Dynamically Modifying End Conditions in a Head-First Impact with a Novel Helmet can Mitigate Neck Injury Metrics: An Experimental Proof-of-Concept Investigation Using Mechanical Surrogates.

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ABSTRACT

Introduction and Objective

Head-first impacts in sports can cause cervical spine injuries and paralysis. Many sports require athletes to wear helmets. The study objective was to determine whether small amounts of induced head motion at impact through a novel helmet can mitigate neck injury potential in head-first impacts.

Methodology

A custom mechanical neck, head, and 'helmet' were used with a drop tower. The helmet model simulates head motion "escape" with two shells; an inner with chinstrap and outer connected through a passive guide mechanism and separated by 1". Upon threshold force development, the inner shell and head are guided into either flexion or extension. A replicated factorial experiment (N=36) was performed consisting of 3 platform angles {0, ±15°}, 2 padding stiffnesses, and 3 escapes {flexion ,extension ,none}. Each impact was imaged at 1000 fps and data signals acquired at 78 kHz. Peak lower neck axial reaction force and sagittal moment were used as injury metrics. Factorial anova with multiple comparisons was used for analysis.

Summary of Results and Current Conclusions

*Axial force: All main effects and interactions except angle*stiffness were significant ($\alpha=0.05$). Promising results are seen in the interaction between escape and platform angle. At -15° (platform is in 15° of extension from anatomic transverse plane causing anterior head translation), the mean peak neck force for the flexion escape was reduced by 27% ($p<0.0005$) from no escape. Similarly, at +15° the extension escape showed 56% reduction ($p<0.0005$). At 0°, flexion and extension escapes showed 40% ($p<0.0005$) and 19% ($p=0.001$) reductions. Sagittal moment: All main effects and interactions were significant. At -15°, both flexion and extension reduced peak moments by 69 and 72% ($p<0.0005$) respectively while at 0° and 15°, only flexion reduced moments by 63 and 34% ($p<0.0005$) respectively. A helmet capable of inducing head motion at impact can mitigate neck axial forces and sagittal moments in a head-first impact.*