Interpretation of Biomechanical Testing of HipSaver® Dual-mechanism Shunting/Absorbing AirPad

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Background: HipSaver pads were tested at the Harvard affiliated laboratory in 1996 and found to offer 10% better impact attenuation than SafeHip® (SafeHip is the product resulting from the initial research efforts as reported in *The Lancet* 1993 341:11-18). Since then HipSaver has researched a variety of materials with various attributes for potential incorporation into the HipSaver product. In August 2000, the selected construction (HSPE4 12.7mm) was sent to the Tampere University of Technology Applied Mechanics Laboratory for impact testing on a mechanical hip system. The research group affiliated with this laboratory is currently most active in the development and biomechanical testing of hip protectors and has several published reports on the subject.

HipSaver Pad Construction: HipSaver encloses a 1/2" (12.7mm) thick damping foam material in a waterproof/air tight pouch. The pads taper down to 1mm at the edge. The pouch is either RF or heat sealed around the perimeter. Pad diameters are 6.5 to 7.5 inches. These pads are sewn into polycotton underwear so as to overlie the trochanters.

Test Results: The test system and protocol are identical to that reported in *Bone* 1999 Aug. 25(2):229-35 (abstract enclosed). The pad being tested is affixed to a surrogate hip bone and then impacted by a swinging pendulum. Load cells capture the amount of force on the system. The test report on HipSaver shows the HipSaver pad (HSPE4 12.7mm) lowered a typical falling force of 7200N to below the fracture threshold of 3100N +/- 1200N. The following table compares the results from the HipSaver test to other pads tested in the *Bone* report (using the identical system and protocol):

Pad Id.	Description	7200N Fall Force Reduced to
KPH2	35mm height, polyethylene shell	760N
SafeHip	25mm height, polypropylene shell	2240N
Saftypants	20mm thick, low density polyethylene (soft)	2270N
HipSaver HSPE4	12.7mm thick, urethane foam in pouch (soft)	1790N

Conclusion: Only KPH2 and HipSaver reduced the applied force clearly below the fracture threshold of 3100N (+/- 1200N). A lower value on this test indicates better protective capacity since the values represent force REDUCTION. The above shows HipSaver to offer 20% more attenuation than Safehip.

The Damping Foam Absorbs the Shock and the Displaced Air Redistributes the Forces in the AirPad:

Although the HipSaver pad has the lowest profile (thinness) and is the softest, it performed remarkably well when compared to the stiffer and thicker pads. This result stems from the fact that the airtight pouch renders an “energy shunting” or diverting effect on the applied force: the initial impact is absorbed by the urethane foam and the displaced air from the foam inflates or distends the surrounding pouch. Hence, much similar to automotive air bag, the force is redistributed over a larger and softer area. This inflation effect can be demonstrated by pushing a HipSaver pad with the heel of the hand and observing the distention of the pouch. The HipSaver pad is thus a dual mechanism “shunting/absorbing” air pad.

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Trochanteric pad tests **HipSaver®**

Two thicknesses of the hip protector type HSPE4 were tested. The thickness of the thinner model was 8.4 mm, the thicker one was 12.7 mm. These pads were enclosed in waterproof nylon and polycotton knit material. These pad tests were performed at the midrange force of 7230N as per the protocol and the testing system described in ***Bone*** 1999 Aug. 25(2):229-35. The above-mentioned force was attenuated by soft tissue to the value of 5600 N, which match the average peak hip impact force measured in the muscle-relaxed state during in vitro falling tests (Robinovitch et al. 1991). Pad named PE30 (thickness 20 mm) was used to simulate the soft tissue and that pad was changed after every impact for a new one. Six impact tests were done for every pad type. Then the force measurements were filtered and evaluations of averaged peak values and standard deviations were calculated to get the maximum compressive impact forces as seen in Table 1. Typical time-dependent test curves of both thicknesses are seen in Figure 2.

Table 1 Averaged trochanteric impact forces and their standard deviations.

Speed	Energy	HSPE4 8.4 mm		HSPE4 12.7 mm	
1.9 m/s	74 Nm	Mean kN	Std kN	Mean kN	Std kN
		2.51	0.071	1.79	0.067

Description of facilities and the calibration

The data acquisition system is based on Microstar Laboratories Data Acquisition Processor DAP 3200A. The DAP 3200A has the DPL operating system.

The acquired data were analyzed by Matlab, which is used to numeric computation and visualization. The Matlab is a trademark of Math Works.

The sampling time was 10 µs. The number of acquired points was 1500 for each test curve. Known pads were used to see the same impact force level as reached in the tests earlier. The test system is seen in Figure 1.

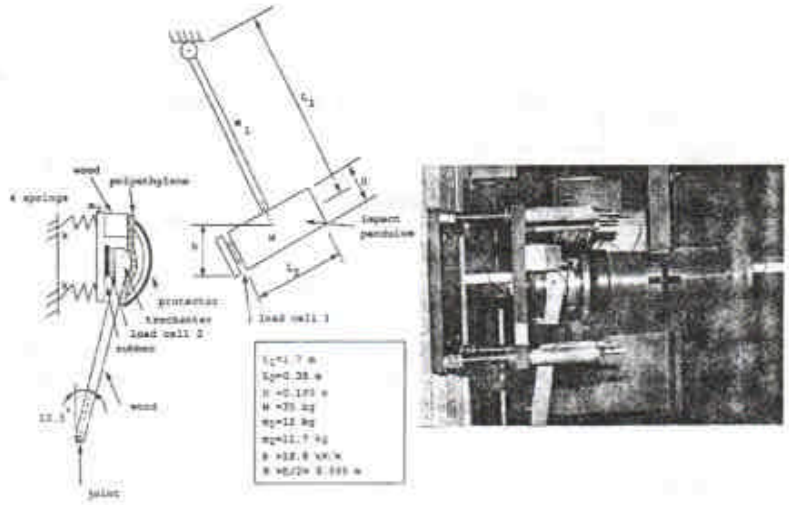

Figure 1 The hip protector testing system.

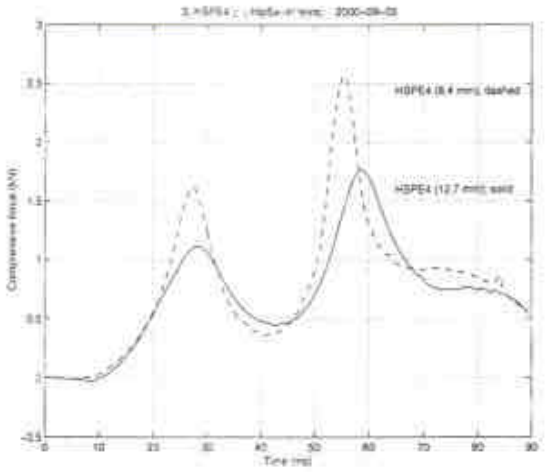

Figure 2 Test curves for the third impact of HSPE4 pf the both thicknesses.

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