

# An evaluation of footwear worn at the time of fall-related hip fracture

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## Abstract

**Background:** a range of footwear features have been shown to influence balance in older people, however, little is known about the relationships between inappropriate footwear, falls and hip fracture.

**Objectives:** to describe the characteristics of footwear worn at the time of fall-related hip fracture and establish whether the features of the shoe influenced the type of fall associated with the fracture.

**Methods:** 95 older people (average age 78.3 years, SD 7.9) who had suffered a fall-related hip fracture were asked to identify the footwear they were wearing when they fell. Footwear characteristics were then evaluated using a standardised assessment form. Information was also collected on the type and location of fall.

**Results:** the most common type of footwear worn at the time of the fall was slippers (22%), followed by walking shoes (17%) and sandals (8%). Few subjects were wearing high heels when they fell (2%). The majority of subjects (75%) wore shoes with at least one theoretically sub-optimal feature, such as absent fixation (63%), excessively flexible heel counters (43%) and excessively flexible soles (43%). Subjects who tripped were more likely to be wearing shoes with no fixation compared to those who reported other types of falls [ $\chi^2=4.21$ ,  $df=1$ ,  $P=0.033$ ; OR=2.93 (95%CI 1.03–8.38)].

**Conclusions:** many older people who have had a fall-related hip fracture were wearing potentially hazardous footwear when they fell. The wearing of slippers or shoes without fixation may be associated with increased risk of tripping. Prospective studies into this proposed association appear warranted.

**Keywords:** *accidental falls, shoes, hip fractures*

## Introduction

Around one in three older people fall at least once each year [1]. Hip fractures are one of the most serious consequences of falls. By the age of 90, up to 32% of women and 17% of men have suffered a hip fracture [2], and by the year 2050 it has been estimated that there will be up to 2.3 million annual hip fractures globally [3]. Risk factors for hip fracture include decreased bone mineral density, increased age, previous falls and fractures, poor health status, inactivity, impaired walking and balance abilities, poor vision, psychoactive drug use and a high caffeine intake [4–6].

A potential risk factor for falls and fractures that has not been addressed in detail is the wearing of inappropriate footwear. It is known that many older people wear footwear with features that are potentially hazardous or at least offer sub-optimal support. Finlay [7] assessed the footwear of 274 patients attending a geriatric hospital and reported that only half were wearing 'adequate' footwear. The most commonly observed inappropriate features were excessively flexible heel counters, high heels and

narrow heels. In addition, 50% of shoes worn had heel slippage and unsatisfactory heel counters were evident in 63% of all slippers. A similar investigation by Dyer *et al.* [8] found that 58% of 112 older people admitted to a falls clinic were wearing 'unsatisfactory' footwear.

A number of recent studies have investigated the influence of various shoe features on balance ability in older people. High heels have been shown to impair balance when standing [9] and responding to perturbation [10], soft-soled shoes impair beam-walking performance [11], and high heel counters have been shown to improve balance compared to standard, low-cut footwear [12]. Inadequate slip resistance of the outsole of the shoe is also thought to increase risk of slipping accidents [13], however no studies have directly evaluated this in elderly subjects. Based on this information, the 'ideal' safe shoe for older people is thought to consist of a low sturdy heel, high heel counter, a thin, firm midsole and a textured sole [14].

The available evidence therefore seems to indicate that inappropriate footwear may impair balance in older people, possibly leading to an increased risk of falling.

However, few studies have directly evaluated the relationship between footwear and falls. Therefore, the aim of this study was to describe the characteristics of footwear worn at the time of fall-related hip fracture in order to establish whether the shoe worn influenced the type of fall that led to the fracture.

## Methods

### Subjects

Ninety-five older people (average age 78.3 years, SD 7.9, range 57.5–92.8) who had suffered a fall-related hip fracture were included in this study. There were 72 women and 23 men. Eleven subjects were residents of aged care facilities and the remainder were community-dwellers. Subjects were either undergoing in-patient rehabilitation (at the Bankstown-Lidcombe Hospital, Sydney, Australia), at the time of the study ( $n=17$ ) or had been discharged from hospital treatment (at one of six Sydney hospitals) after their hip fracture and were seen at home or in a residential aged care facility. To be eligible for the study subjects needed to be cognitively and medically able to answer questions regarding the fall associated with the fracture. In addition, the subjects themselves or a family member had to be able to identify the shoes worn at the time of fracture and, ideally, provide these for assessment by the researchers, or at least, describe them in detail.

Subjects also participated in studies of exercise after hip fracture and had to be cognitively and medically able to carry out an exercise program. The present study was conducted from December 1998 to February 2000. During this time a total of 135 subjects (29 inpatients and 106 community subjects) were recruited for the exercise studies. The 95 subjects who participated in this study were included as they could recall and either provide or clearly describe the shoes worn at the time of fracture. For the exercise studies only two people who were admitted to the rehabilitation ward during the time period of the study did not meet the inclusion criteria. Records of exclusions were not kept for the community study as subjects were recruited from six different hospitals and many different staff members assisted with subject identification.

Ethical approval was obtained from the South Western Sydney Area Health Service Research Ethics Committee, the Hope Healthcare Ethics Committee, and the Central Sydney Area Health Service Ethics Review Committee, and informed consent was obtained from all subjects prior to their participation.

### Interview following fall

Subjects were asked to identify the footwear they were wearing when they suffered the fall associated with their hip fracture. This interview occurred approximately

3 weeks after fracture in the inpatients and approximately 5 months after fracture in the community subjects. The shoe was then assessed by one of three physiotherapists using a standardised footwear assessment form [15], a reliable tool which assesses the following footwear characteristics (see Figure 1):

- i. shoe style: selected from a list of 16 basic shoe styles;
- ii. heel height: categorised in centimetre categories (0–2.5 cm, 2.6–5.0 cm, > 5.0 cm);
- iii. fixation: method of fixing the shoe to the foot, documented as either no fixation, laces, straps/buckles, Velcro<sup>®</sup> or zippers;
- iv. heel counter stiffness: determined by the examiner exerting firm pressure to the rear section of the shoe, and documented as either minimal, <45° or >45°;
- v. longitudinal sole rigidity: determined by the examiner exerting firm pressure to the front of the shoe while the rear section was stabilised. The degree of flexion relative to the horizontal plane was documented as either minimal, <45° or >45°;
- vi. sole flexion point: defined as the point at which the sole flexed when performing the longitudinal sole rigidity test, and documented as either occurring at the level of the metatarsophalangeal joints or proximal to the metatarsophalangeal joints;
- vii. tread pattern: documented as either textured, smooth, partly worn or fully worn;
- viii. sole hardness: determined by the examiner exerting firm downwards pressure on the inner region of the heel of the shoe, and documented as either soft, firm or hard.

This assessment occurred for the shoes of 81 subjects (85%). The remaining subjects were unable to have the shoes brought to the hospital ( $n=4$ ) or had disposed of the shoes ( $n=10$ ). Subjects were also asked to identify the type and location of the fall associated with their hip fracture.

### Statistical analysis

All data were analysed using SPSS Release 10 for Windows (SPSS Inc, Chicago, USA). Relationships between footwear features, location and type of fall

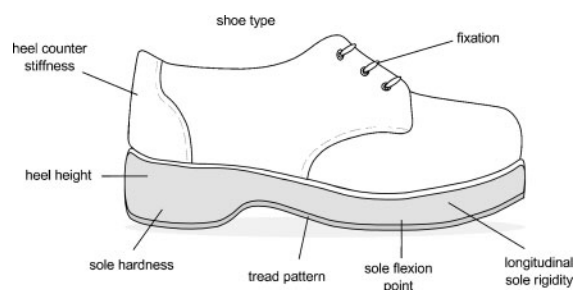


Figure 1. Footwear variables assessed using the Footwear Assessment Form [15].

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were assessed using cross-tabulations and the  $\chi^2$  statistic. Significant associations were then further explored using odds ratios.

## Results

### Footwear type

The type of shoe worn at the time of the fall-related hip fracture is shown in Figure 2. The most common footwear worn at the time of the fall was slippers (22%), followed by walking shoes (17%) and sandals (8%). Few subjects wore high heels (2%).

### Footwear features

The majority of subjects (75%) wore shoes with at least one theoretically sub-optimal feature, including shoes with no fixation (63%), excessively flexible heel counters (43%), soles that flexed proximal to the metatarsophalangeal joints (43%), excessively soft soles (20%) or excessively stiff soles (19%), and smooth soles (11%). However, only 3% wore shoes with a heel height > 5 cm.

Slippers were more likely to exhibit theoretically hazardous features such as no fixation ( $\chi^2=11.47$ ,  $df=1$ ,  $P<0.001$ ), an excessively flexible heel counter ( $\chi^2=17.68$ ,  $df=1$ ,  $P<0.001$ ), and a sole that bends proximal to the metatarsophalangeal joints ( $\chi^2=7.94$ ,  $df=1$ ,  $P=0.005$ ). However, slippers were not more likely to have smooth or fully worn soles compared to other types of footwear.

### Location and mechanism of fall

Most of the subjects ( $n=77$ , 81%) were able to identify the mechanism of the fall associated with their hip fracture. The most commonly reported type of fall was a trip ( $n=32$ ) followed by loss of balance ( $n=24$ ), slip ( $n=14$ ), felt dizzy ( $n=4$ ), legs gave way ( $n=2$ ) and faint ( $n=1$ ). The majority of subjects ( $n=38$ ) fell while walking on one level inside their own home. Ten subjects fell

while walking in their own garden and 31 fell in other outdoor locations. Hip fracture falls also occurred in other indoor locations ( $n=7$ ), own front or back stairs ( $n=5$ ), getting out of bed ( $n=3$ ) and climbing on a chair or ladder ( $n=1$ ).

### Association between fall type and footwear

Subjects who tripped were more likely to be wearing footwear with no fixation compared to those who did not trip [ $\chi^2=4.21$ ,  $df=1$ ,  $P=0.033$ ; OR=2.93 (95%CI 1.03–8.38)]. The most common type of shoe with no fixation was slippers (31%), followed by courtshoes (13%) and moccasins (12%). There was no association between slipping and shoe type or any of the shoe features.

## Discussion

The effect of inappropriate footwear on falls in older people has not been evaluated in detail, despite the observation that many older people wear potentially hazardous shoes [7, 8], and assessment of footwear is recommended as an important component of falls prevention programs [16–19]. The high prevalence of sub-optimal footwear features reported here is consistent with previous studies which have found that older people primarily base their footwear choices on comfort rather than safety [20]. Our results are also similar to a previous investigation by Hourihan *et al.* [21], who reported that of 107 older people who were admitted to hospital following a fall-related hip fracture, 33% were wearing slippers and 68% wore shoes with flexible heel counters at the time of fracture. However, the high prevalence of wearing slippers in older people who have fractured their hip does not necessarily indicate that the slippers caused the fall. As most falls occur within the home, these results may simply represent a survey of the most commonly worn indoor footwear. Indeed, a mail survey of 128 older people who had not fallen conducted by Munro and Steele [22] reported that 35% of men and 38% of women wore slippers in the home.

Nevertheless, we did find an association between fall type and footwear, as subjects who wore shoes without fixation were more likely to have tripped than have suffered another type of fall. Shoes with inadequate fixation tend to promote a shuffling gait, and are more likely to become separated from the foot when walking. It is therefore plausible that wearing shoes with inadequate fixation, such as soft slippers and other indoor slip-on shoes, may predispose to falls by impairing normal gait and acting as an extrinsic tripping hazard. Indeed, two of our subjects who wore shoes without fixation specifically blamed their shoes for the fall: one stated that her slipper ‘got stuck’, causing her to lose balance, while another stated that her moccasin ‘slipped off’ her foot, causing her to trip over it.

A surprising result was that few subjects in our sample were wearing high heels when they fell. This may

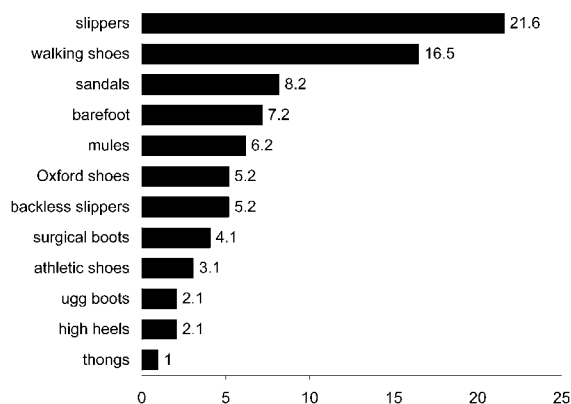


Figure 2. Type of shoe worn at the time of fall-related hip fracture (%).

be because most falls occurred within the home and subjects were wearing their normal indoor rather than outdoor footwear at the time. However, even among those who fell outdoors, only 2% were wearing high heels. The detrimental effects of high heels on gait and balance have been widely reported [9, 10], and many authorities recommend that older people avoid wearing high heels [7, 19, 23]. It is possible that this health promotion message has been effective, and as a consequence many older people are aware of the dangers of high-heeled shoes and rarely wear them. The high prevalence of wearing inadequate indoor footwear suggests that falls prevention programs may need to focus their footwear recommendations on these types of shoes rather than on less commonly worn high heels.

The present study is not without limitations. As with any retrospective study, it is difficult to draw firm conclusions from these results regarding the causative role of shoe features in falls and fractures. As subjects (or their carers) were required to recall which shoes they were wearing when they fell in order to be included in the study, and as the assessment took place several months after fracture, it is possible that a selection bias occurred which favoured more cognitively able subjects. It is also possible that some of the information collected was not entirely accurate. Nevertheless, the associations reported here suggest that further investigation with prospective study methods is warranted. It should be noted that such an investigation would have certain methodological difficulties. Unlike well-researched physiological risk factors for falls such as impaired strength and balance, behavioural risk factors such as footwear use may not be present at all times and can be thought of as 'transient' risk factors. It is very difficult to ascertain if such a risk factor is present prior to a fall and whether it did in fact contribute to any fall experienced in a follow-up period. Nevertheless, we feel that careful attention to older people's footwear is a worthwhile falls prevention strategy, as many older people are unaware of the potential dangers of inadequate footwear, and in certain cases poor footwear may be a needless risk factor that could be easily rectified.

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### Key points

- Many older people who have had a fall-related hip fracture were wearing potentially hazardous footwear when they fell, however, few were wearing high heels.
  - The wearing of slippers or shoes without fixation is associated with an increased risk of tripping.
  - Footwear advice provided to older people at risk of falling should highlight the potential hazards of shoes with inadequate fixation.
  - Older people and care providers need to consider footwear worn at home, as well as footwear worn when going out.
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