SHEAR THICKENING FLUID BASED PROTECTIVE FOAM PADDING

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INTRODUCTION

Unintentional falls are the leading cause of non-fatal injury in almost all age groups (CDC, 2002). These episodes may result in bone fracture, bruising, and/or swelling of the impacted region. In older adults, hip fractures resulting from falls are common and present a significant public health problem due to the difficult recovery and increased risk for secondary health issues.

Previous research has shown that protective padding is effective at reducing the peak force on the hip at impact (Kannus, et al., 1999; van Schoor, et al., 2006). Two types of pads exist currently – those with a hard shell (energy shunting) and those that are soft (energy absorbing). The hard pads have been shown to be more effective in decreasing impact forces, but these pads are often bulky and uncomfortable which reduced patient compliance. An ideal solution is one that combines the comfort of a soft pad with the protective properties of the hard shelled pad.

Shear thickening fluid (STF) is a material that is fluid in its resting state, but hardens once force is applied to it. The purpose of this project was to determine the effectiveness of combining the properties of the shear thickening fluid with soft padding (closed cell foam) in attenuating impact forces.

METHODS AND PROCEDURES

A drop weight impact tester was used to measure the impact force of a 2.5cm round, flat cylinder as it was dropped from 15.9 cm above the sample. The impact tester was fitted with weights totalling 13.4 kg. The load cell in the impact head transmitted information to the computer during the impact tests.

A steel plate served as the base upon which the samples were placed and impacted. Four layers of rubber matting (total 14mm thickness) were placed between the plate and sample (Figure 1). The rubber matting was placed under the sample to represent force attenuation that would occur due to the presence of soft tissue in a typical biological system.

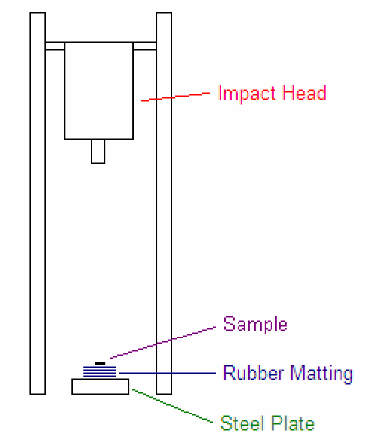

Figure 1. Instrumentation set-up for impact tests.

A calibration run was performed by dropping the impact head directly onto the rubber matting. Following the calibration run, neat foam, a packet filled with STF, a foam/STF combination, and a HipSaver pad were tested.

The foam/STF combination samples were 0.95cm thick foam pads with STF inserted into vertical holes that had been punched into the foam. Holes were placed in a hexagonal pattern using a standard 1/4" diameter punch, approximately 1/4" apart.

The packet filled with STF was constructed to be the same thickness as the neat foam and foam/STF combination samples.

Peak impact force and loading rate data was analyzed using custom LabView software. Due to small sample sizes, only descriptive statistics were run. Averages of 2 trials of each type of sample are reported.

RESULTS AND DISCUSSION

Peak impact forces and loading rates from tests run with no sample, neat foam, STF packet, foam/STF combination, and the HipSaver are shown in Table 1.

The lowest peak impact forces were recorded during the STF packet trials. While this is promising, the weight and form of the STF packet is prohibitive to consideration as a protective product on its own.

The foam/STF combination performed similarly to the HipSaver, a commercially available soft hip protection device. The key advantage to the foam/STF combination is the thickness, or lack thereof. The force attenuation properties of the HipSaver were achieved by a much thinner pad. As previously stated, people are more likely to make use of protective padding if it is comfortable and unobtrusive.

Typical soft hips pads attenuate impact force by absorbing energy. By filling holes in soft foam with STF, impact forces can be absorbed by the foam, while energy is also used by the fluid to harden, thereby transmitting less energy (and force) to the biological tissue underneath the pad.

Although the foam/STF combination did not result in drastically lower forces than the HipSaver product that is currently available, the results were promising. Future projects will focus on developing the current technology to be even more effective at decreasing impact forces in a variety of settings.

REFERENCES

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Table 1. Results from all samples tested. *Weight of HipSaver is approximate as the actual sample is much larger in area than the other samples. This weight is proportionate according to the area of our other samples.

Sample	Thickness (cm)	Weight (g)	Peak Force (kN)	Loading Rate (kN/sec)
Rubber Matting only	N/A	N/A	6.56	.88
Neat Foam	.95	6.6	4.93	.52
STF packet	.95	69.9	3.29	.31
Foam with STF	.95	19.9	3.85	.37
HipSaver	1.5	20.69*	3.89	.37