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:

\[
\text{FOR} = \frac{\text{Impact Force}}{\text{Fracture Threshold}}
\]

When \( \text{FOR} \geq 1 \), hip fx assumed.

To predict net impact force, we took the difference between

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

and

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

Fracture Threshold is then calculated by

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

Model Structure

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

1. Subject Characterization

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

2. Modelling

   The population predicted for each VI is loaded into a specific linear regression model.

Generating Virtual Individuals (VIs)

A sample of VIs was generated to represent the population of interest (Canadians \( \geq 60 \) 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 retrospective 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, \( N = 110 \)

   \[ \text{Acceptable difference threshold} = 5\% \]

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

Population Application Outcomes

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

Validation Results

<table>
<thead>
<tr>
<th></th>
<th>Male (Fracture)</th>
<th>Female (No Fracture)</th>
<th>Female (Fracture)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reported Mean</td>
<td>0.875 (0.21)</td>
<td>1.00 (0.17)</td>
<td>0.410 (0.25)</td>
</tr>
<tr>
<td>Model Mean</td>
<td>0.875 (0.21)</td>
<td>1.048 (0.22)</td>
<td>0.410 (0.25)</td>
</tr>
<tr>
<td>Mean Difference</td>
<td>0.575 %</td>
<td>4.6%</td>
<td>0%</td>
</tr>
</tbody>
</table>

REFERENCES