Fall Cushion for Hip Fracture Prevention

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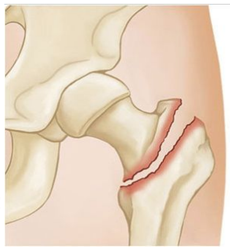
INTRODUCTION

Background:

- 54 million older Americans (65+) are currently at risk of intertrochanteric hip fractures (IHF) resulting from a fall[1]
- 300,000 older individuals are hospitalized each year for hip fractures[2]
- IHF causes a $2.63 billion economic burden on the American healthcare system[1]



Intertrochanteric hip fracture[5]

Problem / Gap:

- Devices that prevent fall injuries like grab bars and fall mats are dependent on location
- Wearable fall injury prevention devices like TangoBelt[3] and Hip'Guard[4] can be noticeable, expensive, and uncomfortable

Grab Bar[6]

TangoBelt[3]

Needs statement:

To reduce occurence and injury extent of **hip fractures** among those who are at **risk of falling**, particularly in the **elderly community**, by creating a comfortable, unobtrusive **fall cushion** that is affordable, aesthetically pleasing, and user-friendly.

PROPOSED SOLUTION

Final Design:

- Discreet undergarment with attached inflatable airbags
- Nylon horseshoe-shaped cushion for maximum diversion of force from hip joint
- Fanny pack containing canisters, electronics and gyroscope / accelerometer sensors
- Reusable & washable girdle

Figure 1: CAD Model of Complete Device Assembly

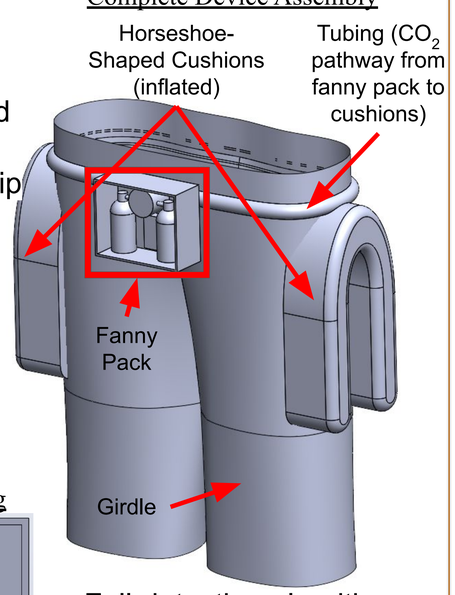
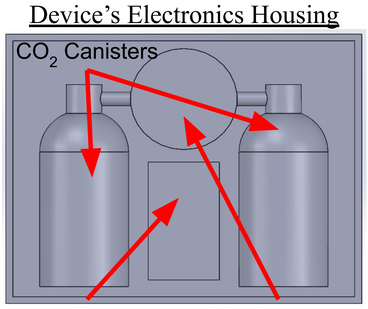


Figure 2: CAD Model of Device's Electronics Housing



- Fall-detection algorithm signals a solenoid valve to open
- Canisters with compressed CO_2 release gas through tubing into the airbag cushions

INFLATABLE CUSHION TESTING

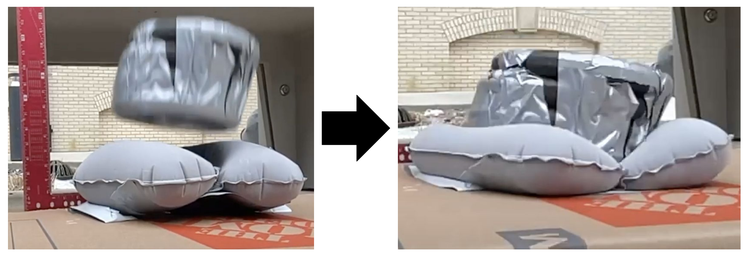
Pressure Testing:

- Used a manometer while the CO_2 canister discharges to measure the pressure while the device is inflated
  - Pressure range reached in cushion: 1.1-1.4 PSI

Impact Testing:

$$Impact\ Force = \frac{mass * gravity\ acceleration * height}{distance\ traveled}$$

- Used the force work equation to calculate that a 45lb plate dropped at 0.7m produces a 5200N impulse
  - 5200N is the median value of the femoral force in an unexpected sideways fall for an average person[7]



- 2.39 in avg. cushion compression at operating pressure
  - Cushion did not leak or lose air pressure after 6 consecutive trials
  - Cushion did not pop after pressure and impact testing

Table 1: Average Compression of the Hip Analog (Silly Putty Ball) With and Without Air Cushion Present

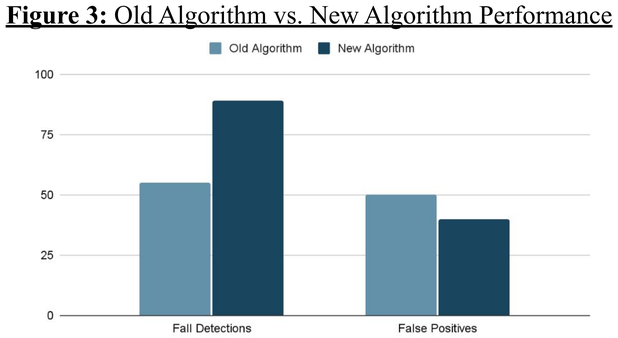
Test Group	Mean Compression of Silly Putty (in)
Control (without cushion)	1.25 ± 0.90
Experimental (with cushion)	0.39 ± 0.15

ELECTRONICS & LATENCY TESTING

Accurate Fall Detection Testing:

- How often does the algorithm detect a fall correctly?
  - The current fall detection algorithm can detect falls accurately, 80% of the time (16 times out of 20 trials)

Figure 3: Old Algorithm vs. New Algorithm Performance



Latency Testing:

- Due to limitations in junction strength, latency from detection to inflation had to be estimated
- Once air valve was opened, the cushions inflated within 2-3 seconds
- Once a fall is detected, the algorithm takes approximately 5 milliseconds to send the signal to the solenoid
  - Response is limited by the baud rate of 9600ms for the microcontroller

GENERAL FEASIBILITY

Cost:

- Manufacturing costs estimated at about $87.15/unit
- Cost to customers is predicted to be less than $200
  - Hip'Guard priced at $800[4]
  - TangoBelt priced at $1500[3]

Table 2: Cost to Produce 100k Devices Annually (per unit)

Components	$87.15
Assembly (labor)	$20.00
Quality Assurance and Testing	$5.00
Total	$112.15

Reimbursement:

- Fall prevention devices (both our device and our competitors) are not listed on the covered medical devices list from the Centers for Medicare and Medicaid Services[8]

Patentability:

- US Patent US5500952A is a "Hip Inflation Protection Device" we believe resembles our project[9]
- Key differences between this device and our own include that our device is **not a belt** and does not include a pleated, folded cushion that expands

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