Measuring the Shock Attenuation Properties of Skateboarding Shoes

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Introduction

Impact forces on the feet in skateboarding can be much higher than in more traditional sports. In a typical two-footed, bail-out landing, skateboarders experienced impact forces averaging 8282 +/- 1913 N (Determan et al., 2004). These large forces help explain why a large proportion of injuries (50%) affect the lower extremity in skaters (Forsman and Eriksson, 2001).

The most common method for testing the shock attenuating properties of athletic footwear is ASTM F1614, which specifies impact energy of 5.0 ± 0.5 J. However, our research on the kinetics of landings in skateboarding (Determan, et al. (2004)), allows us to estimate that the impact energy generated by skateboarders can be as high as 40 to 50 J. To better understand the real world shock attenuation properties of skateboarding shoes, we set out to develop a more realistic and representative impact testing method.

Methods

Four different skateboarding shoes were chosen for testing in our experiment: two cupsole shoes and two vulcanized shoes. Shoe A consisted of a cupsole shoe with a standard 10 mm thick EVA foam (55 Asker C) midsole. Shoe B consisted of the same type of cupsole shoe, but the EVA foam was replaced with a special cushioning device that combined a dilatant mesh material completely encapsulated in a solid viscoelastic gel material. Shoe C consisted of a vulcanized shoe with a 10 mm thick rubber latex foam (45 Asker C) midsole. Shoe D consisted of the same type of vulcanized shoe, but the rubber latex foam was replaced with the same cushioning device used in the Shoe B.

Each shoe was tested on two different impact testers. The first impact tester was a gravity-driven device (Exeter Research, Inc. CompITS) that conforms to ASTM F1614-99 and drops an 8.5 kg missile from 50 mm to create impact energy of 5.0± 0.5 J. The CompITS missile terminates in a 45 mm diameter cylindrical missile head that is flat-bottomed. This standard test was chosen because it is the most common method used to evaluate the cushioning properties of athletic footwear. Our protocol for this *low impact* test called for 25 conditioning pre-impacts followed by 10 measured impacts.

After the shoes were low impacted they were taken to a second *Hi-Impacter* that was a custom-built gravity driven machine that dropped a 7.25 kg missile mass from 605 mm to create an impact energy of 44.0± 0.2 J when maximum midsole displacement during impact is included. We arrived at 44 J of impact energy by examining kinetic and kinematic data of skateboarder's bailing out found in previous internal research. The *hi-impacter* missile mass terminated in a 45 mm diameter cylindrical missile head with a 38 mm radius, curved base. The curved missile base more closely mimicked the natural shape of the base of the human heel when loaded. Each shoe was impacted 3 times on the *Hi-Impacter* after pilot research revealed little or no change in test results during impacts 4 through 10.

Results

Force vs. Displacement graphs and summary impact results for each shoe can be found below in Figure 1 and Table 1 respectively. Shoe A performed the best under low impacts, while shoe B performed the worst. Shoes C and D performed similarly. Under high impacts, Shoe B scored the best followed closely by shoe D. Shoe A performed the worst under larger impact energy. Maximum displacement, (Max.

Disp.) i.e. the compression of the insole-midsole-outsole under low impacts ranged from 34.7 to 41.5%; while displacements under high impact ranged from 71.5% to 85.7%.

The special cushioning device used inside shoes B and D appeared to enhance shock attenuation compared to shoes A and C. With the insert in the EVA cupsole shoe (B) there was an 18% reduction in impact force, while using the insert in the vulcanized shoe (D) resulted in a 2.6% reduction.

Table 1. Impact results for 4 different shoes on the Low-Impacter (LI) and Hi-Impacter (HI).

Shoe	Thickness (mm)	Peak g, LI (g)	Peak g, HI (g)	Force LI (N)	Force HI (N)	Max Disp. LI (%)	Max Disp. HI (%)
A	21.3	18.4	152.2	1,534	10,825	37.8	78.4
B	22.1	23.7	125.0	1,976	8,890	34.8	71.5
C	19.4	21.9	131.0	1,826	9,317	41.5	85.7
D	22.6	21.3	127.6	1,776	9,075	34.7	75.1

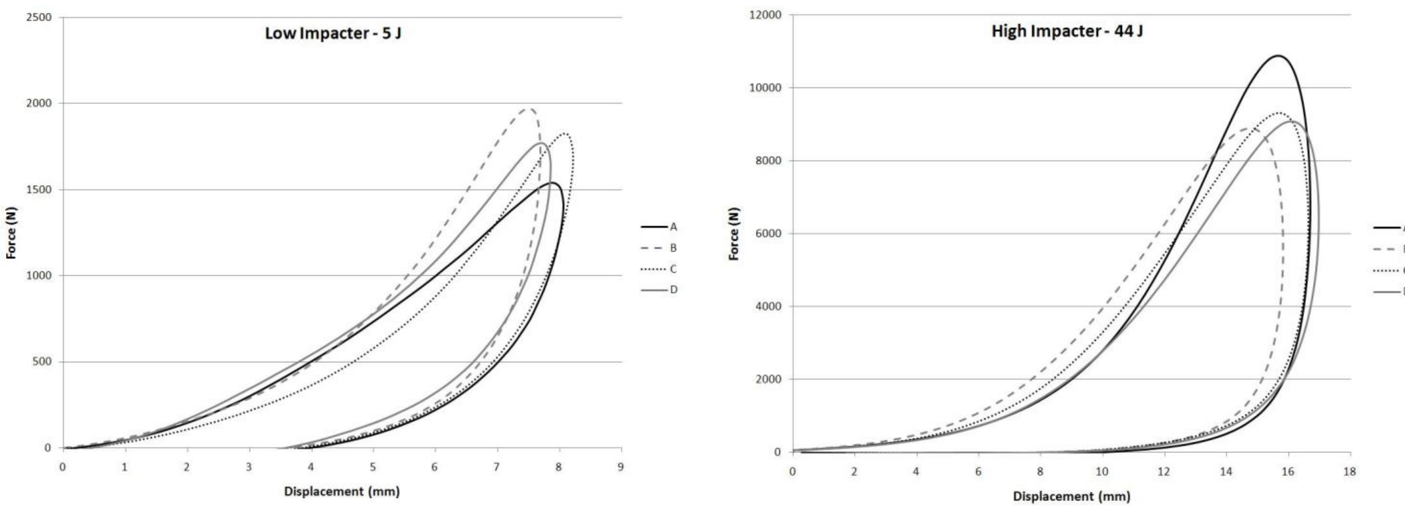

Figure 1. Force (N) vs. Displacement (mm) curves for 4 different types of skateboard shoes under low (5.0 J) and high (44J) impacts. NB: The scale on the vertical axis is not the same for both graphs

Discussion and Conclusions

The two impact test methods told distinctly different stories. The shoe that responded best to 5 J impacts performed the worst under 44 J impacts. Conversely the shoe that performed worst under 5 J impacts did the best under 44 J impacts. Therefore, caution should be used when applying conventional low impact energy testing results to all athletic footwear regardless of sport. Testing methods and standards such as ASTM F1614 may be appropriate for low-load activities such as walking or running, but provide a poor indicator for shock attenuation capability for higher-impact sports such as skateboarding. A new test method should be developed for evaluating the shock attenuation properties of footwear for sports where athletes experience relatively high impact forces to their feet.

References

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