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Analysis of Combat Helmet Performance Integrating Blast Loading and Blunt Impact through Simulation

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The mild traumatic brain injury (mTBI) is one of the most common injuries to service members in recent conflicts. Combat helmets have been designed and evaluated to perform against ballistic and blunt impact threats, but not blast threats. An optimal design of combat helmet considering blunt, ballistic impacts and blast effects is a key requirement to improve the head protection against mTBI. Combat helmets are usually designed based on costly and time consuming laboratory tests. Computational models can offer insights in understanding the force transmission through the head-helmet system into the brain and underlying mechanism of brain injury, and help the development of effective protective design. The objective of this work is to develop a design approach integrating the effect of both blast and blunt threats to a helmet system by utilizing multi-physics computational tools and representative human head and helmet models. The high-fidelity computational models were used to capture the dynamic response of the composite shell, suspension pads, retention straps and head. We used a validated human head model to represent the warfighter's head. The helmet composite shell was represented by an orthotropic elasto-plastic material model. A strain rate dependent model was employed for pad suspension material. Available dynamic loading data was used to calibrate the material parameters. Multiple helmet system configurations subjected to blast and blunt loadings with a combination of loading magnitude and orientation were considered to quantify their influence on brain biomechanical response. Parametric studies were carried out to assess energy absorption for different suspension geometry and material morphology for different loadings. The resulting brain responses in terms of pressure, stress, strain, and strain rate as well as the head acceleration were used with published injury criteria to characterize the helmet system performance through a single metric for each threat type. Approaches to combine single-threat metrics to allow aggregating performance against multiple threats were discussed.

REFERENCES

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