Flooring as an intervention to reduce injuries from falls in healthcare settings: an overview

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Abstract

Background: The aging population is generating increasing concern over the occurrence and associated costs of falls in healthcare settings. Supplementary to the investigation of strategies to prevent falls, is the consideration of ways to reduce the number of injuries resulting from falls in these settings.

Aims: This overview assesses the status of research on flooring in healthcare settings to reduce the incidence of injury resulting from falls.

Methods: A comprehensive literature search carried out in conjunction with a Cochrane Systematic Review on hospital environments for patient health-related outcomes, identified the available evidence. Additionally, searches were conducted in Medline and Scopus specifically to identify studies on flooring types, falls, and injuries. Reference lists of relevant studies and reviews were scanned and relevant authors were approached for further information.

Conclusions: Flooring should be considered as a possible intervention for reducing injuries from falls however more rigorous and higher quality research is needed to identify the most appropriate materials for use.

Keywords: Floors and floor-coverings; falls; older people; injury; hip fractures.

Introduction

Preventing falls and reducing the number of serious injuries resulting from falls in older people is currently high on the national agenda (DoH, 2001). Despite the large quantity of work carried out on falls prevention (Chang *et al*, 2004), falling in the hospital setting remains a significant problem (Vassallo *et al*, 2005; Kerzman *et al*, 2004). This issue is set to become increasingly prominent given that older people, and particularly those requiring mental health care (Morgan *et al*, 1985), are most at risk of falling, and this proportion of the population is growing (Kannus *et al*, 1996). With an age-related increased risk of sustaining an injury from a fall (Kannus *et al*, 1996; Lauritzen, 1996), older people additionally have an increased risk of falling due to a number of age-related risk factors, such as: lower-body weakness, impaired gait and balance, use of psychoactive medications, and visual impairment (Stevens, 2005). Approximately 30% of patient falls result in an injury (Vassallo *et al*, 2005; Morse *et al*, 1985), creating a substantial financial burden on healthcare resources in terms of costs of continued and additional care (National Audit Office, 1996; Zacker & Shea, 1998) and litigation (Robinson, 2001). As efforts to research the effectiveness of falls prevention strategies continue (Oliver, 2004), an additional area of research focuses on injury prevention strategies since the prevention of all falls is impossible. This overview aims to assess the current status of this latter area of research, with a particular focus on the effectiveness of different flooring types on injury reduction.

Methodology

The available evidence reported in this overview was identified in a comprehensive literature search carried out in conjunction with a Cochrane Systematic Review on hospital environments for patient health-related outcomes (Drahota *et al*., 2004). Additionally, searches were conducted in Medline and Scopus to specifically identify studies on flooring types, falls, and

injuries. Reference lists of relevant studies and reviews were scanned and relevant authors were approached for further information.

Rationale for a flooring intervention

Given the weight of importance applied to flooring requirements in children's play areas (British Standard BS EN 1177) it is surprising that such little attention has been paid to the shock-absorbing qualities of flooring in healthcare settings. In part, this may be due to the development of devices such as hip protectors, which can be specifically used by high risk patients, and require little change to the overall hospital environment. A systematic review has assessed the use of hip protectors with older people living in the community or in institutional care as a potential method for reducing hip fractures from falls (Parker *et al*, 2005). The review reveals that compliance with this intervention is poor due to discomfort and practicality, and the effectiveness of hip protectors looks doubtful in the light of the current evidence. A flooring intervention requires no compliance on the part of the patient, and therefore merits investigation.

Modifying the hospital environment to promote patient safety is currently high on the agenda (DoH, 2003) and it is generally acknowledged that putting careful thought into the design and planning of hospital environments may bring high rewards in terms of reducing long-term running costs and improving patient outcomes (Ulrich & Zimring, 2004). Research has been carried out to assess the potential impact of the environment in terms of falls prevention (Connell, 1996); in hospital settings, the efficacy of bedrails (Van Leeuwen *et al*, 2001; Schott & Force, 1999; Hanger, Ball, & Wood, 1999), and bed alarms (Tideiksaar, Feiner, & Maby, 1993) have been considered without finding a reduction in number of falls. Relatively little investigation has been conducted, however, on how the physical healthcare environment can prevent injuries resulting from falls.

Factors for consideration in flooring for healthcare settings

Although not the focus of the present overview, it is none-the-less important to highlight additional factors that need to be considered when choosing the most suitable flooring type for healthcare settings. Flooring in healthcare settings has been considered in terms of bacterial contamination and hospital acquired infections (Skoutelis *et al*, 1994; Anderson *et al*, 1982), ease of use for older walkers and wheelchair users (Wilmot, 1986; Stephens & Goldie, 1999; Glaser *et al*, 1981; Wolfe, Waters, & Hislop, 1977), as well as factors such as maintenance, slip resistance, friction, acoustics and implementation costs (Roder, 1974). Some attention has also been paid to how flooring types affect the risk of falling; Donald and colleagues (2000) compared carpet and vinyl floor coverings in an elderly care rehabilitation ward of a community hospital, with the additional factor of two types of physiotherapy as a falls prevention strategy. Although this study was underpowered with only 54 participants, it found that the least amount of falls happened on vinyl flooring.

It is important to consider the balance between risk of falling and risk of sustaining a serious injury for different flooring types (Simpson *et al*, 2004); for example one type of flooring may drastically reduce the risk of slipping or falling, but when a fall does occur it may be more likely to result in injury, or vice-versa. Some research has considered flooring types as a way of reducing injurious falls, although to date no randomised controlled trials of specific flooring interventions have been conducted.

Current evidence on flooring for injury prevention

A number of studies have assessed the various shock-absorbing properties of flooring types using mechanical testing techniques to simulate falls (Nabhani & Bamford, 2004; Maki & Fernie, 1990; Gardner *et al*, 1998; Minns, Nabhani, & Bamford, 2004). Falls simulators are limited in that they provide only a simple approximation of how a person may fall from a

stationary position; man-made materials are used to simulate the shock absorbency of a human body; and the dynamics of the fall are highly simplified, given that in reality a person may twist, turn, and contract various muscles (Maki & Fernie, 1990). Although testing rigs can evaluate the dampening effect on impact forces of various floor types, injuries such as hip fractures are also dependent on the fall dynamics and bone strength of the faller (Hayes *et al*, 1996), which are aspects that only field studies can capture. To assess the relationship between laboratory test results and flooring performance *in situ*, Gardner and colleagues (1998) developed a 'portable transducer', which they then used in an observational study examining the relationship between impact force and fracture rate on various floors in homes for older people (Simpson *et al*, 2004). Gardner and colleagues (1998) also report on a pilot study, which although lacking in power (with 864 falls and 18 hip fractures occurring on 5 flooring types) shows a trend towards certain flooring types (e.g. PVC and concrete) increasing the risk of fracture.

In their follow-up observational study of falls in nursing home residents (which resulted in 6641 falls and 222 fractures), Simpson and colleagues (2004) found that concrete sub-floors significantly increased the risk of fracture compared to wooden sub-floors. The flooring types in Simpson and colleagues' study were broadly categorised into four groups (with or without carpet, and with wooden or concrete sub-floor). No details of underlays, hard floor coverings or type of carpets are presented; presumably floors referred to in the study as "uncarpeted" are covered with vinyl, however, this is not made clear. Simpson and colleagues were surprised to find that uncarpeted concrete floors actually faired slightly better (although not to a significant degree) than carpeted concrete floors, despite uncarpeted concrete floors having the highest impact force (as measured by the portable transducer). This finding could have been a result of atypical falls happening on this flooring type (mostly found in bathrooms); items may have broken the falls or staff vigilance may have affected reporting of falls in bathrooms.

Alternatively, peak impact force may not be the most appropriate measure to predict fracture risk, and other mechanical properties of floor materials such as energy absorption maybe more closely correlated. Simpson and colleagues (2004) state that they are currently investigating this theory further.

In another field-based study, Healey (1994) retrospectively analysed a random sample of 225 accident forms reporting falls on a care of the elderly unit. Although the abstract reports different figures from the results section, the main findings were that vinyl flooring appears to sustain more injurious falls than carpet. Injury in this study is broadly defined as anything from the patient complaining of pain through to bruises, lacerations and fractures. Contrary to the findings of Donald and colleagues (2000), this sample contained many more incidents of falls on vinyl (186 vs. 27), which could be a result of sampling error, an artefact of where vinyl was present in the wards (e.g. around the patient bed where most falls occur [Morgan *et al*, 1985]) or as an indication that falls are more likely to occur on vinyl (e.g. due to slipperiness). No specific information is given as to whether the floor coverings had underlays or if the materials were laid on concrete or wood.

Some manufacturers are now developing flooring with shock-absorbent properties for healthcare settings; although no longer under development, The Penn State Safety Floor is one such example. This flooring is designed with two layers separated by columns, which remain rigid to withstand everyday activities, but which will momentarily buckle under high impact to absorb some of the force of a person falling. This expensive flooring has been laboratory tested with promising results (Casalena *et al*, 1998a; Casalena *et al*, 1998b). A further cost-effectiveness analysis of the system has been conducted (Zacker & Shea, 1998), estimating a payback period of 10.5yrs based on direct costs only, and just over 11 months when both direct and indirect costs are considered. Due to the implementation requirements, Minns and

colleagues (2004) assert that this flooring is “an impractical solution in homes and hospitals already built”. The Penn State Safety Floor has never been assessed in a healthcare setting and the project has been discontinued. One of its original inventors, Dr. Timothy C. Ovaert, currently at the University of Notre Dame in Indiana, has developed a different safety floor under the trade name SorbaShock, which is approximately one year away from production and installation (T. Ovaert, personal communication, December 5, 2006). This new flooring has yet to be trialled in a clinical setting. Hayes and colleagues (1996) report briefly on the development of an alternative flooring type using elastomers, and state that this has also undergone laboratory testing with promising results.

A range of further flooring solutions have been assessed; Maki and Fernie (1990) mechanically tested 13 different floor coverings, finding that impact attenuation in simulated hip impacts improves with the introduction of underlays and that carpets provide better impact attenuation than hard floorings, such as linoleum and vinyl. Thick carpets with underlays create logistical problems in institutional settings however, with issues surrounding the rolling resistance of wheelchairs and beds, and sanitation issues arising from spilled bodily fluids (Zacker & Shea, 1998). Maki and Fernie (1990) only tested the impact of one type of underlay with different types of carpet, and not with vinyl flooring types, which are more suited to clinical settings. Nabhani and Bamford (2004) tested 17 types of underlay with two different types of vinyl and one type of carpet. They concluded that although the standard underlay (typically containing: 13% rubber; 65% filler; 19% process oil and chemicals; and 4% pigment and regrind) significantly reduces impact forces to the hip, other potential underlays, which contain for example, polyurethanes (such as Sorbothane®), have much better dampening properties. They also highlighted the need to assess other materials and the impact properties of underlays over time, as it is likely they will degrade as the flooring ages. A further study assessing some additional underlay materials concluded that Sorbothane® and PVC foam offer the best

solution (Minns, Nabhani, & Bamford, 2004). As a result of this laboratory research, a floor-covering with a shock-absorbent underlay has been developed, taking into account rigidity (for ease of installing), thickness, and its associated problems concerning traction and piercing. The present authors, in collaboration with Prof. Minns and others, are in the process of applying for the funds to trial this particular flooring product in a clinical setting.

A flooring product manufactured by Altro (a private Limited Company), has recently been assessed in a unit caring for elderly mentally ill patients at North Tyneside General Hospital (unpublished data)[2]. This study utilised a 'controlled before and after' methodology, collecting data two years prior and two years after the new flooring was laid in the ward, with areas nearby (corridor, lounge, etc.) remaining as a control. The study found that fewer falls (n=127) and resulting fractures (n=1) occurred on the new flooring (2mm non-slip vinyl with 4mm thick 'Altro Everlay B' underlay and concrete sub-floor) as compared to the old flooring (carpet with concrete sub-floor), on which 203 falls occurred with six fractures. The findings from the control areas, fitted with carpet over concrete sub-floor, remained fairly constant during the study period, with 162 falls and one fracture occurring in the first two years of study, and 188 falls and two fractures occurring in the second two years of study. Although this study is small in size, and the control areas are not directly comparable to the intervention area, it has addressed some of the methodological issues posed by previous research, through conducting a prospective intervention study in a clinical setting.

Conclusions

The use of more appropriate flooring in healthcare settings does appear to be a viable option for the reduction of injuries from falls. Current findings from field studies are largely inconclusive due to weak study designs and lack of specificity in describing the types of floors

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assessed; although it can be concluded, based on the current evidence, that concrete sub-floors sustain more injuries than wooden sub-floors. Future field studies assessing the effectiveness of floor coverings need to provide more details specifying the properties of the floor materials under evaluation. Laboratory tests suggest that certain floor coverings offer superior shock-absorbency, despite this, the degree to which laboratory test results reflect "real world" application is questionable. Manufacturers are developing flooring to specifically target injury prevention in healthcare settings; these technologies need to be assessed for both clinical and cost effectiveness before being incorporated into current practice.

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Conflicts of interest

The authors are in the process of a grant application to investigate the efficacy of a flooring product assessed by Minns (2004).