Age and Ageing 2002; **31:** 343–348

The influence of outside temperature and season on the incidence of hip fractures in patients over the age of 65

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Abstract

Background: it is often assumed that hip fractures occur more commonly in winter, but the evidence is conflicting. It is important to clarify this issue to aid planning of health resources and understanding of the aetiology of these fractures in the elderly.
Aim: to determine whether the incidence of fractures altered with the daily temperature, seasons or months of the year.
Method: over a five-year period we studied 818 patients, over the age of 65, who presented to one district general hospital with a fracture of the proximal femur.
Results: no significant difference was found in the incidence of fractures with different temperatures, changes of temperature, season or month of the year. Also, there was no significant difference in the characteristics of patients (age, sex, pre-injury mobility, residence, functional and mental scores) presenting in different seasons or temperature ranges. Patients presenting in winter months had a significantly longer inpatient stay, which may have been due to the strain on the social services over this time.
Conclusion: other factors must be analysed when considering the aetiology of hip fractures in the elderly. There may be no extra demand on surgical facilities or other acute resources to treat hip fractures during the winter months in southern England.

Keywords: *hip fracture, aetiology, temperature, elderly*

Introduction

Hip or femoral neck fractures represent an increasing cause of morbidity and mortality in the Western world. Improved understanding of the epidemiology of the fracture may help to stem this rise and aid in the planning of future health services. The aims of this study are to determine if the incidence of hip fracture is affected by outside temperature or season, and to discover if the characteristics of patients alter with different temperature ranges or with different seasons.

Patients and methods

A study was made of all patients over the age of 65 who presented to one district general hospital with a fractured hip (cervical or pertrochanteric femoral fracture), over a five-year period. Patients who suffered high velocity trauma or who had pathological fractures were excluded. Various data were collected including type of fracture, surgical intervention (if any), pre-injury mobility and residence and length of hospital stay (Table 1). The pre-injury functional and cognitive scores were collected retrospectively, usually on the day after admission. The Barthel index was used to measure physical ability and the Kew test was used to measure cognitive impairment [1, 2]. The Barthel index is a validated score out of twenty, which measures activities of daily living. The Kew test is an error score out of fourteen, with a score of four or more indicating cognitive impairment. If the patient was cognitively impaired, information was gained from relatives and carers wherever possible.

Table 1. Information collected and results

Total number of patients	818		
Age	Median 83	Range 65–103	
Sex	Female	670	(81.9%)
	Male	148	(18.1%)
Pre-injury mobility	No aids	508	(62.1%)
	Stick	162	(19.8%
	Crutches	7	(0.9%)
	Frame	106	(13%)
	Non-mobile	29	(3.5%)
	Unknown	6	(0.7%)
Pre-injury Residence	Home	491	(60%)
	Residential home	71	(8.7%)
	Nursing home	76	(9.3%)
	Hospital	98	(12%)
	Unknown	82	(10%)
Type of fracture sustained	Sub-capital	401	(49%)
	Pertrochanteric	417	(51%)
Operation	None	16	(2%)
	Screw fixation	82	(10%)
	Hemiarthroplasty	312	(38.1%)
	Dynamic hip screw	387	(47.3%)
	IM hip screw (IMHS)	11	(1.3%)
	Total hip replacement	10	(1.2%)
Length of hospital stay	Days (median)	18	
	Unknown	40	(5%)
Pre-injury functional score	Barthel Score (mean)	17	
	Unknown	265	(32%)
Pre-injury mental test score	Kew Test		
	<4	405	(73%)
	$\geqslant 4$	150	(27%)
	Unknown	263	(32%)
Inpatient mortality		83	(10.2%)
Change of accommodation		250	(33%)
	Unknown	60	(7.5%)

The day of admission was taken as the day of injury, unless there was a definite history of injury in the days or weeks prior to admission.

The maximum and minimum daily temperatures for the catchment area of the hospital were obtained from the local meteorology office (Bristol Weather Centre). Seasons were classified as Winter (December, January, February), Spring (March, April, May), Summer (June, July, August) and Autumn (September, October, November).

The information collected was stored on a computer database (Microsoft FoxPro).

The incidence of hip fracture was calculated for each month and season, and for each temperature range of 5°C for both the minimum and maximum temperature recorded on the day of injury, over the study period. The characteristics of patients sustaining hip fractures, length of hospital stay and requirement for a change in accommodation from the pre-injury residence were also analysed with respect to these variables.

Statistical analysis was performed using the Chi-squared, Mann–Whitney and Kruskall–Wallis tests.

Results

A total of 818 patients were studied, 196 male and 622 female, with a median age of 83 years (range 65–103). The hospital served a local population of approximately 220 000 and remained open for all trauma admissions, with no patients being referred elsewhere. A summary of the data collected is shown in Table 1.

The influence of both maximum and minimum daily temperatures on the incidence of hip fracture was measured. It was not possible to show any direct relationship between outside temperature and the incidence of hip fracture, due to small numbers of patients in each group, particularly in the extremes of temperature. There were no significant differences found in the number of fractures occurring per day, when comparing different temperature ranges for both maximum and minimum temperatures (maximum temperature $P=0.903$, minimum temperature $P=0.948$, Kruskall–Wallis test). In the 77 days over the five-year period when the temperature fell below freezing, there was no increase in the rate of fracture.

A significant change of temperature has been suggested as a cause of increased fracture rate, and so the number of fractures presenting during a day when the temperature changed by 5°C or more was calculated. There was no significant difference found in the mean number of patients presenting on either the day of the temperature change, or the day after, compared to the other days.

The mean incidence of hip fracture per month and season were analysed. Each month was averaged to a 30-day period, to eliminate the variation in the number of days per month (Figures 1 and 2). No significant change was found in the mean number of patients presenting per month or season over the five-year period studied.

Characteristics of patients (i.e. age, sex, type of fracture, pre-injury mobility, residence, functional and cognitive scores) were analysed in relation to presentation in the different maximum and minimum temperature ranges (Tables 2 and 3). There was no significant difference in such characteristics. Similarly, the characteristics of patients admitted in different seasons were assessed and no significant difference found.

There was no significant seasonal variation in numbers of patients requiring a change of accommodation from pre-injury residence (Figure 3). The only significant difference demonstrated was in the length of hospital stay of patients admitted in the winter months, who stayed a significantly longer time than those admitted in the summer months ($P=0.003$ Mann–Whitney test) (Figure 4).

Discussion

Hippocrates first drew attention to the importance of the climate in relation to disease in his writings *On Airs, Waters and Places* over 2400 years ago:—"Whoever wishes to investigate medicine properly should proceed thus: in the first place to consider the seasons of the year and what effects each produces . . ." [3].

It has been a long held belief that there is an increase in hip fractures in the elderly in the winter months. This has been attributed both to colder temperatures affecting the body metabolism causing an increased susceptibility to falls, and to longer nights with increased hours of darkness, though there is no evidence to support this. Fourteen previous studies have examined seasonal variation and the incidence of hip fracture, of which some have also looked at the influence of temperature.

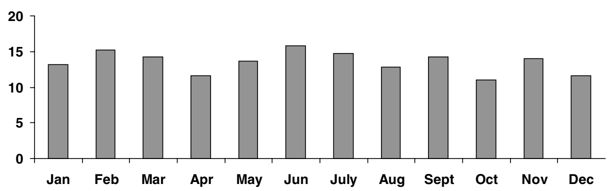

Figure 1. Mean fractures per month (30 day period).

These vary considerably in size of population and number of fractures assessed, and in the country or region studied, from a small town to areas spanning 15° of latitude, with the resultant change in climate. Of these fourteen studies, seven showed an increase of fractures in the winter months, three showed an increase in summer months and four showed no seasonal variation.

In 1955 Stewart first reported a seasonal variation in a study of 190 cases in Dundee, Scotland [4]. Both this study, and a larger study of 621 387 patients from the United States found a higher rate of fracture in the winter months [5]. The latter study encompassed an area of over 15° of latitude with huge variations in climatic conditions. Two reports from Goteborg in Sweden, possibly studying the same group of patients, describe a moderate increase in winter months [6, 7]. A further study of 3053 patients from Stockholm obtained similar results [8]. The only previous English report came from Nottingham [9]. This study of 774 patients from 1980–1982 showed an increase in the incidence of fracture in the winter months. A winter peak and summer trough were also seen in Hong Kong, with the local mean temperature ranging from 17°C in the winter to 28°C in the summer [10].

Three studies, all involving less than 500 patients, show a summer peak in the incidence of hip fractures in

Table 2. Minimum daily temperature and patient characteristics

Min. daily temp. °C	No. of patients (%)	Age	Sex	Type of fracture	Pre-injury mobility	Pre-injury residence	Pre-injury Barthel score (median)	Pre-injury Kew score	Length of stay (days) median
<0	28 (3.4%)	83	M 1 F 27	S—14 P—14	N—20 S—6 F—1 I—1	O—15 RH—4 NH—4 H—2 Unknown—3	19 Unknown—6	14 < 4 8 ⩾ 4 Unknown–6	20 Unknown—1
0–4	144 (17.6%)	83	M 21 F 123	S—70 P—74	N—92 S—28 C—2 F—15 I—7	O—81 RH—21 NH—15 H—12 Unknown—15	17 Unknown—30	76 < 4 39 ⩾ 4 Unknown—29	20 Unknown—4
5–9	301 (36.8%)	83	M 70 F 231	S—155 P—146	N—188 S—55 C—4 F—36 I—13 Unknown—5	O—192 RH—18 NH—24 H—35 Unknown—32	17 Unknown—116	134 < 4 51 ⩾ 4 Unknown—116	19 Unknown—16
10–14	277 (33.9%)	82	M 47 F 230	S—132 P—145	N—171 S—61 F—38 I—6 Unknown—1	O—171 RH—20 NH—24 H—36 Unknown—26	18 Unknown—99	144 < 4 35 ⩾ 4 Unknown—98	17 Unknown—17
15–19	68 (8.3%)	83.5	M 9 F 59	S—30 P—38	N—37 S—12 C—18 F—16 I—2	O—32 RH—8 NH—9 H—13 Unknown—6	17 Unknown—14	37 < 4 17 ⩾ 4 Unknown—14	15 Unknown—2

M = male; F = female; S = Subcapital; P = Pertrochanteric; N = No aids; S = Stick; C = crutches; F = frame; I = Immobile; O = own home; RH = Residential home; NH = Nursing home; H = Hospital.

the elderly. Rowe reported on 405 patients from South Korea [11], Rodriguez studied 301 subcapital fractures in Spain and Tambakis from New York reported on 180 fractures [12, 13].

Several explanations for winter and summer peaks have been suggested, some more plausible than others. Ralis *et al.* attempted to determine the cause of an increased fracture rate in the winter by comparing a four-day period when ice and snow were present with the same period in a subsequent year which was snow and ice free [14]. In the days with freezing conditions there was a 3.5-fold increase in the number of hip fractures but the numbers reported were small (fourteen fractures compared to four). Douglas suggested an association between haemorrhagic disease of the newborn and the later incidence of hip fracture, which he observed had a similar seasonal variation [15]. Barstow noted an increase in the incidence of fracture in very thin patients in the winter months and suggested that impairment of body temperature control led to hypothermia, lack of co-ordination, and injury [9]. Chiu suggested that in the winter months the 'hindrance of free movements and increased clumsiness of patients with many layers of clothes put on during the cold weather' could contribute (even though the mean winter temperature was 17°C) [10]. In contrast, the Korean study suggested the higher incidence in summer was due to the increased activity carried out by the patients [11]. Tambakis postulated that the increase in summer could be explained by an increased fluid intake and hence greater urgency to urinate during the warmer months [13].

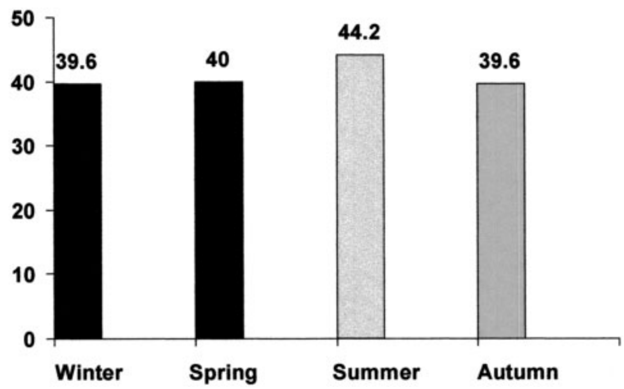

Figure 2. Mean number of fractures per season.

Table 3. Maximum daily temperature and patient characteristics

Max. daily temp. °C	No. of patients (%)	Median age	Sex	Type of fracture	Pre-injury mobility	Pre-injury residence	Pre-injury Barthel score (median)	Pre-injury Kew score	Lengh of stay (days) median
<0	1 (0.1%)	82	M 0 F 1	S—1 P—0	N—1	O—1	Unknown—1	Unknown—1	20
0–4	21 (2.6%)	83	M 2 F 19	S—10 P—11	N—16 S—2 F—1 I—2	O—13 RH—1 NH—5 H—2	17 Unknown—6	10<4 5⩾4 Unknown—6	14.5 Unknown—2
5–9	115 (14%)	83	M 19 F 96	S—58 P—57	N—69 S—25 C—2 F—13 I—6	O—75 RH—11 NH—14 H—10 Unknown—5	17 Unknown—22	62<4 31⩾4 Unknown—22	22 Unknown—11
10–14	294 (39.5%)	84	M 60 F 234	S—152 P—142	N—189 S—56 C—4 F—32 I—8 Unknown—5	O—155 RH—34 NH—15 H—34 Unknown—56	18 Unknown—124	126<4 44⩾4 Unknown—124	19 Unknown—19
15–19	229 (28%)	82	M 39 F 190	S—123 P—106	N—141 S—50 F—29 I—9	O—144 RH—15 NH—27 H—31 Unknown—18	17 Unknown—71	118<4 41⩾4 Unknown—70	18 Unknown—6
⩾20	158 (19.3%)	84	M 28 F 130	S—90 P—76	N—92 S—29 C—1 F—31 I—1 Unknown—1	O—103 RH—10 NH—21 H—21 Unknown—3	17 Unknown—41	89<4 29⩾4 Unknown—40	15 Unknown—2

M = male; F = female; S = Subcapital; P = Pertrochanteric; N = No aids; S = Stick; C = crutches; F = frame; I = Immobile; O = own home; RH = Residential home; NH = Nursing home; H = Hospital.

The remaining four studies have demonstrated no seasonal variation. Swanson, in a follow up of the original study from Dundee, Scotland showed no difference in 1975 and 1980 [16]. Shapiro studied approximately 2000 cases in two separate five-year periods (1958–1962 and 1968–1972) and found no significant pattern [17]. Lund, in a small study from Denmark, and Pedrazzoni, who looked at two different regions in Italy with 7637 cases, both reported similar findings [18, 19].

These results are in agreement with the present study in which no significant seasonal variation could be demonstrated.

Only one study recorded the mean daily temperature but this did not report any significant correlation with fracture rate [9]. The present study which is larger in size, similarly showed no correlation with the mean outside maximum and minimum daily temperatures; this discounts some of the previous theories suggesting temperature or its change as a cause of the reported seasonal variation.

It was thought that patient characteristics may vary between the seasons with only the more active and mobile venturing outside in the winter months and so being vulnerable to injury, with the less mobile more likely to fall when they ventured out in the summer months. Information on where the patients fell (i.e. inside or outside) was unfortunately unavailable but no significant difference was found in the characteristics of patients falling in different temperature ranges or seasons (for example in the days below 0°C).

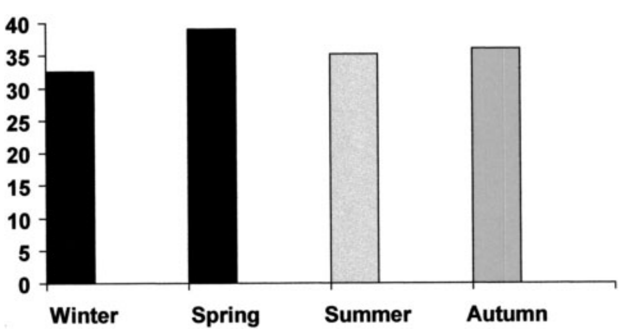

Figure 3. Change of accommodation (%).

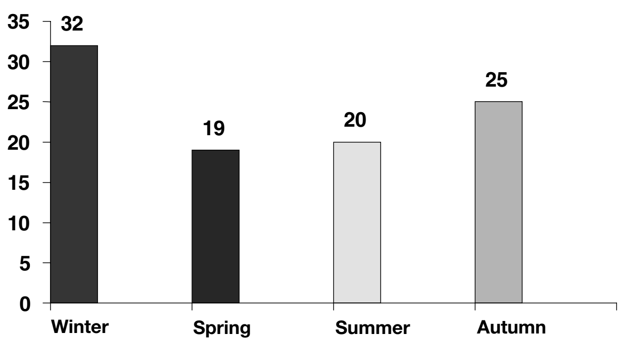

Figure 4. Median length of stay for patients who changed accommodation (Days).

This study has shown no significant correlation between temperature and season with the incidence of hip fractures in the elderly. One limitation of this study is the lack of information recorded on the place of injury (inside and outdoors), which might highlight the effect of falling or slipping on ice. However, the absence of any observed increase in incidence of hip fractures in the winter months suggests such a factor is causally minor. The findings of this study may be most appropriate to similar regions in the South of England where there is no major variation in seasonal temperatures. In countries in which subzero temperatures are more marked or prolonged in winter months, then icy conditions may be a more important factor in the incidence of hip fracture.

The only significant seasonal difference found in the current study was an increased length of hospital stay in the winter months. It is recognized that patients who require a change in accommodation from their pre-injury residence will have a longer hospital stay. However this was not the cause for a prolonged stay in patients admitted in the winter months in this study, as there was no significant increase in patients changing accommodation from their pre-injury residence. Instead, it is postulated that this increased stay may be due to excessive demand on the social services, due to the increase in the overall number of elderly patients admitted to hospital at this time. There was no increase in the rate of post-operative complications to account for an increased length of hospital stay.

This study of 818 patients with hip fractures showed no variation in hip fracture rate with either temperature or season. The implications from this study are that other factors must be analysed when considering the aetiology of hip fractures in the elderly. There should, therefore, be no extra demand on surgical facilities or other acute resources to treat hip fractures during the winter months in this country.

Key points

- It is often assumed that hip fractures occur more commonly in winter but evidence is conflicting.
- This study showed no association between the incidence of hip fractures and different temperatures, changes of temperature, season or month of the year.
- There is no significant difference in the characteristics of patients presenting in different seasons or temperature ranges.
- Patients presenting in the winter months had a significantly longer hospital stay.
- Other factors rather than season and weather should be analysed when considering the aetiology of hip fractures in the elderly.

Acknowledgements

The authors would like to thank Frenchay Hospital for their help in data collection, Bristol Meteorology Office for the daily temperatures, and Clare Swinburn for help with the analysis of the data.

References

1. Stone SR, Ali B, Auberleek I, Thompsell A, Young A. The Barthel index in clinical practice: use in a rehabilitation ward for elderly people. J Roy Coll Phys Lond 1994; 28: 419–23.

2. Towle D, Wilcock GK, Surmon D. The Kew Test—study of reliability and validity. J Clin Exp Gerontol 1987; 9: 245–6.

3. Hippocrates. On Airs, Waters, and Places. c. 400BC.

4. Stewart IM. Fractures of neck of femur. Incidence and implications. Br Med J 1955; 1: 698–701.

5. Jacobsen SJ, Goldberg J, Miles TP, Brody JA, Stiers W, Rimm AA. Seasonal variation in the incidence of hip fractures among white persons aged 65 years and older in the United States, 1984–1987. Am J Epidemiol 1991; 133: 996–1004.

6. Zetterberg C, Andersson GBJ. Fractures of the proximal end of the femur in Goteborg, Sweden, 1940–1979. Acta Orthopaed Scand 1982; 53: 419–26.

7. Zetterberg C, Elmerson S, Andersson GBJ. Epidemiology of hip fractures in Goteborg, Sweden, 1940–1983. Clin Orthop 1984; 191: 43–51.

8. Holmberg S, Thorngren K. Statistical analysis of femoral neck fractures based on 3053 cases. Clin Orthop 1987; 218: 32–41.

9. Barstow MD, Rawlings J, Allison SP. Undernurition, hypothermia, and injury in elderly women with fractured femur: an injury response to altered metabolism? Lancet 1983; 1: 143–6.

10. Chiu KY, Ngand TP, Chow SP. Seasonal variation of fractures of the hip in elderly persons. Injury 1996; 27: 333–6.

11. Rowe SM, Yoon TR, Rang DH. An epidemiological study of hip fractures in Honman, Korea. Int Orthop 1993; 17: 139–43.

12. Rodriguez J, Herrara A, Canales V, Serrano S. Epidemiological factors, morbidity and mortality after femoral neck fractures in the elderly. Acta Orthop Belg 1987; 53: 472–9.

13. Tambakis A, Weinsaft P. Fractures of the femoral neck. A ten-year review. Geriatrics 1967; 22: 122–8.

14. Ralis ZA. Epidemic of fractures during period of snow and ice. Br Med J 1981; 282: 603–5.

15. Douglas AS. Seasonality of hip fracture and haemorrhagic disease of the newborn. Scott Med J 1993; 38: 37–40.

16. Swanson AJG, Murdoch G. Fractured neck of femur. Pattern of incidence and implications. Acta Orthop Scand 1983; 54: 348–55.

17. Shapiro S, Andelson L, Oseasesohn R. A study of racial difference, seasonal variation, and temporal variation in hip fracture-related mortality. J Chron Dis 1977; 30: 185–92.

18. Lund B, Sorensen OH, Christensen AB. 25-Hydroxycholcalciferol and fractures of the proximal femur. Lancet 1975; 2: 300–2.

19. Pedrazzoni M, Alfano FS, Malvi C, Ostanello F, Passeri M. Seasonal variation in the incidence of hip fractures in Emilia-Romagna and Parma. Bone 1993; 14: S57–63.

Received 25 September 2000; accepted in revised form 15 March 2002