fractures of the proximal end of the femur shows a steady increase in Göteborg, Sweden, during the 1960s and 1970s. The fracture incidence increased from about 3 per 1000 in 1965 to 5 per 1000 in 1979, and the yearly number of fractures in the city from 104 in 1940 to 788 in 1979.

A prognosis shows that the fracture incidence will double in 16 years in men and in 30 years in women. With the present trend the total fracture incidence will double over the next 20 years.

This is a challenge to the orthopaedic surgeon as well as to all socio-medical services to improve methods of treatment and of rehabilitation. Only prophylactic measures can reduce fracture incidence, however.

The study shows that it is imperative to think in terms of prevention. If not, our orthopaedic services will be grossly inadequate within a short period of time.

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