BICYCLE HELMET PERFORMANCE OVER A WIDE RANGE OF IMPACT SPEEDS

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INTRODUCTION
Helmets reduce the frequency and severity of head and brain injuries resulting from bicycle crashes by attenuating head acceleration and distributing the impact force. The effectiveness of helmets in mitigating injury has led to laws requiring certified bicycle helmet use in many jurisdictions.

Modern certified helmets generally consist of an expanded polystyrene (EPS) energy absorbing liner covered with either a thin (traditional style) or a thick (BMX/skate style) outer shell. Traditional helmets are typically certified to bicycle helmet standards, while BMX/skate helmets are certified to bicycle, snow sport, and/or skateboarding helmet standards. Some helmets are not certified to any standard.

Bicycle helmets are typically tested only under the conditions stipulated by one or more standards. In actual impacts, however, helmets are subjected to many different types of impacts. This study investigates the impact attenuation performance of various bicycle helmets over a range of impact speeds at, above and below those specified in the standards.

METHODS
Twelve helmet models were tested: six traditional and six BMX/skate style. Ten of the helmets had EPS liners and were certified to one or more of the CPSC, Snell, ASTM, CE-EN or AS/NZS standards. Two of the BMX/skate style helmets were not certified and had either a soft 2-stage foam liner or a Brock® foam liner.

All helmets were size medium and fit the magnesium alloy headform (ISO J, Half Magnesium K1A, Cadex, Inc.). A 3.2m tall monorail and trolley system was used. The frontolateral aspect (i.e., the temple area) of each helmet struck a flat steel anvil. This impact location was below the test line typically used in helmet certification testing, but in a location we see many helmets hit in actual collisions. For impact speeds up to 7.7 m/s, the helmets were dropped from an appropriate height. Above this speed, an elastic slingshot was used to increase the speed of the helmet. To date, 105 impacts at speeds between 2 and 10 m/s have been conducted.

RESULTS
Peak headform acceleration increased with increasing impact speed (Figures 1 and 2). All of the helmets with EPS liners showed similar peak accelerations up to about 6 m/s—the typical impact speed of bicycle helmet standards. Above this impact speed, there was increased variability in the performance of the certified helmets. The peak accelerations of the two uncertified helmets (without EPS liners) diverged from the certified helmets at impact speeds in the range of 3 to 5 m/s.

Figure 1: Peak acceleration of the traditional bicycle helmets.
Figure 2: Peak acceleration of the BMX/skate style helmets.

DISCUSSION & CONCLUSIONS
This study compared the impact attenuation performance of various bicycle helmets at impact speeds of 2 to 10 m/s. Differences were observed between the certified and non-certified helmets, as well as between the basic and top-of-the-line traditional race helmets.

The two non-certified helmets performed poorer than the certified versions of these helmets, despite looking similar to a consumer. Neither of the two uncertified helmets would meet the impact attenuation requirements of any current bicycle, snow sport and/or skateboarding standards.

For the certified helmets, the thinnest and lightest helmets—often the most expensive helmets—provided less impact attenuation at the high impact speeds. These helmets appeared to be optimizing factors other than impact performance above the impact levels prescribed in the various standards.