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

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This novel approach moves beyond individuals to predict fracture risk at the population level. A valuable tool for a-priori prediction of intervention approaches.

INTRODUCTION

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].

Currently, there exists no model to predict hip fx risk on a population level. Such a model would be valuable in developing prevention and intervention policies.

This study's main goal was to develop and validate a **mechanistic, probabilistic model** to predict population-level **hip fracture risk** for older adults.

METHODS

Model Development

Factor of Risk (FOR) principles were applied, where:

$$FOR = \frac{Impact\ Force}{Fracture\ Threshold}$$

When *FOR* ≥ 1, hip fx assumed.

To predict net impact force, we took the difference between

$$Peak\ Impact\ Force\ (N) = \sqrt{2ghmk}, \text{ [4]}$$

and

$$Soft\ Tissue\ Force\ Attenuation\ (N) = 71 * tstt. \text{ [5]}$$

Fracture Threshold is then calculated by

$$Fracture\ Threshold\ (N) = 8207 * Femoral\ neck\ BMD - 568.62. \text{ [6]}$$

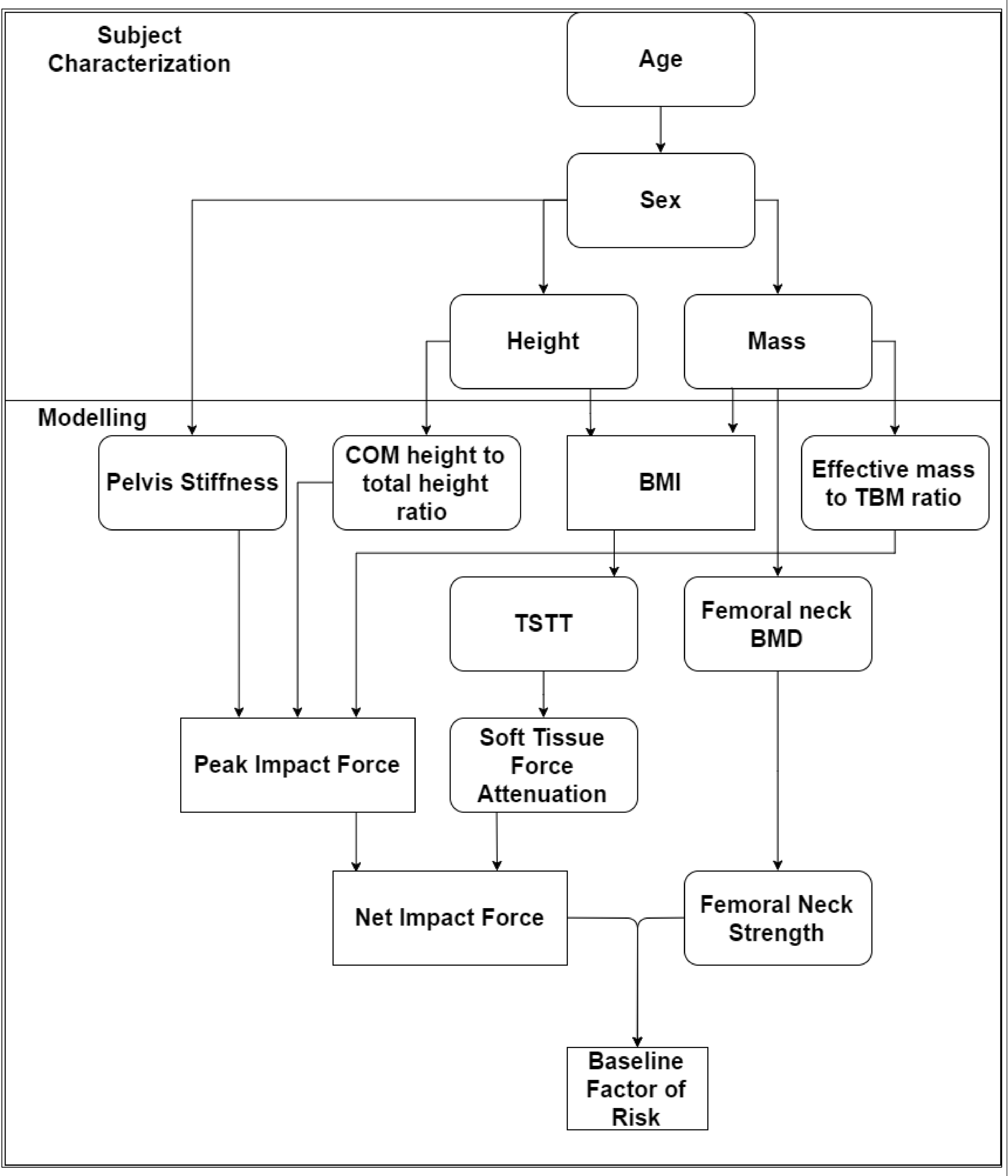

Figure 1: Model Structure Flowchart

METHODS

Model Structure

As seen in **Figure 1**, the model is separated into two main portions:

1. **Subject Characterization**
2. **Modelling**

The first portion generates virtual individuals (VI) that represent a given population. The physical characteristics of the VIs are used as the inputs for the predictive equations in the second portion.

Generating Virtual Individuals (VIs)

A sample of VIs was generated to represent the population of interest (Canadians ≥ 60 yrs of age).

Physical characteristics assigned to VIs for mechanistic model included:
- mass, height, etc.

- Population probability distributions defined for each characteristic
- With the exceptions of age and sex, normal distribution were employed.
- Pseudo-random sampling ensured representative values assigned.

Model Validation

- We compared our FOR output to retro-spective study values (Dufour et al, 2012) from four groups:
  - Male, No Fracture), N = 399
  - Male (Fracture), N = 26
  - Female (No Fracture), N = 565
  - Female (Fracture), N = 110
- **Acceptable difference threshold = 5%**

Population Application

- 100 000 VI samples generated.
  - Distributions drawn from Statistic Canada data for adults 60-100 years.
- Mean (SD) *FOR* calculated by age (5 year bins) and sex.
- Sex-specific linear regression models generated for age-related FOR changes.

RESULTS

Validation Results

	Male (No Fracture)	Male (Fracture)	Female (No Fracture)	Female (Fracture)
Reported Mean (SD) [7]	0.87 (0.16)	1.00 (0.17)	0.41 (0.21)	0.49 (0.17)
Model Mean (SD)	0.875 (0.21)	1.048 (0.22)	0.410 (0.25)	0.485 (0.25)
Mean Difference (%)	0.575 %	4.8%	0%	-1.02%

Table 1: Reported vs Model Group Mean (SD) FOR

RESULTS

Population Application Outcomes

- Male Mean (SD) FOR: 0.940 (0.314)
- Female Mean FOR: 0.469 (0.296)
- Age Effect - Male mean FOR: R^2 0.995
- Age Effect - Female mean FOR: $R^2$0.925

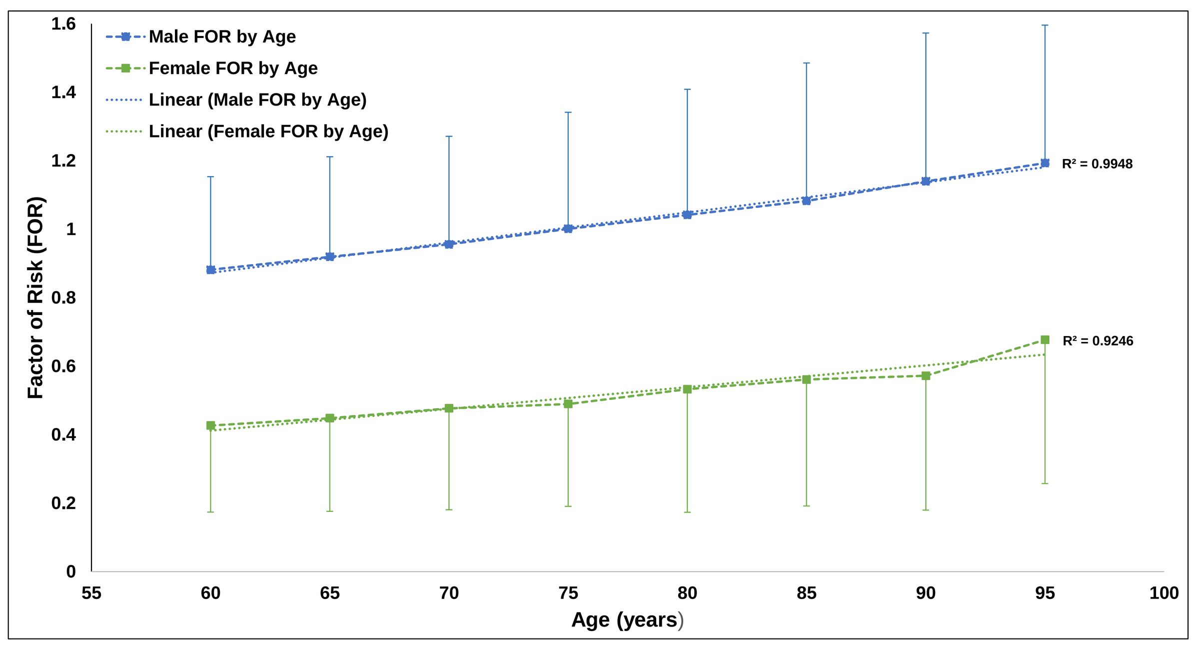

Figure 2: Group mean FOR by age (5-year bins) and sex

DISCUSSION

- Novel model of population level hip fracture risk developed
- Model validated against epidemiological data (within 5%)

- Model predicted population-level hip fx risk for entire Canadian older adults
  - *FOR* increases with age for both males and females
  - *FOR* greater for males (aligns with Dufour et al, 2012), but counter to current fx rates.

FUTURE WORK

- ***Intervention** submodule* – explore the effects of prevention approaches.
  - Pilot work indicates that 'safety flooring' substantially reduces FOR and hip fx risk
  - ***Fall Risk** submodule* - apply to each VI

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