Investigating Tuned Magneto-Rheological Reservoirs, Compression Systems, and Shear Thickening Fluids to Improve Mean Peak Acceleration as Measured by High-G Accelerometers in Hockey Headgear

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The prevention of concussion and sub concussive injury in helmeted activities are of great military, commercial, legal, and medical interest. A Summation of Tests for the Analysis of concussion Risk, is defined by mapping actual on ice impact data to pendulum-modulated impact conditions at different energy angles, locations, and accelerations. As defined by Virginia Tech STAR equation $\sum(L=1)^4 \sum(\theta=1)^3 [E(L,\theta) \times R(a,\alpha)]$. Linear(a) and rotational(α) acceleration are the only potentially modifiable risks in this equation. For this experiment, a four meter pendulum was closely replicated so interventions can be mapped back to actual player impact data. This year a multitude of protective systems were designed to potentially improve helmet safety. Interventions for this year include a threaded, compression spring design, and tuned magnetorheological systems along with the following Shear Thickening Fluids interventions (1) Calcium Carbonate/Water, (2) Fumed Silica/Polyethylene Glycol, (3) Colloidal Silica/ Polyethylene Glycol, and (4) Polyethylene Glycol(comparator). Helmet constructs were tested for their potential to decrease mean peak linear and rotational acceleration. The internal or external location of Shear Thickening Fluids were explored and confirmed to be an important factor in mitigating mean peak acceleration. When compared to the neat(control) helmets, interventions engineered in this experiment including shear thickening fluids, spring systems, and magnetorheological reservoir designs all significantly out perform ($p<.01$) a neat helmet. These findings point to a likelihood of a reduced concussion risk as a function of linear(a) and rotational(α) head acceleration values, when using these interventions.

Awards Won:

Intel ISEF Best of Category Award of $5,000

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