SAFETY FLOORING TO REDUCE THE RISK OF FALL-RELATED INJURIES – CHARACTERIZING FOOTFALL DEFLECTIONS VS ENERGY ABSORPTION DURING SIMULATED IMPACTS

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INTRODUCTION
Nearly 54, 000 Canadians over the age of 65 are hospitalized for a fall each year [1], leading to direct treatment costs of approximately $2 billion [2]. The most severe fall-related injuries in the elderly are hip fracture and traumatic brain injury, which are commonly caused by falls and often lead to death or drastic reductions in quality of life. With the proportion of Canada’s population over the age of 65 projected to reach 25% by the year 2041 [3], injury rates are expected to increase dramatically.

‘Safety floors’ aim to decrease the risk of fall-related injuries by absorbing impact energy during falls. Ironically, excessive floor deflection during walking or standing may increase fall risk. In this study we used a materials testing system to characterize the ability of a range of floors to absorb energy during simulated head and hip impacts whilst resisting deflection during simulated single-leg stance during gait.

METHODS
Three general categories of floors (4 carpets, 4 ‘safety floors’, and 4 bedside mats) were impacted with custom head, hip and foot indenters using a servohydraulic material testing system (FastTrack™ 8872 System, Instron Corporation, Canton, MA, USA).

Based on the force-deflection profiles, peak deflection was measured for simulated single-leg stance, while energy absorption was calculated for simulated head and hip impacts. Additionally, the ratio of energy absorption (during head and hip trials) to peak deflection (during simulated single-leg stance) was calculated for each floor condition. A two-way ANOVA was used to determine whether energy absorption was influenced by indenter shape (head vs hip) across flooring conditions. One-way ANOVAs were then employed to determine whether the three outcome variables – peak deflection, energy absorption, and energy-to-deflection ratio – were influenced by floor condition. If significant results were observed, post-hoc Dunnett’s tests were performed to determine whether outcomes were significantly different from the commercial carpet (control condition).

RESULTS
We found that average energy absorption values for all safety floors (mean (SD) = 14.8 (4.9) J) and bedside mats (25.1 (9.3) J) were 3.2 to 5.4 fold greater than the control condition (commercial carpet). Indenter shape also had a significant influence as floors absorbed 9.6% more energy for hip versus head indentation trials. While footfall deflections for the safety

![Figure 1: Mean energy absorption ($e_{\text{hip}}$) during hip trials, footfall deflection ($d_{\text{max}}$) during simulated single-leg stance, and energy-deflection ratios ($e_{\text{hip}}$-ratio) for all floor conditions.](image)

distorted floors (1.8 (0.7) mm) were not significantly different from the control carpet (3.7 (0.6) mm), they were consistently below 2 mm, a design criterion recommended for safety floors [5]. Peak deflections were significantly higher for two of the bedside mats. Finally, all of the safety floors, and two bedside mats, displayed 3 to 10 times the energy-absorption-to-deflection ratios observed for the baseline carpet (Figure 1).

DISCUSSION & CONCLUSIONS
Overall, these results suggest that the ‘safety floors’ we tested effectively addressed two competing demands required to reduce fall-related injury risk; namely the ability to absorb substantial impact energy without increasing footfall deflections. This study contributes to the literature suggesting that safety floors are a promising intervention for reducing fall-related injury risk in older adults without introducing elevated fall risks.

REFERENCES