

# Effect of Seasonality, Weather and Holidays on the Incidence of Proximal Hip Fracture

Lior Koren MD<sup>1</sup>, Adi Barak RN<sup>2</sup>, Doron Norman MD<sup>1</sup>, Ofer Sachs MD<sup>1</sup> and Eli Peled MD<sup>1</sup>

<sup>1</sup>Division of Orthopedic Surgery and <sup>2</sup>Department of Emergency Medicine, Rambam Health Care Campus, affiliated with Rappaport Faculty of Medicine, Technion-Israel Institute of Technology, Haifa, Israel

**ABSTRACT:** **Background:** Proximal hip fractures in the elderly are common and place a heavy burden on health resources. Researching the timing of these fractures could contribute to diverting resources towards peaks in incidence and investing in prevention at certain times.

**Objectives:** To examine the effect of seasonality, weather and Jewish holidays on hip fracture incidence in older adults. The study population comprised 2050 patients aged 65 years or more who sustained a proximal hip fracture.

**Methods:** The computerized files of the patients were reviewed for trends in incidence by season, precipitation, minimum and maximum temperatures, day of the week, and certain Jewish festivals.

**Results:** Hip fractures were more likely to occur in the winter than in the summer ( $P < 0.0001$ ). Factors that significantly correlated with hip fracture were the maximum daily temperature ( $r = -0.746$ ,  $P = 0.005$ ) followed by the minimum daily temperature ( $r = -0.740$ ,  $P = 0.006$ ) and precipitation ( $r = 0.329$ ,  $P = 0.02$ ). There were fewer fractures on Saturdays (the Sabbath) as compared to other days of the week ( $P = 0.045$ ). Researching the incidence on Jewish holidays, we found an elevated incidence on Passover ( $P < 0.0001$ ) and a reduced incidence on the Day of Atonement (*Yom Kippur*) ( $P = 0.013$ ).

**Conclusions:** In older people there is an elevated incidence of proximal hip fractures during the winter and on the Jewish festivals. On weekends and on the Day of Atonement the incidence of proximal hip fractures was reduced.

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**KEY WORDS:** hip fracture, seasonality, temperature, Jewish holidays

**H**ip fractures in the elderly are common, accounting for more than 250,000 fractures annually in the United States alone [1], exerting a heavy burden on health resources [2-4]. Studying the timing of these fractures could help in the attempt to divert resources towards peaks in incidence and investing in prevention at certain times. The seasonality of hip fractures in the elderly has been documented in several geographic locations as well as in both genders and various age groups [5-7]. Most of the publications report that more fractures occur during the winter, i.e., the cold and rainy seasons [6,8,9], while others showed no

seasonal variation [10]. There are several hypotheses as to why more hip fractures occur during the winter. Less sunlight has been suggested as one possible explanation [7,11,12]. Reduced light may result in a decline in visual acuity as well as reduced synthesis of vitamin D that may result in osteomalacia. Freezing conditions can contribute by increasing the risk of slipping [13]. Furthermore, in the winter there is impaired thermoregulation, hypothermia and consequent motor coordination deficit that predispose the elderly to fall [14].

The seasonality of hip fractures in the Mediterranean climate has not been widely studied. Of the three studies we found, two described a rise in the incidence of fractures during the winter [8,15] while one did not [10]. In Israel we did not find any research investigating this interesting connection. Also important in the timing of fractures and providing insight into their pathomechanism is the incidence on days of various religious festivals and holidays. References to this in the literature were scarce [17].

## PATIENTS AND METHODS

We examined the computerized discharge files of all proximal femoral fractures admitted to our hospital from August 2003 to July 2010 (7 years in total). Included were patients aged 65 and above. A proximal femoral fracture was included if it was situated between the subcapital region up to 5 cm below the lesser trochanter as seen on both lateral and antero-posterior views on X-rays. The day of admission was considered the day of the fracture as it was observed that most of the patients arrived several hours after the injury. Also, in terms of logistic implications, the day of admission is more relevant than the day of the injury.

The total number of hip fractures occurring in each month during the 7 year study period was adjusted to its 30.4 day equivalent to compensate for the unequal number of days in each calendar month. The number of fractures occurring in each season was determined according to the following categories: winter – December, January, February; spring – March, April, May; summer – June, July, August; and autumn – September, October, November. Variations in the incidence between seasons were evaluated.

The average number of fractures on each day of the week was noted and compared to the average number for the rest of

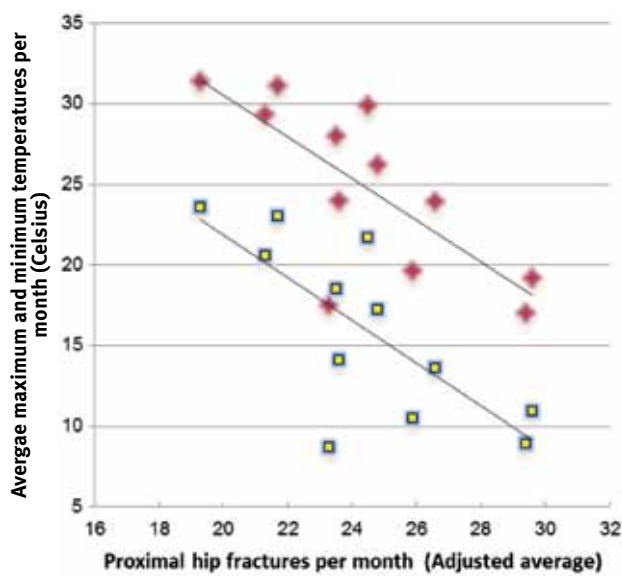
**Table 1.** Patients' characteristics

	N (%)
All	2050 (100%)
<b>Mean age (range) (yr)</b>	
82.16 (65–107)	
65–74	404 (19.7%)
< 75	1646 (80.3%)
<b>Gender</b>	
Male	570 (27.8%)
Female	1480 (72.2%)
<b>Religion</b>	
Jews	1762 (86.0%)
Non-Jews	288 (14.0%)

the week. The amount of precipitation and average minimum and maximum temperatures of each month in Haifa were obtained from the Israeli meteorological service. This was correlated with the adjusted number of hip fractures for each of the corresponding calendar months. The climatic variations in the incidence of fractures were investigated further for gender differences. Likewise, the age group above 75 was investigated for climate alteration in incidence.

The variations in incidence on the holidays were also investigated. Since the large majority of our patients were Jewish we questioned whether more fractures occurred on the Jewish holidays. The time of the holiday was considered as the day before, the day itself, as well as the day after, in order to minimize delays in admission. The holidays that were examined were the High Holy Days of *Rosh Hashana* (Jewish New Year) and *Yom Kippur* (Day of Atonement); and the festivals of *Sukkot* (Feast

**Figure 2.** Average maximum and minimum daily temperatures per month and the number of proximal hip fractures in those months

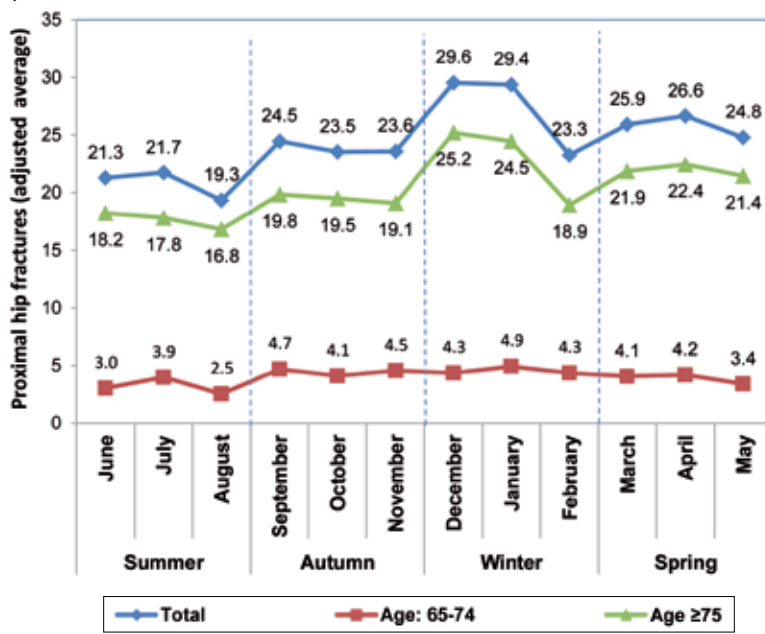


of the Tabernacles) and *Pesach*, namely the *Seder Pesach*, which is the celebratory Passover meal. The Ethics Committee of the Rambam Health Care Campus approved the study protocol.

**DATA ANALYSIS**

The data were analyzed with SPSS version 18. Data were demonstrated with mean ± standard deviation. Pearson's correlation was used for the relation between precipitation and fracture incidence. The Spearman-rho correlation was used for the relation between gender, seasonality and different ages and fracture incidence. Fisher's exact test was used for the relation between categorical variables.  $P < 0.05$  was considered as significant.

**Figure 1.** Adjusted average incidence of proximal hip fractures for each month in the years 2003–2010



**RESULTS**

During the 7 years of the study, 2050 patients aged 65 years and above were admitted with a proximal femoral fracture. Patient characteristics are shown in Table 1. The majority (72.2%) of patients were women. The mean age of the population was 82.2 years.

There was a significant correlation between seasons and the incidence of fractures ( $r = -0.295, P = 0.006$ ) [Figure 1]. The number of fractures was significantly elevated during the winter as compared to the summer ( $P < 0.0001$ ). The trend was more significant in males ( $r = -0.318, P = 0.003$ ) and not significant in females ( $r = -0.198, P = 0.71$ ). The trend was also more evident in patients over the age of 75 ( $r = -0.289, P = 0.08$ ) and not statistically significant for the group aged 65–74 ( $r = -0.43, P = 0.70$ ).

Specific weather parameters were evaluated. The highest association was observed for the maximum and minimum daily temperature ( $r = -0.746, P = 0.005$  and  $r = -0.740, P = 0.006$  respec-

**Table 2.** Days of the week

	Frequency	Percentage	P
Sunday	309	15.1	0.476
Monday	312	15.2	0.370
Tuesday	310	15.1	0.426
Wednesday	304	14.8	0.614
Thursday	268	13.1	0.228
Friday	296	14.4	0.900
Saturday	251	12.2	0.045
Total	2050	100.0	

tively) [Figure 2] followed by precipitation ( $r = 0.329, P = 0.02$ ). The higher the temperature, the lower the incidence of fractures. The more it rained, the more fractures occurred.

With regard to the days of the week, there were fewer fractures on Saturdays ( $P = 0.045$ ) [Table 2]. Regarding the Jewish holidays, there were significantly more fractures on Passover ( $P < 0.0001$ ) and fewer fractures on Yom Kippur ( $P < 0.013$ ). There were more fractures on Rosh Hashanah and Sukkot but this difference did not reach statistical significance ( $P = 0.419$  and  $P = 0.075$  respectively).

## DISCUSSION

Our study strengthens the significance of the summer-winter seasonal variation in the incidence of proximal hip fractures in the elderly. Our results consolidate this relation in the Mediterranean climate. This climate is a variant of the subtropical climate that has warm to hot, dry summers and mild to cool, wet winters. Most research to date supports this increased incidence in the winter in this climate [8,15,18], although one study in a younger population (above the age of 50) found no such correlation [10]. Research showed that seasonality of hip fractures in the elderly was more significant as age progresses [19]. Our results concur with this observation: the seasonal variation was more significant in patients over the age of 75.

Several mechanisms have been proposed for the high incidence of hip fractures during the winter months. One is the amount of sunshine. The number of daylight hours correlates with the levels of serum 25-hydroxycholecalciferol (a vitamin D metabolite). Vitamin D has a marked influence on the degree of osteoporosis [15]. Furthermore, vitamin D was found to improve muscle strength and coordination in the elderly, both important factors in preventing falls [16]. However, it was shown that in the lower latitudes there is less variation in the synthesis of vitamin D between seasons [20]. Compared to Scandinavia and most of Europe, Israel is situated at a lower latitude. Thus, in Israel the seasonal variation is less likely to occur due to depleted vitamin D synthesis. Another theory proposes that the reduced sunshine in the winter reduces visual acuity [7], which

predisposes to falls. Another factor to be considered is the drop in temperature during winter. We found that maximum and minimum temperatures during the day were closely connected to a higher incidence of hip fractures. Lower temperatures have been recognized as a cause of blood pressure and hemodynamic changes [21] as well as reduced dexterity [22] and, hence, frequent falls and fractures [23]. During the winter there is also an increase in precipitations. Rainfall was shown in our study to correlate with a rise in incidence of hip fracture. Past research has shown that slippery conditions greatly enhance the incidence of fractures [12], explaining this relationship. Concerning gender, as expected more females had hip fractures in our study; nevertheless, the ratio of men to women shifted more toward men during the winter. It was shown that older men are more likely than older women to go out on colder days [7] and, therefore, are at increased risk of sustaining a hip fracture.

When observing the trend of fracture incidence on the different week days, it was found that the incidence on Saturdays was lower. Saturday (the Sabbath) is the Jewish equivalent of Sunday in Christianity. Turner et al. [23] pointed to a similar trend of reduced hip fracture incidence during weekends. This trend may suggest a correlation between the activity of the elderly and their incidence of hip fractures. Further, the decline in incidence on weekends has implications on prognosis. Several studies demonstrated that patients with hip fractures admitted on the weekend have an elevated risk of surgical delay, prolonged hospitalization, and even an elevated incidence of complications [24,25]. The reduced incidence on weekends is therefore favorable.

The incidence on Jewish holidays can provide further insight on risk factors for these fractures. To the best of our knowledge, this correlation has been described in only one study. In that 1977 study, Poggrund et al. [17] reviewed 570 fractures that were admitted to Jerusalem hospitals. There were more fractures on Passover, *Shavuot* (festival of weeks) and Rosh Hashanah. In our study there was a significant elevated rate of fractures ( $P < 0.0001$ ) on Passover. Passover is associated with intense activity as the family gathers for a celebratory meal (the Seder). This activity for the elderly seems to be a risk factor for a fracture. On the Jewish New Year (Rosh Hashanah) and Sukkot, the family usually gets together for a festive meal, and the incidence was also elevated, but not statistically significant. It can be hypothesized that there are fewer family gatherings on those holidays. In contrast to Passover, Yom Kippur is a day of atonement and fasting. It is customary to refrain from using any electrical equipment and from driving. On this day there were significantly fewer fractures ( $P = 0.013$ ). This also strengthens the notion of a connection between the level of activity of the elderly and the incidence of hip fractures. When the elderly dress up and travel to a family dinner, as on Passover, they are more at risk of a fall and fracture than on a day of resting and fasting, namely, Yom Kippur.

Our observations on seasonality and timing of hip fractures in the elderly can help in prevention of this injury. The elevated incidence during winter implies that we should raise awareness among the elderly with regard to the risk of slippery conditions, the importance of keeping warm, improving light conditions and not wearing cumbersome clothing.

Furthermore, in view of the variation in incidence according to the season, the day of the week, and religious holidays, resources should be diverted to these times of elevated occurrence. This can be done at the level of prehospital, emergency room, hospitalization ward, operating room, and rehabilitation facility.

#### LIMITATIONS

The study is a single-center observation. National, multi-centered research is still needed to consolidate the findings. With regard to defining the festivals, they were considered as the day before, the day itself and the day after, in order to minimize events causing delay in admission. Nevertheless, a minority of the patients might have been admitted 2 or more days after the day of occurrence, causing some bias.

#### CONCLUSIONS

There is a rise in proximal hip fractures among the elderly during the winter that is closely related to temperature. The theory of depleted vitamin D does not seem to explain the elevated incidence of proximal hip fractures during that season. The rise in incidence during the winter is more profound in the more elderly and in males. Our research shows a reduced incidence of proximal hip fractures on the weekend and on Yom Kippur and a higher incidence on days of festivity.

#### Corresponding author:

**Dr. L. Koren**

Division of Orthopedic Surgery, Rambam Health Care Campus, Haifa 31096, Israel

**Fax:** (972-4) 854-3893

**email:** koren\_lior@yahoo.com

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### “Not everything that is faced can be changed, but nothing can be changed until it is faced”

James Baldwin (1924-1987), African-American novelist, essayist, playwright, poet and social critic whose writings explore racial, sexual and class distinctions in Western societies, particularly mid-20th-century America

### “A musician must make music, an artist must paint, a poet must write, if he is to be ultimately at peace with himself. What one can be, one must be”

Abraham Maslow (1908-1970), American psychologist best known for the Maslow hierarchy of needs, a theory of psychological health predicated on fulfilling innate human needs in priority, culminating in self-actualization. A psychology professor at Brandeis University, Brooklyn College, New School for Social Research and Columbia University, he stressed the importance of focusing on the positive qualities in people, as opposed to treating them as a “bag of symptoms”