PREDICTING POPULATION LEVEL-HIP FRACTURE RISK: A NOVEL PROBABILISTIC MODELING APPROACH INCORPORATING FACTOR-OF-RISK PRINCIPLES

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Fall related injuries are a serious concern for older adults, specifically for hip fractures (fx), where 95% are due to falls [1]. In Canada alone, there are ~25000 hip fx/year [2], accounting for over one third of all fall-related hospitalizations, costing $650 million annually [3]. While models are available for predicting an **individual's** risk of hip fx, there exists no model to predict risk on a **population level,** which would be valuable in the development of prevention and intervention policies. Accordingly, the goal of this study was to develop and validate a mechanistic, probabilistic model to predict population-level hip fracture risk for older adults.

A novel multi-level model was developed using a mechanistic Factor of Risk (FOR) [4] model (calculates fx risk) within a probabilistic modelling framework (generates population-relevant 'virtual-individuals' [VI]). The FOR model included impact force and bone strength prediction sub-models which utilized inputs including: height, mass, pelvic stiffness, femoral neck BMD, age and sex. Monte Carlo methods were used to generate VI's and randomly assign physical characteristics (mass, height, sex, age, pelvic stiffness) based on population distributions. Impact force and bone strength (and subsequent FOR) were computed for every VI. The model was validated by utilizing inputs and comparing outputs from Dufour et al's (2012) retrospective study that calculated FOR for male and female hip fx patients and controls. For the study's primary application, the overall model was run using Statistics Canada population data to generate the distributions of physical characteristics of older adults aged 60-100 (100,000 iterations). Each of these virtual individuals were fed into the mechanistic FOR model, and a distribution of FOR was then compiled for the Canadian older adult population.

The model validation results demonstrated that the means and standard deviations of the 4 groups were all within 5% of the values reported by Dufour et al, 2012 (see Table 1). For the study's primary application for the Canadian population, the mean (SD) FOR for Females was 0.335(0.24) and 0.859(0.25) for Males. When sorted by age, there was no clear increase in FOR for males or females (Male $R^2 = 0.057$, Female $R^2 = 0.014$). The simulated population was slightly younger, heavier, had higher BMI and higher trochanteric soft tissue thickness (TSTT) than the Dufour et al, 2012 sample.

This study marks the first use of mechanistic, probabilistic modeling for hip fracture risk assessment on a population level. Simulating the Canadian older adult population resulted in estimated FOR values slightly lower than those of the control groups reported in Dufour et al, 2012; this is due to population differences, namely higher BMI (and TSTT) resulting in greater amounts of force attenuation. This approach could be used to mechanistically predict the effectiveness of interventions or preventative methods at a population level. While the current model has limitations (e.g. it does not incorporate differences in fall-rates across ages and gender), it provides a solid foundation that will support the development of even more robust predictive algorithms.

References: [1] Wolinsky et al. (2009). Journal of Gerontology 64(2); 249-55.; [2] Statistics

Canada. Canadian community health survey - annual component (CCHS). Health Survey. Ottawa: Statistics Canada; 2012. Report No.: 3226; [3] Wiktorowicz et al. (2001). Osteoporosis International 12(4); 271-78; [4] Dufour et al. (2012), Osteoporosis International 23(2); 513-20.

	Male no Fracture	Male Fracture	Female no Fracture	Female Fracture
Reported mean (SD)	0.87 (0.16)	1.00 (0.17)	0.41 (0.21)	0.49 (0.17)
Model Validation mean (SD)	0.88 (0.21)	1.05 (0.22)	0.41 (0.25)	0.49 (0.25)

Table 1: Group mean (SD) FOR reported by Dufour et al, 2012 compared to the group mean OR values obtained from the model validation simulation.