

Quantifying Kinematic and Vibrational Responses in Hockey-Style Catcher's Mask

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Introduction:

Tipped foul ball impacts to catchers' masks are the leading cause of concussions in baseball, with Major League Baseball catchers experiencing a concussion rate of 3 per 100,000 athletic exposures. Catchers typically wear either traditional or hockey-style helmets with the mask made of steel or aluminum wire. Hockey-style helmets provide greater head coverage than traditional masks and manage impact energy with their shell and interior padding. Though these helmets can greatly reduce accelerations experienced, it has been observed that these types of impacts can excite the first resonant frequency of the head. This may partially explain why these concussions still occur.

Objective:

This study aimed to evaluate the kinematic and vibration responses of the head during direct catcher mask ball impacts and to assess whether the head's vibrational response can be attenuated with a floating mask design.

Methodology:

This study compared responses between a bare head, an unaltered catcher's mask, and five catcher's masks altered using different damping materials. Regulation high school baseballs were launched at 70 ± 3 mph, captured with a laser speed gate, by a custom pitching machine into a medium NOCASE headform mounted on a Hybrid III 50th percentile neck and a 16 kg sliding torso mass. The headform was instrumented with three linear accelerometers and a triaxial angular rate sensor with data collected at 20 kHz and low-pass filtered according to the SAE J211 CFC 1000 for linear accelerations and 180 for rotational accelerations. Three trials per mask condition and one trial per bare head condition were conducted. The modified mask used a floating mask with three 1.5 x 1 x 1-inch blocks of damping material at the forehead and one at the chin, which were attached between the mask and helmet. X-acceleration was analyzed as it is the dominant axis of loading for frontal impacts. Acceleration measurements were compared in the time domain as peak accelerations and in the frequency domain as the percentage change in the area under the curve between the frequency ranges 0-250 Hz and 250-2000 Hz.

Results:

The bare-head impact showed high oscillatory responses in the time domain, with a peak x-acceleration of 528 g and a resonance peak around 1000 Hz. The unaltered hockey-style helmet reduced peak x-acceleration to 28.5 g, but an oscillatory response was still present. Signal content above 250 Hz decreased 93.2-97.5% in the helmeted conditions compared to the bare head, and by 36.6-55.5% below 250 Hz. With damping materials, peak x-accelerations changed minimally, increasing by materials A, B, and C and decreased with materials D and E with an overall increase by 8.9% on average. All materials decreased signal content above 250 Hz by 57.5-63.5% compared to the unaltered helmet.

Conclusions:

Changes in mask design using certain damping materials may involve tradeoffs, such as increasing peak acceleration and low-frequency content while decreasing high-frequency content.

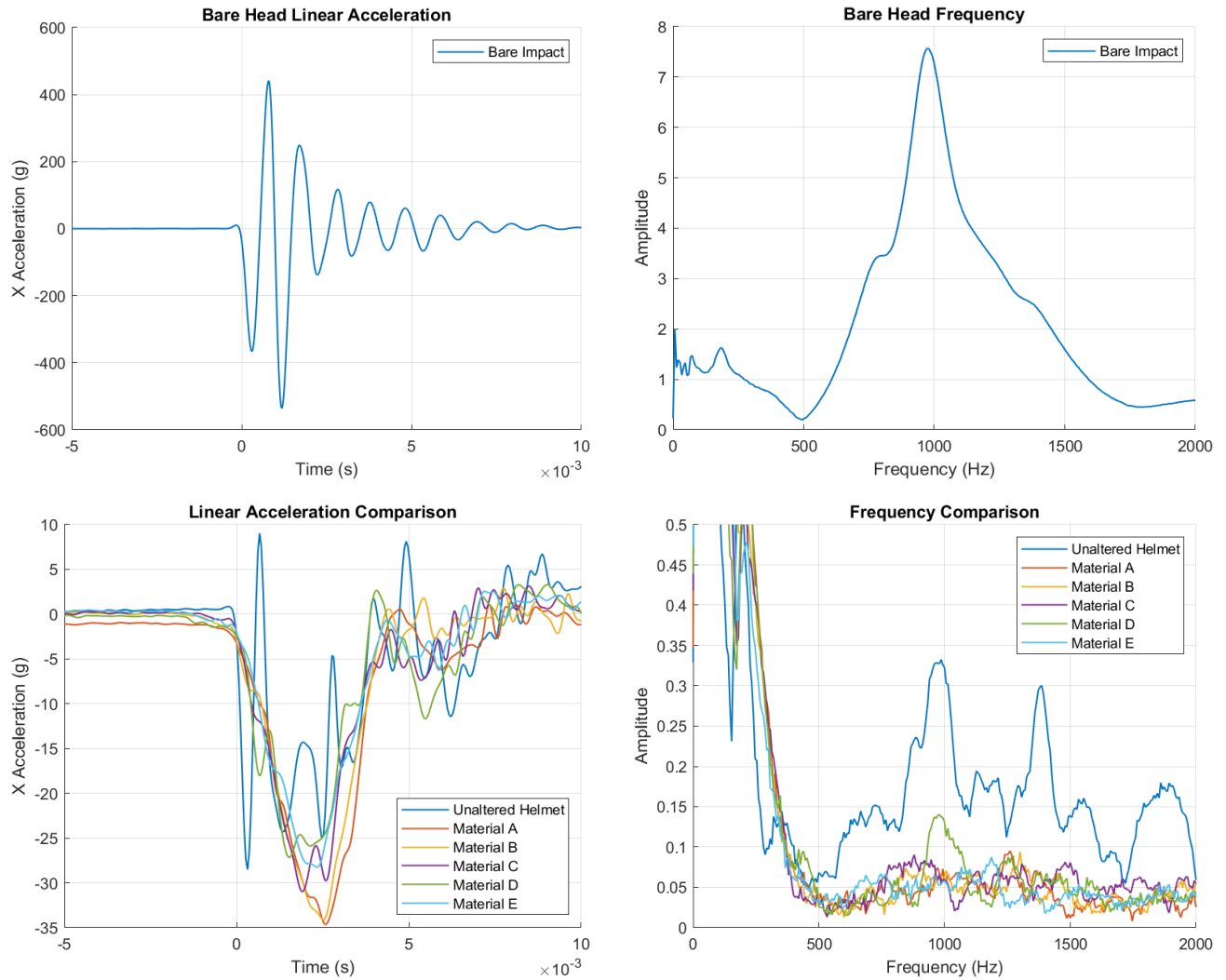


Figure 1 - Bare head impact acceleration and frequency response; Unaltered helmet and material add-on acceleration and frequency responses