A Serious Side of Gravity: Preventing Falls and Fall-Related Injuries

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For 65+ populations, falls are responsible for:

- **60%** of all injury-related deaths
- **84%** of all injury-related hospitalizations
- **38%** of hospital admissions related to falls are for **hip fractures**
- 1 in **4** older adults hospitalized for hip fractures die within the first year.
- **90%** of traumatic brain injuries (TBI). **50%** of all injury related death are due to TBI.
Hip Fractures among Canadian Seniors

Over 26,000 Canadians aged 65+ fractured their hip in 2010

% of hip fractures are caused by falls

Annual health care cost = over $1 Billion

Numbers and related costs will increase as our population ages
Those at Greatest Risk

- Those at greatest risk for falls and hip fractures are residents of long term care facilities.
- Although only 7% of adults aged 65 and over live in residential care, this group accounts for more than 25% of all hip fractures due to falls, and an estimated $250 million in annual medical costs.
Hip fractures in long-term care

- 30 to 50% fall annually
- 40% experience recurrent falls
- Account for 52% of all fall-related hospital admissions
- Less than 15% regain pre-injury physical function
Residents especially susceptible

4 to 10.5 times more likely to fracture a hip due to:

- Poor cognition
- Frailty
- Inadequate protective responses
**Video capture of falls**
- 270 cameras in common areas
- capture 160 falls per year
- cause and circumstances of falls and fall injuries
- real-time evaluation of interventions

**Wearable fall sensors**
- unobtrusive
- occurrence, cause, and circumstances of falls, regardless of where they occur
- information logged or transmit wirelessly to care providers
- real-time evaluation of interventions

**Next-generation hip protectors**
- integrated into pant, skirt, or undergarment
- incorporate airbags activated by fall sensor
- attenuate impact force by 95% (four times more than existing devices)
- low profile during normal wear
- sensors monitor adherence in wearing device, positioning, impact occurrence

**Compliant flooring**
- passive protection (not reliant on user compliance)
- attenuate impact force by 40%
- negligible effect on balance and mobility
- optimised for use in care facilities (hygiene, durability, rolling resistance of wheelchairs)
Collaborators

Stephen Robinovitch, PhD (SFU) - PI
Fabio Feldman, PhD (Fraser Health)
Dawn Mackey, PhD (SFU)
Andrew Laing, PhD (U. Waterloo)
Greg Mori, PhD (SFU)
Ed Park, PhD (SFU)
Teresa Lui-Ambrose, PT, PhD (UBC, CHHM)
Andrew Sixsmith, PhD (SFU)
Habib Chaudhury, PhD (SFU)
Joanie Sims-Gould, PhD (CHHM)
Aleks Zecevic, PhD (Western U)
Heather McKay, PhD (CHHM)
Vicky Scott, RN, PhD (BCIRPU)
Ming Leung, PT, MSc (Fraser Health)
Gina Gaspard (Fraser Health)
Video-based recording of the cause and circumstances of falls in long-term care

• To record the cause and circumstances of real-life falls in residential care using networks of video cameras

• To provide insight on the mechanics of injurious versus non-injurious falls, role of bone fragility versus fall severity, etc.
Ethics

• approved by the Office of Research Ethics at Simon Fraser University
• secondary use of video data (owned by facilities)
• removal of facial (identifying) features
Video capture of the circumstances of falls in elderly people residing in long-term care: an observational study

Stephen N Robinovitch*, Fabio Feldman*, Yijian Yang, Rebecca Schonnop, Pet Ming Lueng, Thiago Sarraf, Joanie Sims-Gould, Marie Loughin

Table 2: Estimated proportion of participants falling at least once, and average number of falls per participant, attributable to various causes of falling

<table>
<thead>
<tr>
<th>Cause</th>
<th>Number of falls</th>
<th>Percentage*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorrect transfer or shifting of bodyweight while</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitting down or lowering</td>
<td>16</td>
<td>8%</td>
</tr>
<tr>
<td>Getting up or rising</td>
<td>13</td>
<td>6%</td>
</tr>
<tr>
<td>Walking forward</td>
<td>12</td>
<td>6%</td>
</tr>
<tr>
<td>Initiation of walking</td>
<td>11</td>
<td>5%</td>
</tr>
<tr>
<td>Walking and turning</td>
<td>9</td>
<td>4%</td>
</tr>
<tr>
<td>Standing and turning</td>
<td>8</td>
<td>4%</td>
</tr>
<tr>
<td>Walking backward or sideways</td>
<td>7</td>
<td>3%</td>
</tr>
<tr>
<td>Standing quietly</td>
<td>7</td>
<td>3%</td>
</tr>
<tr>
<td>Standing and reaching</td>
<td>6</td>
<td>3%</td>
</tr>
<tr>
<td>Hit or bump while</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standing quietly</td>
<td>10</td>
<td>5%</td>
</tr>
<tr>
<td>Collapse or loss of consciousness while</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitting down or lowering</td>
<td>7</td>
<td>3%</td>
</tr>
<tr>
<td>Getting up or rising</td>
<td>6</td>
<td>3%</td>
</tr>
<tr>
<td>Loss of support with external object</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitting down or lowering</td>
<td>7</td>
<td>3%</td>
</tr>
<tr>
<td>Getting up or rising</td>
<td>6</td>
<td>3%</td>
</tr>
</tbody>
</table>

In descending order of frequency. *Of 227 total falls captured. †Of 215 falls analysed, after exclusion of cases for which the faller could not be identified (six), and cases for which the team could not identify the cause of the fall (six).

Table 6: Combinations of cause and activity associated with six or more falls
37% of falls caused head impact, unaffected by hand impact (which occurred in 71% of cases)

Head impact more likely in forward falls, no effect of hand impact
Supporting Knowledge for Injury Prevention in Seniors (SKIPS)

Fall and Injury Prevention in Long Term Care
Considerations for Evidence-Based Practice

http://www.sfu.ca/tips/research/structured-program-knowledge-exchange/
Principles of care:
- Leave one unattended and the others will follow
- Manage one and you will also help manage the others
### Most Common Risk Factors

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>RR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscle Weakness</td>
<td>4.4</td>
</tr>
<tr>
<td>History of falls</td>
<td>3.0</td>
</tr>
<tr>
<td>Gait deficit</td>
<td>2.9</td>
</tr>
<tr>
<td>Balance deficit</td>
<td>2.9</td>
</tr>
<tr>
<td>Use assistive device</td>
<td>2.6</td>
</tr>
<tr>
<td>Visual deficit</td>
<td>2.5</td>
</tr>
<tr>
<td>Arthritis</td>
<td>2.4</td>
</tr>
<tr>
<td>Impaired ADL</td>
<td>2.3</td>
</tr>
<tr>
<td>Depression</td>
<td>2.2</td>
</tr>
<tr>
<td>Cognitive impairment</td>
<td>1.8</td>
</tr>
<tr>
<td>Age &gt;80</td>
<td>1.7</td>
</tr>
</tbody>
</table>
Risk factors for falls

- History of falls in the last 6 months
- Impaired balance, mobility, muscle weakness, co-ordination
- Impaired Safety Awareness – lack of insight/judgment
- Risk taking behavior
- Cognitive impairment e.g. memory loss, disorientation, delirium
- Agitation and restlessness
- Sleep disturbance
- Syncope and dizziness
- Use of Restraints
- Fear of falling
- Medication – dosage/recent changes
- Dehydration/malnourishment
- Incontinence/Bowel – urgency and frequency
- Poor proprioception and tactile sensation e.g. feet
- Vision/hearing impairment

- Use of mobility aid/wheelchair
- Footwear – incorrect fit and slip sole
- Poor physical environment
Probability of Having Falls

Percent Falling vs. Number of Risk Factors

- 0 risk factors: 8%
- 1 risk factor: 19%
- 2 risk factors: 32%
- 3 risk factors: 60%
- 4+ risk factors: 78%
Understanding the Factors that Influence Clinical Effectiveness of Hip Protectors
An overview of results from clinical trials of hip protectors
A. HIP PROTECTOR EFFECTIVENESS
(INTENTION-TO-TREAT)

Parker et al. Cochrane-review 2005 & BMJ-review 2006:

* 14 randomized trials included

* CONCLUSIONS:

1. In institutions with high rates of hip fracture, the use of hip protectors may help to reduce the risk of hip fracture (Pooled RR = 0.77, 95% CI 0.62-0.97)

2. Hip protectors are ineffective for community-dwelling older adults
Oliver et al. BMJ meta-analysis 2007. (HIP PROTECTOR EFFECTIVENESS IN CARE HOMES)

* 11 trials included (10 randomized)
* CONCLUSIONS:
  There is some evidence that use of hip protectors in care homes prevents hip fractures (Rate Ratio = 0.67, 95% CI 0.46 0.98)
B. HIP PROTECTOR EFFICACY
(RISK OF HIP FRACTURE IN PROTECTED VS. UNPROTECTED FALLS)

- **Kannus et al. N Engl J Med 2000** (KPH Hip Protector): Adjusted RH = 0.13, 95% CI 0.03-0.50

- **Cameron et al. Injury Prev 2003** (Hornsby Healthy Hip?): RR = 0.23, 95% CI 0.08-0.67

- **Forsen L et al. Injury Prev 2004** (Safehip): Adjusted OR = 0.31, 95% CI 0.13-0.75
C. HIP PROTECTOR EFFICACY
(RISK OF HIP FRACTURE IN A PROTECTED VS. UNPROTECTED HIP DURING A FALL, THE UNILATERAL HIP PROTECTOR STUDY)

Kiel et al. JAMA 2007 (Fallgard protector)

When the residents wore the unilateral hip protector at the time of the hip fracture, there were 13 hip fractures in protected hips vs. 7 fractures in unprotected hips

Thus, the risk for a hip fracture at the protected side = 13/7 = 1.86 (N.S.)
Two factors primarily determine clinical effectiveness

-
- comfort
- appearance
- ease of putting on
- Laundering
- staff commitment

Compliance (adherence)

Biomechanical Effectiveness

- geometry
- materials
- mis-positioning

Clinical Effectiveness
CONSENSUS STATEMENT

Hip protectors: recommendations for biomechanical testing—an international consensus statement (part I)

S. N. Robinovitch · S. L. Evans · J. Minns · A. C. Laing · P. Kannus · P. A. Cripton · S. Derler · S. J. Birge · D. Plant · I. D. Cameron · D. P. Kiel · J. Howland · K. Khan · J. B. Lauritzen

Table 2  Recommended design parameters of biomechanical test systems for measuring the force attenuation provided by hip protectors

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>RECOMMENDED VALUE OR TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic design</td>
<td>Impact pendulum or drop tower</td>
</tr>
<tr>
<td>Effective (drop) mass</td>
<td>28 kg (acceptable range, 22–33 kg)</td>
</tr>
<tr>
<td>Effective pelvic stiffness</td>
<td>47 kN/m (acceptable range, 39–55 kN/m)</td>
</tr>
<tr>
<td>Soft tissue covering</td>
<td>Polyethylene or polyurethane foam rubber</td>
</tr>
<tr>
<td>Minimal thickness of soft tissue covering over the greater trochanter</td>
<td>18 mm</td>
</tr>
<tr>
<td>Impact velocity</td>
<td>3.4 m/s</td>
</tr>
<tr>
<td>Peak compressive force in unpadded case</td>
<td>3.5–4.5 kN</td>
</tr>
<tr>
<td>Time to peak compressive force in unpadded case</td>
<td>30–50 ms</td>
</tr>
<tr>
<td>Filtering of force signals</td>
<td>Low pass recursive, cut off frequency = 50 Hz</td>
</tr>
</tbody>
</table>
Simon Fraser University Hip Impact Simulator

N = 15
BMI = 23.6 ± 2.1 kg/m²
Age = 77.5 ± 8.5 yrs
Biomechanical Performance

Percent Femoral Force Attenuation with Respect to Unpadded Condition
Hip Protector Placement

Percent attenuation in peak femoral force relative to the unpadded condition.
Some hip protectors do not cover the greater trochanter

Figure 2. Position of the GT marker on the top row-hard shells (from left to right): RemployS Caress, FallGuard, KPH, SafeHip. Bottom row-soft pads (from left to right) HipShield, HipSaver, PoseyHipsders, Lyds, Sanavida.

Source: Minns et al., Age and Ageing, 2007
"The effect of hip protectors is obviously linked to where the protector is, whether it is on the hip or in the drawer."

(Ekman et al. 1997)
Key messages

✓ Organizational commitment
✓ Dedicated champion to motivate, mentor, and monitor
✓ Involve everyone responsible for resident safety
✓ Staff education of the benefits and correct use
✓ Engage and educate residents and families
✓ Choose from hip protector models with proven efficacy
✓ Put in place protocols for ensuring adequate supply, variety of models, correct fit, and laundering
Hip protectors cannot prevent fracture in all circumstances:

- use of hip protectors with poor biomechanical performance
- incorrect placement
- very week bones
- impact other then directly to the hip
- spontaneous fractures without obvious impact
Education about Hip Protectors

Aging is a contact sport.

Does your team have the right gear?
The Bottom Line

• Hip protectors are effective for those in LTC facilities
• Not all hip protectors are equally effective
• User compliance heavily influences their clinical effectiveness
• Many actions can be taken in LTC facilities to enhance compliance

www.agingisacontactsport.com
The Flooring for Injury Prevention (FLIP) Trial: Can Compliant Flooring Reduce Injuries Due to Falls in Long-Term Care?
Force reduction provided by SmartCells during a simulated fall on the hip averaged 34%.

Laing et al., Accident Analysis & Prevention, 2009

Force reduction provided by SmartCells during a simulated fall on the head averaged 70%
Compliant floors reduce peak force with minimal influence on balance or mobility of older women

- 15 women ranging in age from 65 - 90 yrs (mean = 75, SD = 8)

<table>
<thead>
<tr>
<th></th>
<th>Rigid Floor</th>
<th>Approx 1” SmartCells</th>
<th>Approx 4” Tile</th>
<th>Approx 4” Firm Foam</th>
<th>Approx 4” Soft Foam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force attenuation %</td>
<td>0</td>
<td>25.4</td>
<td>47.2</td>
<td>76.6</td>
<td>52.4</td>
</tr>
<tr>
<td>GUG [balance test] time (seconds)</td>
<td>11.7</td>
<td>11.4</td>
<td>12.2</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>[balance] Recovery success</td>
<td>.79</td>
<td>.89</td>
<td>.79</td>
<td>.45</td>
<td>.67</td>
</tr>
<tr>
<td>Sway range (mm)</td>
<td>15.1</td>
<td>18.7</td>
<td>20.3</td>
<td>33.3</td>
<td>23.4</td>
</tr>
<tr>
<td>Sway velocity (mm/second)</td>
<td>8.0</td>
<td>9.1</td>
<td>9.3</td>
<td>20.3</td>
<td>12.8</td>
</tr>
<tr>
<td>Balance confidence</td>
<td>9.5</td>
<td>9.6</td>
<td>9.3</td>
<td>5.4</td>
<td>5.5</td>
</tr>
<tr>
<td>Practicality</td>
<td>9.1</td>
<td>8.5</td>
<td>8.2</td>
<td>2.6</td>
<td>1.9</td>
</tr>
</tbody>
</table>
FLIP Trial will address 3 aims:

1. To determine the effect of compliant flooring on fall-related injuries in long-term care

2. To determine the effect of compliant flooring on healthcare utilization in long-term care

3. To assess perceptions about compliant flooring among key stakeholder groups
FLIP Trial Design

New Vista = 236 rooms

Exclude 86 rooms
- 49 Willow Grove (non-ambulatory)
- 37 floor cannot be raised 1”

150 single-occupancy rooms across 4 villages will be randomized within villages

Intervention (INT) flooring 1” SmartCells w/ vinyl cover

Control (CON) flooring 1” plywood w/ vinyl cover

CON will also be installed in adjacent hallways

Common areas will NOT be modified. Thus, 3’ long transition ramps are required between hallways and common areas

Primary outcome
• moderate/severe fall-related injuries

Secondary outcomes
• all fall-related injuries
• falls

Notification & Installation
16 rooms/wk for ~10 wks

Assess baseline characteristics

Track outcomes for 4 years
Vitamin D Protocol for Residential Care

Fabio Feldman, PhD
Manager, Seniors Falls and Injury Prevention
Fraser Health

Adjunct Professor, Biomedical Physiology and Kinesiology
Simon Fraser University
Fall prevention with supplemental and active forms of vitamin D: a meta-analysis of randomised controlled trials

H A Bischoff-Ferrari, director of centre on aging and mobility,12 B Dawson-Hughes, director of bone metabolism laboratory,3 H B Staehelin, professor emeritus,4 J E Orav, associate professor of biostatistics,5 A E Stuck, professor of geriatrics,6 R Theiler, head of rheumatology,7 J B Wong, professor of medicine,8 A Egli, fellow,1 D P Kiel, associate professor of medicine,9 J Henschke, fellow10

WHAT THIS STUDY ADDS

A dose of 700-1000 IU supplemental vitamin D a day reduced falls by 19%, and by up to 26% with vitamin D₃, within 2-5 months of treatment initiation

Vitamin D may not reduce falls at doses of less than 700 IU a day
Authors’ conclusions
There is evidence that multifactorial interventions reduce falls and risk of falling in hospitals and may do so in nursing care facilities. **Vitamin D supplementation is effective in reducing the rate of falls in nursing care facilities.** Exercise in subacute hospital settings appears effective but its effectiveness in nursing care facilities remains uncertain.
Vitamin D & Muscle Function

• Mediated through highly specific receptor in muscle tissue
• ↑ function when Vitamin D levels >40 nmol/L
• Deficiency:
  – Muscle weakness & pain
  – ↓ mobility & ↓ walking distance, ↑ fall risk
  – Difficulty in mounting stairs/rising from chair
  – Increased body sway

Bischoff-Ferrari 2004
Prevention of Nonvertebral Fractures With Oral Vitamin D and Dose Dependency

A Meta-analysis of Randomized Controlled Trials

Heike A. Bischoff-Ferrari, DrPH; Walter C. Willett, DrPH; John B. Wong, MD; Andreas E. Stuck, MD; Hannes B. Stachelin, MD; E. John Orav, PhD; Anna Thoma, MD; Douglas P. Kiel, MD; Jana Henschkowsky, MD

**Conclusion:** Nonvertebral fracture prevention with vitamin D is dose dependent, and a higher dose should reduce fractures by at least 20% for individuals aged 65 years or older.
Other Benefits

• Cancer Prevention
• Reduce risk of cardiovascular disease
• Positive effects on immune responses
• Reduce Mortality
Vitamin D Protocol for Residential Care

**Inclusion Criteria:** All seniors 65 years and older living in residential care facility

**Exclusion Criteria:** Those with hypercalcaemia and/or severe renal failure (GFR<20ml/ min)

**Dosage:** 2x 10,000 IU/week, no loading dose
Risk of Harm

*Upper tolerable limit

Vitamin D daily dosage

2,000 IU

2,858 IU

4,000 IU*

10,000 IU*

Osteoporosis Canada

fraserhealth

INSTITUTE OF MEDICINE
OF THE NATIONAL ACADEMIES

THE ENDOCRINE SOCIETY®
The vitamin D protocol will be initiated by the physician by completing and signing the vitamin D pre-printed order:

- within the first 6 weeks of a resident moving in
- at first care conference
Vitamin D Protocol
Tool Kit

Vitamin D: A Proven D-fence

Background
Vitamin D is an important factor in maintaining strong bones and muscles. It’s not uncommon for Vitamin D levels to decrease with age, especially when less time is spent in the sun, which is one of the main natural sources of Vitamin D. Taking Vitamin D supplements is therefore a positive way to boost Vitamin D levels and strengthen muscles and bones.

Frequently Asked Questions

How does Vitamin D work to reduce the risk for falls and fractures?
Vitamin D has been shown to have a positive effect on strengthening muscles which play an important role in balance and mobility. It also helps maintain healthy bones for assisted with the absorption of calcium into bones.

Are there any other health benefits of taking Vitamin D supplements?
Low levels of Vitamin D have been linked to many serious chronic illnesses, including heart disease, multiple sclerosis, cardiovascular diseases, some cancers and diabetes.

Are all residents eligible for Vitamin D supplements?
Vitamin D supplements are available to residents, as long as the physician determines it is appropriate. Some residents with certain medical conditions may not be eligible.

Does everyone receive the same dose?
You, as a resident, will be prescribed a single daily dosage of 1000IU to 2000IU of Vitamin D, as per your physician.

What form does the supplement take?
The supplements come in tablet form. However, if swallowing becomes an issue, liquid or chewable forms are also available.
## Cost of Vitamin D

<table>
<thead>
<tr>
<th></th>
<th>Weekly Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraser Health Operated</td>
<td></td>
</tr>
<tr>
<td>Residential Care Facilities</td>
<td>$0.42</td>
</tr>
<tr>
<td>Health Service Providers for Residential Care</td>
<td>$0.50</td>
</tr>
</tbody>
</table>
Effectiveness and Safety of A High Dose Weekly Vitamin D (20000 IU) Protocol in Older Adults Living in Residential Care

<table>
<thead>
<tr>
<th>(n=236)</th>
<th>Mean (95% CI)</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum 25 hydroxyvitamin D, nmol/L</td>
<td>102 (98, 106)</td>
<td>-</td>
</tr>
<tr>
<td>&lt; 40</td>
<td>-</td>
<td>7 (3)</td>
</tr>
<tr>
<td>&lt; 50</td>
<td>-</td>
<td>15 (6)</td>
</tr>
<tr>
<td>&lt; 75</td>
<td>-</td>
<td>45 (19)</td>
</tr>
<tr>
<td>≥100</td>
<td>-</td>
<td>100 (52)</td>
</tr>
</tbody>
</table>
Safety Superheroes Program
-an intergenerational approach to fall prevention-

SAFETY SUPERHEROES
Preventing Grandparents From Falling

Crystal Stranaghan & Izabela Basmuk

Created to help kids and families learn how to keep their grandparents and loved ones safe from falls

a project brought to you by:
Our school program features interactive workshops as well as a variety of different learning tools that can be used to check for understanding and challenge students to apply what they’ve learned at home and out in their local communities.
Safety Superheroes Program
—an intergenerational approach to fall prevention—

• 30 volunteers trained
• 13 delivered the program

Burnaby Falls Prevention Society

• 9 elementary schools
• 62 classes (grades K – 5)
• 1290 students participated
Acknowledgments

Injury Prevention and Mobility Laboratory

SFU

CIHR IRSC

Centre for HIP Health and Mobility

technology for injury prevention in seniors tips
Fabio.feldman@fraserhealth.ca
www.sfu/tips
www.agingisacontactsport.com
www.safetysuperheroes.ca