Journal of Clinical Gerontology & Geriatrics 22 (2011) 13–16

Contents lists available at ScienceDirect

Journal of Clinical Gerontology & Geriatrics

journal homepage: www.e-jcgg.com

Original article

Higher incidence of falls in winter among older people in Hong Kong

Pui-Yee Yeung, BSc(OT), MPhil [a,*], Pui-Hing Chau, BSocSc(Stat), PhD [b], Jean Woo, MB BChir, MD, FRCP, FRACP, FFPH [a], Veronica Wai-Ting Yim, MBBCh, MRCS, FHKAM(A&E), MSc [c], Timothy Hudson Rainer, MBBCh, MD, MRCP [c]

[a] Department of Medicine and Therapeutics, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong
[b] Faculty of Social Sciences, The University of Hong Kong, Hong Kong
[c] Accident and Emergency Medicine Academic Unit, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong

ARTICLE INFO

Article history:
Received 7 February 2010
Received in revised form
6 January 2011
Accepted 23 January 2011

Keywords:
Aged
Elderly
Falls
Seasons
Weather

ABSTRACT

Purpose: This study aims at determining whether there is a seasonal pattern of falls among older people in Hong Kong and exploring the possible mechanisms underlying the seasonal pattern.
Methods: The falls data were obtained from a 1-year prospective study conducted in 2006–2007 which includes all the older people aged 60 years or more with a fall presenting to Accident and Emergency Department of a regional hospital in Hong Kong. The occurrence of falls among the 12 months was recorded and was used to correlate with weather data, including air temperature, relative humidity, and rainfall, in each month during the study period. Analyses were also carried out to examine if there was any signification association between occurrence of falls in four seasons and various factors, including age, gender and living arrangement of the fallers, location of falls, and predisposing factors for their falls.
Results: There was a peak in occurrence of falls among the older people during winter. A significant correlation was found between a higher number of falls and lower air temperature and lower relative humidity. Age, gender, and location of falls for the fallers were not associated with the peak seasons (winter and autumn) and nonpeak seasons (spring and summer). Significantly larger proportion of falls occurred among people living in old age home during the peak season compared with the nonpeak season. Higher proportion of fallers during the peak season had lower limbs weakness as compared with that in nonpeak season. Multivariate logistic regression showed that only living arrangement and risky behavior were significantly associated with fall occurrence in peak season.
Conclusion: A higher incidence of falls in winter among older people in Hong Kong was observed and possible mechanisms contributing to this seasonal pattern were explored. Further studies on intervention to minimize its impact on risk of falling among older people are indicated.

1. Introduction

Seasonal variation of falls and hip fractures has been documented in some but not all previous studies conducted in various countries with different latitudes and weather conditions. Some studies indicate a significant seasonal pattern of falls with a higher occurrence of falls or hip fractures in winter[1–12] but other studies do not show such a significant seasonal variation in occurrence of falls or hip fractures.[13–22] A previous study, which compared the extent of seasonal variation of hip fracture at three regions with different latitudes, indicated that Hong Kong has a greater extent of seasonal variation than that in Scotland and Auckland.[8] As the winter temperature in Hong Kong is higher than that in Scotland and Auckland, this finding suggested that geographical, physiological, and behavioral factors other than climatic factors alone may contribute to such a seasonal pattern of fracture.[8] Another local study[5] also confirmed a seasonal pattern of hip fracture in Hong Kong with a significant higher proportion of hip fracture cases reported in winter as compared with summer.

Although it has been observed that there is an increased rate of falls in winter in local clinical settings, no published study documented seasonal pattern of falls in Hong Kong. The objective of present study is to determine whether there is a seasonal pattern of falls in older people in Hong Kong and to explore possible mechanisms underlying the seasonal variation.

* Corresponding author. Department of Medicine and Therapeutics, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong.
E-mail address: pyyeung@cuhk.edu.hk (P.-Y. Yeung).

2210-8335
doi:10.1016/j.jcgg.2011.02.002

2. Methods

Older people aged 60 years or more with a fall presenting to Accident and Emergency (A&E) Department in a regional hospital in Shatin district in Hong Kong were included in a 1-year prospective study conducted in 2006–2007.[23] The A&E Department records, which were marked with an index "fall" regardless of any precipitating factors for the fall, were collected during the 1-year period. There were 2942 falls occurring during this 1-year period, which were contributed by 2608 fallers. Information regarding the fallers' age, gender, and date of presentation to the A&E Department with a fall was obtained through reviewing their A&E Department records. As the exact date for falls occurring was difficult to determine, the date of presentation was taken as the date for occurrence of falls assuming that the time gap between the two dates is insignificant. Of the 2608 older fallers presenting to A&E Department during the study period, 807 (27%) attended a falls assessment clinic and completed a comprehensive assessment covering a wide range of information, such as circumstances and consequences of falls and measurements relating to their physical, cognitive, functional, mobility, and psychosocial status. Details of the comprehensive assessment have been described elsewhere.[23]

The occurrence of fall in each calendar month during the study period was recorded. Repeated falls occurring in the same person on different occasions were counted as separate cases. To compensate for the unequal length of months, the total number of falls occurring in each month was adjusted to a 30-day equivalent period. It was noted that the four seasons in Hong Kong may not be strictly categorized according to calendar months. For the purpose of this study, a year was classified into the four seasons, each consists of 3 months as follows: spring consists of March, April, and May; summer consists of June, July, and August; autumn consists of September, October, and November; and winter consists of December, January, and February.

Poisson regression was used to examine if there was any significant difference for the occurrence of falls among the four seasons. The adjusted monthly number of falls was used as the dependent variable and season was used as the independent variable. Incidence rate ratio was estimated by taking exponential of the regression coefficient. A significant difference in number of falls occurring in spring, summer, and autumn as compared with winter was indicated by a p value being less than 0.05 (i.e., an incidence rate ratio being significantly different from 1).

Weather information regarding the mean daily maximum, mean, and minimum air temperature (degrees Celsius), relative humidity, and rainfall in each month during the study period was obtained from the official report published by the Hong Kong Government Observatory.[24] The weather data were used to correlate with the adjusted monthly number of falls. Pearson correlation coefficients were estimated and a correlation significantly different from zero was indicated by a p value being less than 0.05.

For those fallers who completed the comprehensive assessment at the falls assessment clinics, chi-square test and t test were adopted to examine if there was any significant association (i.e., p value < 0.05) between various factors and the fall occurrence in peak season. These factors included (1) characteristics of the fallers, such as age, gender, and living arrangement (living at their own home and in old age home); (2) location of fall (inside or outside home); and (3) predisposing factors identified during the comprehensive assessment, such as lower limbs weakness, unsteady gait, trip, slip, risky behavior, footwear problem, dizziness, syncope, drowsiness, palpitation, and knocked down by others. Using multivariate logistic regression, the influence of these factors was examined collectively. The odds of a fall occurring in peak seasons as compared with nonpeak season was used as dependent variable and all these factors were used as independent variables. Odds ratio was estimated by taking exponential of the regression coefficient. Factors that significantly associated with fall occurrence in peak season were indicated by a p value of less than 0.05 (i.e., an odds ratio being significantly different from 1). All the statistical analyses were performed using SPSS version 16.0 (SPPS Inc., Chicago, IL, USA).

3. Results

A total of 2942 falls were identified at the A&E Department during the study period. Falls were more likely to occur at December and January (Fig. 1). The average adjusted monthly number of falls in winter was the highest among the four seasons (Table 1). The results of the Poisson regression indicated that there was significantly (p value < 0.001) more falls occurring in winter when compared with that in either spring or summer. During spring and summer, there were respectively 20% and 38% fewer falls when compared with winter. However, no significant difference in fall occurrence was found between winter and autumn.

Table 2 shows the Pearson correlation coefficients between weather variables and the adjusted number of falls in each month. Number of falls was inversely correlated with average daily air temperature (maximum temperature, $r = -0.72$; mean temperature, $r = -0.71$; minimum temperature, $r = -0.70$) and relative humidity ($r = -0.74$) but not rainfall. Dry and cold weather is the typical weather in winter.

As the numbers of fall in winter and autumn were not significantly different, the two seasons were grouped as peak season, whereas spring and summer were grouped as nonpeak season for subsequent analyses. Table 3 shows the characteristics of the fallers and predisposing factors of falls among the fallers who attended the falls clinics. Significantly larger proportion of falls occurred among people living in old age home during the peak season when compared with that in the nonpeak season (20.5% *vs.* 11.8%). On the other hand, the peak and nonpeak seasons were not associated with fallers' age and sex and the location of falls. Among all predisposing factors, only lower limb weakness was significantly associated with fall occurrence in peak season. Higher proportion of fallers during the peak season had lower limbs weakness as compared with that in nonpeak season (31.4% *vs.* 23.3%). Multivariate logistic regression showed that when taking into account all potential factors, only living arrangement and risky behavior were significantly associated with fall occurrence in peak season. Fallers living in old age homes were 2.1 times (95% confidence interval: 1.4–3.3) more likely than those living at own home, and fallers who had risky behavior were 1.7 times (95% confidence interval: 1.1–2.8) more likely than those without risky behavior to have fall occurrence in peak season.

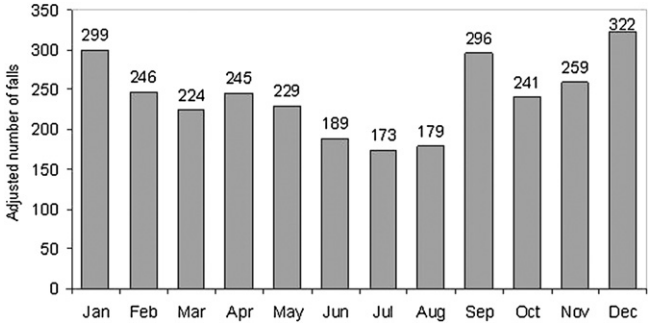

Fig. 1. Adjusted number of falls during a 30-day period, by month, 2006–2007.

Table 1
Average adjusted monthly number of falls by season and incidence rate ratio estimated from Poisson regression

Seasons	Average adjusted monthly number of falls	Incidence rate ratio	95% Confidence interval
Spring (Mar–May)	233	0.805*	(0.729–0.889)
Summer (Jun–Aug)	180	0.624*	(0.560–0.695)
Autumn (Sep–Nov)	265	0.918	(0.834–1.011)
Winter (Dec–Feb)	289	1	—

* A p value less than 0.001.

4. Discussion

This study found a peak in fall occurrence during winter as compared with spring and summer. There was no significant difference in the age and gender of the older people who fell in the peak and nonpeak seasons. A significant correlation was also found between a higher number of falls and lower (maximum, mean and minimum) air temperature and lower relative humidity. This association with temperature has been reported in three previous studies with one indicated for rate of falls in New Zealand[1] and another two indicated for rate of hip fractures in Hong Kong and Australia.[6,7] Falls during winter may be attributed to slipping on icy pavements or roads in some geographical areas but not in subtropical Hong Kong. Other factors, such as behavioral or physiological factors, may be involved, and all these factors may be interrelated. This is supported by the argument stated by Lord et al[25] that a fall is usually contributed by the interaction between an individual's physical abilities and an environmental hazard. Findings and explanations given by studies in Western countries may not be fully applicable because of differences in population characteristics and living environment.

Hong Kong is one of the most densely populated areas in the world. Because of high population density in Shatin where the present study covered, that is, 8842 persons/km^2,[26] more than 80% of the older fallers were living in public or private flats and the remaining were residing at old age homes in the present study. The public flats where the older persons lived with or without their family members are usually limited in space. The average living space per person in public housing is 12.5 m^2.[27] Therefore, vertical space is used for storage of household contents. Some older people have the habit of climbing on a stool or chair to place or retrieve objects. Other typical risky behaviors taken by the older people included hurrying, running, and carrying heavy goods.[28] About 12% of the subjects who completed the comprehensive assessment were found to be engaging in those risk-taking behaviors during their falls. Such risk-taking tasks would become more challenging in winter as the older people tend to put on many layers of clothes under a cold environment. The wooden materials used tend to be stiff, and multiple layers of clothing are usually worn, which may restrict their movement and make them more susceptible to falling.

Table 2
Pearson correlation coefficient between weather conditions and the adjusted number of falls in each month

Weather conditions	Correlation with adjusted monthly number of falls
Maximum air temperature	−0.719*
Mean air temperature	−0.706†
Minimum air temperature	−0.703†
Relative humidity	−0.743*
Total rainfall	−0.328

* A p value less than 0.001.
† A p value less than 0.05.

Table 3
Factors associated with fall occurrence in nonpeak and peak seasons

Factors	Nonpeak season (spring & summer)	Peak season (autumn & winter)	p
Characteristics of fallers			
Age (mean ± SD)	78.5 ± 7.9	78.7 ± 8.0	0.726
Male (%)	29.3	33.8	0.178
Living in old age home (%)*	11.8	20.5	0.001
Location of falls			
Indoor (%)	53.2	52.9	0.951
Predisposing factors			
Lower limbs weakness (%)†	23.3	31.4	0.011
Trip (%)	20.1	22.2	0.469
Unsteady gait (%)	19.0	24.6	0.056
Slip (%)	13.5	10.5	0.183
Risky behavior (%)	10.1	13.3	0.160
Dizziness (%)	9.5	10.5	0.648
Footwear problem (%)	8.0	9.6	0.447
Knocked down (%)	4.3	4.1	0.905
Syncope (%)	2.6	3.9	0.296
Drowsiness (%)	1.4	1.5	0.918
Palpitation (%)	1.1	1.7	0.490

SD = standard deviation.
* A p value less than 0.001.
† A p value less than 0.05.

In our study, results from multivariate logistic regression also showed that risky behavior was one of the factors associated with fall occurrence in peak season.

The increased incidence of falls in winter could also be explained by the higher prevalence of lower limbs weakness contributing to the falls in winter compared with summer. It is possible that older people may spend more time staying indoors during cold weather, which could lead to vitamin D deficiency because of lack of exposure to sunlight. Insufficiency in vitamin D has been associated with increased fall risk because of diminished muscle strength.[29,30]. Moreover, people are less active in colder climates with reduced participation in physical activity, which may decrease their lower limbs strength and endurance and hence increases their risk of falling.[31] The findings that lower limbs weakness was not significantly associated with fall occurrence in peak season in multivariate logistic regression may be because of the confounding of its effect with other factors.

The result of the present study indicated that the increased risk of falling in peak season for the older people living in old age home was significantly higher than those living in own home. Those older people living in old age home are more frailer than those living in their own home. A previous local study[32] showed that malnutrition is common among the old age home residents. Another local study[33] showed that the body temperatures of old age home residents decrease significantly with lower ambient temperatures. Both studies indicated that the old age home residents are at risk of having impairment in thermoregulation and neuromuscular function under cold environment. Thus, the seasonal effect on the thermoregulation and neuromuscular function for this frail group of old age home residents is expected to be more marked compared with those older people living in their own home.

No significant difference was found between the number of falls indoors and outdoors between the peak and nonpeak seasons. The present study demonstrated a similar seasonal pattern of falls occurring inside and outside compared with a study in New Zealand.[1] The proportion of falls indoors and outdoors in the present study was similar (i.e., 53% *vs.* 47%, respectively). Hong Kong has a subtropical climate where extreme weather conditions, such as

ice and snow, do not occur. Such environmental hazards are not present in Hong Kong and would not have an effect on increasing the likelihood of falling in outdoor environment.

In response to those possible factors contributing to the increased number of falls among the older people in winter, some measures could be taken to reduce their risk of falling. Maintaining proper heating or suitable temperature within the homes of the older people may reduce the effect of temperature change on risk of falling. Educational programs on highlighting the environmental hazards and minimizing risky behaviors could be provided to the older people. Facilitating their participation in physical activities to maintain muscle functions and vitamin D supplementation may be effective means of preventing falls in winter, especially for old age home residents. Innovative clothing for the older people could be explored further. There are new materials for clothing, which have the properties of comfort, lightness, and thermal protection with six times more insulation than the traditional polar fibres.[34] The older population could constitute a substantial market for such clothing products.

There are some limitations in the present study. It included only 1-year data for analysis. A longer time series would be more preferable, which could provide stronger evidence to support the observation. Meanwhile, the weather in Hong Kong changes gradually and the four seasons are not as distinct as could be classified by calendar year. Yet, the classification is necessary to facilitate the analysis. Lower limbs weakness, which was identified as a major predisposing factor for falls in the present study was a self-reported condition and it was not based on objective measurements. The present study did not include those older people who fell but did not attend A&E Department as these may represent the less injurious falls. Older falls presenting to A&E Department may represent more serious and injurious falls, which have a direct and greater impact on the health care system and costs, and therefore the present study focused on this group of fallers. Despite the limitations, the present study documented the detailed history of predisposing factors for falls for analysis.

In summary, there was a peak in occurrence of falls among the older people during winter in Hong Kong. Possible mechanisms contributing to the seasonal pattern may include geographical, behavioral, and physiological factors. Further studies on intervention to minimize the impact of seasonality on risk of falling among older people in Hong Kong are indicated.

Acknowledgments

The authors are grateful to Mr Wayne Chan, Mr Dick Cheung, Ms Tiffany Lai, Ms Garis Ng, and Mr Stones Wong for their contributions and efforts in data collection for this study. The equipment used in the falls assessment clinic was funded by the School of Public Health and Primary Care of the Chinese University of Hong Kong.

References

1. Campbell AJ, Spears GFS, Borrie MJ, Fitzgerald JL. Falls, elderly women and the cold. *Gerontology* 1988;**34**:205–8.
2. Hemenway D. The effect of climate on fractures and deaths due to falls among white women. *Accid Anal Prev* 1990;**22**:50–65.
3. Jacobsen SJ, Goldberg J, Miles T, Brody JA, Stiers W, Rimm AA. Seasonal variation in the incidence of hip fracture among white persons aged 65 years and older in the United States 1984-1987. *Am J Epidemiol* 1991;**133**:996–1004.
4. Lau EMC, Gillespie BG, Valenti L, O'Connell D. The seasonality of hip fracture and its relationship with weather conditions in New South Wales. *Aust J Public Health* 1995;**19**:76–80.
5. Chiu KP, Ng TP, Chow SP. Seasonal variation of fractures of the hip in elderly persons. *Injury* 1996;**27**:333–6.
6. Berg WR, Alessio HM, Mills EM, Tong C. Circumstances and consequences of falls in independent community dwelling older adults. *Age Ageing* 1997;**26**:261–8.
7. Bulajic-Kopjar M. Seasonal variations in incidence of fractures among elderly people. *Injury Prev* 2000;**6**:16–9.
8. Douglas S, Bunyan A, Chiu KH, Twaddle B, Maffulli N. Seasonal variation of hip fracture at three latitudes. *Injury* 2000;**31**:11–9.
9. Crawford JR, Parker MJ. Seasonal variation of proximal femoral fractures in the United Kingdom. *Injury* 2003;**34**:223–5.
10. Mirchandani S, Aharonoff GB, Hiebert R, Capla EL, Zuckerman JD, Koval KJ. The effects of weather and seasonality on hip fracture incidence in older adults. *Orthopedics* 2005;**28**:149–55.
11. Alvarez-Nebreda ML, Jiménez AB, Rodríguez P, Serra JA. Epidemiology of hip fracture in the elderly in Spain. *Bone* 2008;**42**:278–85.
12. Kojima S, Furuna T, Ikeda N, Nakamura M, Sawada Y. Falls among community-dwelling elderly people of Hokkaido, Japan. *Geriatr Gerontol Int* 2008;**8**:272–7.
13. 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** (Suppl 1):S57–63.
14. Parker MJ, Martin S. Falls, hip fractures and the weather. *Eur J Epidemiol* 1994;**10**:441–2.
15. Jacobsen SJ, Sargent DJ, Atkinson EJ, O'Fallon MW, Melton III LJ. Population-based study of the contribution of weather to hip fracture seasonality. *Am J Epidemiol* 1995;**141**:79–83.
16. Luukinen H, Koski K, Kivela SL. The relationship between outdoor temperature and the frequency of falls among the elderly in Finland. *J Epidemiol Community Health* 1996;**50**:107.
17. Parker MK, Twemlow TR, Pryor GA. Environmental hazards and hip fractures. *Age Ageing* 1996;**25**:322–5.
18. Aharonoff GB, Dennis MG, Elshinawy A, Zuckerman JD, Koval KJ. Circumstances of falls causing hip fractures in the elderly. *Clin Orthop Relat Res* 1998;**348**:10–4.
19. Loftus CM, Osnes EK, Falch JA, Kaastad TS, Kristiansen IS, Nordsletten L, et al. Epidemiology of hip fractures in Oslo Norway. *Bone* 2001;**29**:413–8.
20. Chesser TJS, Howlett I, Ward AJ, Pounsford JC. The influence of outside temperature and season on the incidence of hip fractures in patients over the age of 65. *Age Ageing* 2002;**31**:343–8.
21. Saari P, Heikkinen E, Sakari-Rantala R, Rantanen T. Fall-related injuries among initially 75- and 80-year old people during a 10-year follow-up. *Arch Gerontol Geriatr* 2007;**45**:207–15.
22. Stevens JA, Thomas KE, Sogolow ED. Seasonal patterns of fatal and nonfatal falls among older adults in the U.S. *Accid Anal Prev* 2007;**39**:1239–44.
23. Yeung PY, Woo J, Yim VWT, Rainer TH. Heterogeneity of health profiles of older people presenting to an accident and emergency department with a fall. *Int J Gerontol* 2009;**3**:156–62.
24. Hong Kong Government Observatory. *The year's weather—2006 and 2007*. Hong Kong: Hong Kong Government Observatory. Available at, http://www.hko.gov.hk/wxinfo/pastwx/ywx.htm; 2009. Date accessed: December 10, 2009.
25. Lord SR, Sherrington C, Menz HB, Close JCT. Environmental risk factors for falls. In: Lord SR, Sherrington C, Menz HB, Close JCT, editors. *Falls in older people: risk factors and strategies for prevention*. 2nd ed. New York, NY: Cambridge University Press; 2007. p. 151–60.
26. CSDHKSAR (Census and Statistics Department of the Hong Kong Special Administrative Region). *Population density by district council district, 1996, 2001 and 2006*. Hong Kong: CSDHKSAR. Available at, http://www.bycensus2006.gov.hk/FileManager/EN/Content_981/a202e.xls; 2007. Date accessed: December 10, 2009.
27. Hong Kong Housing Authority. *Housing in figures 2009*. Hong Kong: Hong Kong Housing Authority. Available at, http://www.housingauthority.gov.hk/hdw/content/document/en/aboutus/resources/statistics/HIF2009.pdf; 2009. Date accessed: December 10, 2009.
28. Zhang JG, Ishikawa-Takata K, Yamazaki H, Ohta T. Is a type A behavior pattern associated with falling among the community-dwelling elderly? *Arch Gerontol Geriatr* 2004;**38**:145–52.
29. Bischoff-Ferrari HA, Dawson-Hughes B, Willett WC, Staehelin HB, Bazemore MG, Zee RY, et al. Effect of vitamin D on falls. A meta-analysis. *JAMA* 2004;**291**:1999–2006.
30. Pasco JA, Henry JM, Kotowicz MA, Sanders KM, Seeman E, Pasco JR, et al. Seasonal periodicity of serum vitamin D and parathyroid hormone, bone resorption, and fractures: the Geelong osteoporosis study. *J Bone Miner Res* 2004;**19**:752–8.
31. Shekelle PG, Maglione M, Chang JT, Mojica W, Morton SC, Suttorp M, et al. *Falls prevention interventions in the Medicare population. RAND evidence report and evidence based recommendations*. Baltimore, MD: United States Department of Health; 2003.
32. Woo J, Chi I, Hui E, Chan F, Sham A. Low staffing level is associated with malnutrition in long-term residential care homes. *Eur J Clin Nutr* 2005;**59**:474–9.
33. Kwok T, Hui E, Woo J. Are older people living in the subtropics at risk of hypothermia? *Aust N Z J Med* 1997;**27**:76. Abstract.
34. Cornet G. Innovations in the clothing for the elderly. In: Graafmans J, Taipele V, Charness N, editors. *Gerontechnology: a sustainable investment in the future*. Amsterdam, The Netherlands: IOS Press; 1998. p. 432–5.