PROBABILISTIC MODEL APPROACHES FOR COMPARING THE EFFECTIVENESS OF INTERVENTIONS TARGETING REDUCED RISK OF HIP FRACTURE

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The elevated incidence of fall-related hip fractures in the older adult population have led to the development of interventions that target these injuries. While pharmacological interventions are commonly used to improve bone strength, mechanical/physical interventions (such as hip protectors and safety flooring) have been developed to reduce applied loads. Previous studies have demonstrated the ability of these interventions to reduce fall-related impact loads in laboratory settings [1,2]. While clinical trials provide details related to hip fracture risk reduction, they can take years to complete and have associated methodological challenges. Therefore, the objective of this study was to use a mechanistic, probabilistic model of impact dynamics to predict the clinical effectiveness of safety flooring and hip protectors at reducing hip fracture risk.

Data from studies investigating the effects of a hip protector (HipSaver) and a safety floor (SmartCells) on impact force during simulated lateral impacts (using human volunteers and a mechanical test system, respectively) was used to develop impact force attenuation regression equations based on the physical characteristics of the volunteers and the mechanical test system. These equations were used in conjunction with a probabilistic model to predict fracture risk. This model first generated a sample (N = 100000) of virtual individuals (VI) that were representative of the older adult population in terms of physical characteristics. The model then estimated each VI's Factor of Risk (FOR) [3] as the ratio of predicted impact force from a standing height fall (lumped-element model) and predicted femur strength (using regression approaches [4]). Next, the model used the intervention force attenuation regression equations to predict intervened impact force, and the associated intervened FOR (IFOR) was calculated for each VI for both the hip protector and safety flooring interventions. The estimated risk reduction provided by each intervention was characterized as the difference in factor of risk between the baseline (FOR) and intervened (IFOR) conditions.

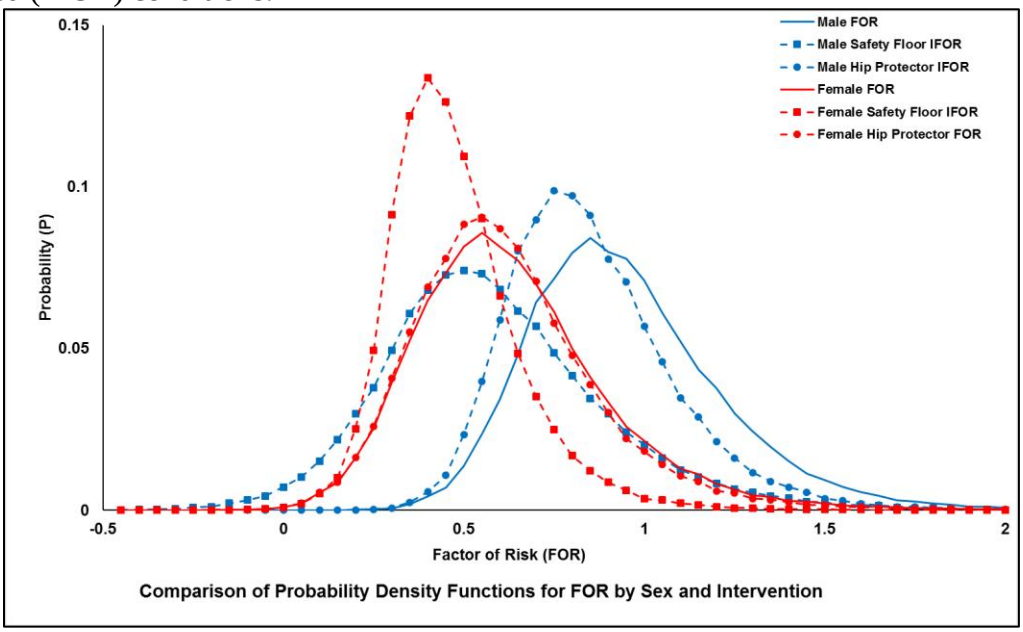

Figure 1: The Probability Density Functions for female (Red) and male (Blue) FOR (Solid line: Baseline FOR, Dashed Squares: Safety Floor IFOR, Dashed Circles: Hip Protector IFOR)

The intervention regression equations revealed that there was a significant relationship between physical characteristics and force attenuation for both the hip protector (R^2=0.279, p=0.028) and the safety floor (R^2=0.899, p<0.001). For females, mean (SD) FOR in the baseline condition was 0.61 (0.28); IFOR decreased to 0.59 (0.27) and 0.45 (0.19) for the hip protector and safety flooring interventions, respectively. The effects were more pronounced for males; mean (SD) FOR in the baseline condition was 0.93 (0.28) compared to IFOR values of 0.83 (0.23) and 0.56 (0.31) for the hip protector and safety flooring interventions, respectively.

	Baseline FOR	**Hip Protector IFOR**	**Safety Floor IFOR**
Male mean(SD)	0.93 (0.28)	0.83 (0.23)	0.56 (0.31)
Reduction from Baseline (%)		10.60%	39.80%
Female mean (SD)	0.61 (0.28)	0.59 (0.27	0.45 (0.19)
Reduction from Baseline (%)		3.30%	26.20%

Table 1: Sex-specific and condition-specific (baseline, hip protector intervention, and safety floor intervention) mean (SD) FOR and IFOR; percent reduction between baseline FOR and either intervention IFOR is presented for each sex.

This study provides the first estimates of hip fracture risk reduction with the introduction hip protectors or safety flooring on a population level. More generally, this study provides a proof of concept for using a population level probabilistic model as a virtual test for proposed interventions, towards estimating the injury risk reduction capacity of interventions whose biomechanical effectiveness have been characterized in laboratory settings. While this study is limited by its assumptions, it provides theoretical evidence that hip protectors, and particularly safety flooring, can reduce the risk of hip fractures in the older adult population.

References: [1] Laing et al. (2011). Journal of Biomechanics 44(15); 2627-37.; [2] Bhan et al. (2014). Journal of Biomechanics 47(10); 2391-7.; [3] Dufour et al. (2012). Osteoporosis International 23(2); 513-20.; [4] Roberts et al. (2010). Bone 46(3); 742-6.