CLINICAL PAPER SUMMARY

Impact attenuation of commercial hip protectors: design parameters driving performance

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INTRODUCTION

Hip fracture is a serious concern and major driver of hospital care for the elderly population with incidence rates greater than heart attack, cancer, or stroke (Roche et al 2005). The 30 day mortality rate for such injuries has been reported anywhere between nine to sixty-five percent based on comorbidities and surgical complications (Moran et al 2005). Upon observation of long-term outcomes, a recent investigator reported women were twice as likely to die four years after surgery compared to those who did not experience the injury (Empana et al 2004). Hip protectors, or shields, have been shown as an effective prophylactic method to mitigate the risk of hip fracture in the elderly population (Kannus et al 2000) with a reported decrease of approximately 50%.

The drive to provide an ever-decreasing sized shield has led to controversy over the design parameters driving impact performance and the establishment of standardized methods to test and evaluate new protection technologies (Robinovitch et al 2009).

The motivation behind this study was to determine contributing factors in the design of the hip protector shields that would aid in the effectiveness of attenuating the impact force, while investigating design parameters that may affect compliance.

MATERIALS AND METHOD

Five commercially available hip protector shields (Impactwear™, HipSaver™, Fall-Safe™, SAFEHIP™, Posey Hipsters™) were tested. Five shields of each design were tested for a total of 25 shields. All shields used in this study were made of soft materials. Shields were tested using a combination of previously recommended guidelines (Robinovitch et al 2009 and van Schoor et al 2006) utilizing a surrogate femur (Sawbones Inc) and soft tissue (CF45 CONFOR blue foam). All shields were tested at the impact force (5kN) and at five positions around the shield (center, 5cm proximal, 5cm distal, 5cm anterior, 5cm posterior). For each shield the peak impact force, and % attenuation (peak force of shielded impact divided by peak force of unshielded impact) were determined. The following design parameters were evaluated: height, width, area, thickness, and weight. All statistical analysis was performed with standard commercially available software JMP v5. Mean and standard deviation for all outcome measures were calculated for each design group. Multivariate linear regression modelling was utilized to test for specific design parameters influence on impact performance.

RESULTS

As shown in Figure 3 Shield A exhibited the smallest area footprint, height, thickness, and weight of all designs. Shield D exhibited the largest area footprint and height. Shield B exhibited the largest thickness. Shield C exhibited the largest width. At the 5kN level the means of all Shields were below one standard deviation below the IHPRG recommended threshold as shown in Figure 4. Evaluating each design parameters influence on impact performance revealed the area (or footprint) of the shield was the most significant predictor of performance at the 5kN impacts.

At the 5kN level, it was found that for every 100cm^2 increase in coverage area the peak force decreased by 100 N and the impact attenuation increased by 2%.

SHIELD	Area (sq. in.)	Height (in.)	Thickness (in.)	Weight (oz.)	Width (in.)
A	28.99	6.15	0.47	2.16	6.93
B	38.68	7.00	0.72	3.82	5.54
C	44.15	7.52	0.64	2.70	7.48
D	44.22	7.67	0.71	3.27	6.72
E	29.57	6.65	0.54	2.63	5.66

Figure 3. Design parameters of 5 tested shields.

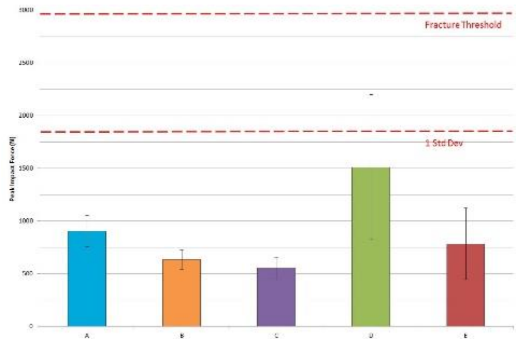

Figure 4. Peak impact force for each shield design during 5kN. All data is represented as mean +/- standard deviation. Fracture thresholds and subsequent standard deviation are annotated in red.

CONCLUSIONS

According to previous research the mean fracture force threshold for an older female (age 80) is about 2,800 N (Robinovitch et al 2009). Our results indicate that all currently available shield technologies perform below this threshold when evaluated using commonly accepted methods for testing and evaluation.

We observed one shield (Shield A) was the smallest, lightest, and thinnest shield of all the designs evaluated. This same design exhibited impact performance at levels similar to other larger, heavier, and thicker designs. Aesthetics and comfort are paramount for effective adoption of hip protection technology amongst its users but cannot sacrifice biomechanical performance. Out of the 5 shields evaluated during this study, Shield A was found to combine design parameters that could best assist in improving compliance while biomechanically comparable to its competitors.

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