Age and Ageing 2004; **33:** 242–246
DOI: 10.1093/ageing/afh071

Does the type of flooring affect the risk of hip fracture?

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Abstract

Background: the number of hip fractures occurring worldwide in 1990 was estimated at 1.7 million and is predicted to rise to 6.3 million by 2050. The vast majority occur as a result of simple falls and the impact of the femoral trochanter with the floor. Previous studies have addressed the problem from the patient's side of the impact. Little research has been carried out on the other surface involved in the impact, the floor.
Study location: 34 residential care homes.
Methods: (1) The mechanical properties of the floor were measured with force transducers. (2) The number and location of falls and fractures on the various floors were recorded prospectively for 2 years. The threshold for reporting falls in different care homes was assessed using a standardised set of scenarios.
Results: a total of 6,641 falls and 222 fractures were recorded. Wooden carpeted floors were associated with the lowest number of fractures per 100 falls. The risk of fracture resulting from a fall was significantly lower compared to all other floor types (odds ratio 1.78, 95% CI 1.33–2.35). The mean impact force was significantly lower on wooden carpeted floors: 11.9 kN compared to the other floor types.
Discussion: the possible implications of our findings are considerable. Residents of homes are typically frail and many have a propensity to falls. In designing safer environments for older people, the type of floor should be chosen to minimise the risk of fracture. This may result in a major reduction in fractures in the elderly.

Keywords: *hip fractures, osteoporosis, impact, flooring, aged, elderly*

Introduction

The injuries arising from falling accidents represent a major health problem for older people. The number of hip fractures occurring worldwide in 1990 was estimated to be 1.7 million and has been predicted to rise to 6.3 million by 2050 owing to the increase in the elderly population [1]. It may be that the recently observed increase in age-specific incidence of proximal femoral ('hip') fractures observed in many countries, including England [2], may be levelling off [3]. Even if this proves to be the case, the overall number of fractures will continue to rise with the anticipated increase in the number of older people. Sixty-year-old women and men with residual life expectancies of 21 and 17 years have been estimated to have a 14% and 6% residual life time risk of hip fracture [4]. This represents a substantial and increasing health care problem.

Although in rare cases fractures arise purely from muscle forces, fatigue fractures or indirect trauma [5–7], the vast majority occur as a result of simple falls and the impact of the femoral greater trochanter with the floor [8, 9]. The incidence of falls increases with age, and in later life women have a greater impairment of both balance and muscle power (which are needed to correct destabilisation), which results in women being subjected to more falls than men [10–14]. Women are also more likely to sustain a fracture of the hip from a fall, because of the age-associated increase in the prevalence of osteoporosis [15].

A number of studies have addressed the problem from the patient's side of the impact [16]. Impact force increases directly with the weight and falling height of the body, and its effect varies with the degree of padding of the greater trochanter by soft tissue and clothing. Appropriately designed hip protectors can prevent against hip fractures but many older people at risk of falling are unwilling to wear them and compliance has been estimated at only 25–30% in care homes [17–22]. Further difficulties with protectors have been reported as a result of displacement of the pads from the greater trochanteric region prior to the fall.

Very little research has been carried out on the other surface involved in the impact, the floor. The peak impact force might be substantially reduced by a floor covering or sub-floor with greater energy absorbing qualities. The option therefore of making floors safer to fall on is attractive provided that such floors do not disproportionately increase the risk of falling. In this paper we report an observational study linking hip fracture risk with flooring type in residential homes for older people.

Methods

The aim of the study was to evaluate whether the floor properties had a significant effect on the risk of a fracture occurring in a fall. To achieve this, information was required on the mechanical properties of the floor, and on the frequency of falls and fractures on the various floor surfaces.

The mechanical properties of the floor surface

A transducer was developed that could be dropped onto the floor to simulate and measure the peak impact force during a fall by a person of average height and weight [19]. The transducer used spring compression to measure peak forces arising from impact. The weight of the transducer was scaled down to 1/16 of the average body weight of an elderly person, as was the spring stiffness that simulated the compliance of the skeletal structure. A layer of closed-cell polyurethane was laid over the impact point to simulate the soft-tissue impact protection at the hip over the greater trochanter.

Epidemiological data

Study location

Thirty-four residential care homes for older people within the catchment area of the Accident and Emergency service of the John Radcliffe Hospital, Oxford agreed to take part in the study over the period 1998–2000. The homes were similar in their admission criteria and in the range of mobility of their residents.

Falls and fracture data

Data on the number and location of falls were recorded prospectively for a minimum of 2 years from the falls register of each home. These data were collated with clinical records from the Accident and Emergency service of the John Radcliffe Hospital. Comparability of the recording of falls in the different homes was assessed by constructing a set of scenarios and then asking a senior staff member from each home confidentially to indicate which scenarios would be recorded. In order to validate reporting of hip fractures, the radiographs of the residents reported to have had a fracture were reviewed. This confirmed that all the residents that were recorded in the homes' records as having sustained a fracture in a fall had been correctly identified.

On site measurement of impact forces

The mechanical properties of the various types of floors in the residential homes were examined using the transducer. This method proved simple and easily transportable to the homes, where the nature of the underfloor structure and the floor covering as well as the impact force in each room were recorded. Tests to establish the accuracy of the transducer were performed and the error was found to be <0.06 kN at 15 kN force.

Analysis

The floor types were classified as:

i. Wood sub-floor with no carpet
ii. Wood sub-floor with carpet
iii. Concrete sub-floor with no carpet
iv. Concrete sub-floor with carpet

It is possible that floor coverings with low impact force measurements might increase the risk of a fall occurring to a similar or greater degree that it reduced the risk of a fracture associated with a fall. To explore this it would be necessary to obtain estimates of person-hours of exposure to risk on different forms of floor covering. Risk would vary with the activity of the resident; standing and walking representing higher risk than sitting or lying. To obtain the necessary data the technique of non-participant observer time sampling was performed. At specified points in time observers recorded where residents were and what they were doing (standing, walking, sitting or sleeping). The sampling was undertaken at periods of particular activity, such as mealtimes, during a typical weekday or weekend day. Unfortunately owing to uncertainties in the accuracy of coding we concluded that the data were not sufficiently reliable to be analysed. The results presented are restricted to examination of the risk of a fracture resulting from a fall on different floor types.

Results

A total of 34 homes took part in the study, and 733 rooms were surveyed.

Characteristics of floors surveyed

The distribution of floor surfaces is shown in Table 1. Wooden sub-floors were more common than concrete floors and most floors were carpeted. Nearly 29% of

Table 1. Distribution of sub-floors, carpeted and un-carpeted floors in 733 rooms

	Wood	Concrete	Total
Carpeted	327	228	555
Un-carpeted	85	93	178
Total	412	321	733

concrete floors were uncarpeted, compared with 21% of wooden floors.

Impact properties of the floors

Mean peak impact forces varied significantly with the type of floor surface (ANOVA $P<0.001$), as shown in Table 2. The highest impact forces were associated with uncarpeted concrete floors and the lowest with carpeted wooden floors. Other floor combinations were intermediate, but concrete floors generated higher forces than wooden floors, and carpeted floors lower forces than uncarpeted ones.

Numbers of falls by floor type

A total of 6,641 falls were recorded during the 2 years of the study. Table 3 summarises the numbers of falls observed on the different floor types. These findings represent to an inextricable degree the time spent at risk of falling by residents in rooms with different flooring, and the contribution of particular flooring as an actual cause of falling. Although more falls occurred in carpeted than uncarpeted floors, this is likely to represent, at least in part, the relative amounts of time that residents spent walking and standing in corridors, lounges and dining rooms rather than in uncarpeted bathrooms and other utility rooms.

Table 2. Mean impact force by sub-floor and carpeting

Floor type	Mean peak impact force (kN)
Concrete – uncarpeted	12.4 (0.12)
Wood – uncarpeted	12.2 (0.12)
Concrete – carpeted	12.2 (0.20)
Wood – carpeted	11.9 (0.20)

Proportion of falls resulting in a hip fracture

There were 222 hip fractures associated with the 6,641 falls. Table 4 summarises the data relating to floor types. Wooden carpeted floors were associated with the lowest number of fractures per 100 falls, and the risk of a fracture resulting from a fall was significantly greater for all other floor types combined (OR 1.8, 95% CI 1.33, 2.35). In comparison with wooden sub-floors, concrete sub-floors were associated with a statistically significantly higher risk of fracture in a fall. On wooden floors there were 2.5 hip fractures per 100 falls compared with 4.1 on concrete floors (relative risk 1.7, 95% CI 1.26–2.18).

Contrary to expectations, carpeting was not associated with a significantly lower risk of hip fracture following a fall. The difference between carpeted and uncarpeted wooden floors fell just short of statistical significance, and the association with carpeting on concrete floors was the opposite of expected, with a lower risk, though not significantly so, associated with the uncarpeted floors. Comparison with Table 1 shows that the risk of fracture in falls on uncarpeted concrete floors was also anomalously low in terms of peak impact force, which was highest on that type of floor.

Discussion

Our findings on impact forces associated with simulated falls are in good agreement with the laboratory based data [23, 24]. In our study, the first to combine mechanical and clinical aspects, the most significant finding was the relationship between the type of flooring and the risk of incurring a fracture in a fall.

Although we were unable to ascertain whether the risk of falling varied with floor type, if we were to assume that the risk of falling were uniform across all floor types, and that the point estimates of risk of hip fracture in a fall were accurate, the following estimates can be made. From Table 4, subject to the above assumptions, it emerges that the risk of breaking a hip in a fall would be reduced by 80% if carpets were laid on uncarpeted wooden floors. However, since most falls in the homes studied occurred on wooden

Table 3. Numbers of falls per room by floor covering and sub-floor

	N (rooms)	*N* (falls)	Falls per room	RR (95% CI)
Wood – uncarpeted	85	266	3.1	1.00
Concrete – uncarpeted	93	492	5.3	1.69 (1.31, 2.17)
Wood – carpeted	327	2812	8.6	2.74 (2.24, 3.36)
Concrete – carpeted	228	3071	13.5	4.3 (3.47, 5.33)
Total	733	6641	9.06	

Table 4. Fractures per 100 falls by floor type

	N (falls)	*N* (fractures)	Fractures per 100 falls	RR (95% CI)
Wood – carpeted	2812	65	2.31	1
Wood – uncarpeted	266	11	4.14	1.8 (0.96, 3.35)
Concrete – carpeted	3071	134	4.36	1.9 (1.41, 2.53)
Concrete – uncarpeted	492	12	2.44	1.1 (0.57, 1.94)
Total	6641	222	3.34	

floors that were already carpeted, the number of fractures that might have been prevented by such a change would have been only 5, or 2.3% of the total of 222 fractures observed. By similar reasoning, substituting carpeted wooden floors for carpeted concrete floors would have prevented 63 fractures (28.6% of the total). The anomalous feature of Table 4 is clearly the low risk of hip fractures being incurred from falls on uncarpeted concrete floors, despite the impact force (Table 1) being greatest on this type of floor. These falls mostly occurred in bathrooms and toilets, 65% of which had this type of flooring compared with less than 6% of other rooms. It may be that falls in bathrooms and toilets were atypical in one way or another. Possibly staff were particularly vigilant during such falls and reported milder or less complete falls than were reported elsewhere in the homes. Possibly in the crowded environment of bathrooms and toilets, falls were broken by the resident seizing handrails or being prevented from hitting the floor by washbasins, baths or toilet fittings. Further observational data will be required to pursue these hypotheses. It is also possible that mechanical properties other than peak impact force, such as energy absorption, peak rate of loading and peak strain define the properties of the floor surface that determine the risk of fracture. We are currently investigating this further.

The possible implications of our findings, if confirmed by further studies, are considerable. Residents of homes are typically frail, and many have entered institutional care because of a propensity to falls. In designing safer environments for older people in general, and those who are frail in particular, the type of flooring and floor covering may need to be taken into consideration. Whether concrete sub-floors could be made safer by thick carpets and underlays would depend on whether this resulted in an increase in the risk of falling that outweighed the benefit from the reduction in risk of a hip fracture occurring from a fall. But it may be possible to engineer a floor with an even lower risk of a hip fracture occurring from a fall.

Key points

- An observation study in 34 residential care homes, on 6,641 falls and 222 fractures was carried out.
- Concrete sub-flooring and carpeting significantly alter the impact absorbing properties of a floor. The mean impact force was lowest on wooden carpeted floors (11.9 kN).
- Wooden carpeted floors were associated with the lowest number of fractures per fall (OR 1.78).
- Changes to the flooring in residential care homes could reduce the number of hip fractures.

Funding

The research was funded by Research into Ageing. Mr Roberts was funded as a research fellow of the Royal College of Surgeons of England during part of this research.

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Received 14 March 2003; accepted 28 October 2003

Age and Ageing 2004; **33:** 246–252
DOI: 10.1093/ageing/afh076

Published electronically 8 March 2004

Sooner and healthier: a randomised controlled trial and interview study of an early discharge rehabilitation service for older people

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Abstract

Background: hospitals are under pressure from admissions of increasing numbers of older people. Older people may suffer unnecessary activity limitation after acute illnesses through lack of appropriate rehabilitation.
Objective: to evaluate an early discharge and rehabilitation service for older people.
Design: a randomised controlled trial comparing an early discharge and rehabilitation with standard hospital aftercare. Outcome measures assessed at 3 and 12 months were the Barthel Index, Nottingham Extended Activities of Daily Living and EuroQol (for patients) the General Health Questionnaire (for patients and carers). Use of services over 12 months was recorded. An interview study of patients and staff was conducted.
Setting and intervention: the early discharge and rehabilitation service offered a home-based rehabilitation and care programme for up to 4 weeks.
Participants: 370 hospitalised older medical and surgical patients were included in the randomised controlled trial. Twenty patients and 11 staff were interviewed.
Results: subjects in the early discharge rehabilitation service group used fewer days in hospital at 3 months (mean difference 9, median difference 4 days, 95% CI of median difference 2–8). At 3 months the early discharge and rehabilitation service patients had better Barthel scores (mean difference 1.2, 95% CI 0.4–1.9), Nottingham Extended Activities of Daily Living kitchen scores (mean difference 1.2, 95% CI 0.2–2.3), Nottingham Extended Activities of Daily Living domestic scores (mean difference 1.1, 95% CI 0.2–2.0) and General Health Questionnaire scores (mean difference 2.4, 95% CI 0.7–4.1). Significant Nottingham Extended Activities of Daily Living domestic and General Health Questionnaire benefits remained at 12 months. The early discharge and rehabilitation service carers had better General Health Questionnaire scores at 3 months (mean difference 2.0, 95% CI 0.1–3.8). The interviews suggested that the early discharge and rehabilitation service was patient-centred, set clear goals, worked as a team, and considered physical, psychological, social and environmental issues. It was found to be highly satisfactory.
Conclusions: some older people can be discharged from hospital sooner, with better health outcomes using a well-staffed and organised patient-centred early discharge service providing rehabilitation.

Keywords: *rehabilitation, patient discharge, randomised controlled trial*