Mechanical Engineering Master's Defense

Finite Element Modeling of Human Brain Response to Football Helmet Impacts

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abstract

The football helmet is a device used to help mitigate the occurrence of impact-related traumatic (TBI) and minor traumatic brain injuries (mTBI) in the game of American football. The current design methodology of using a hard shell with an energy absorbing liner may be adequate for minimizing TBI, however it has had less effect in minimizing mTBI. The latest research in brain injury mechanisms has established that the current design methodology has produced a helmet to reduce linear acceleration of the head. However, angular accelerations also have an adverse effect on the brain response, and must be investigated as a contributor of brain injury. To help better understand how the football helmet design features effect the brain response during impact, this research develops a validated football helmet model and couples it with a full LS-DYNA human body model developed by the Global Human Body Modeling Consortium (v4.1.1). The human body model is a conglomeration of several validated models of different sections of the body. Of particular interest for this research is the Wayne State University Head Injury Model for modeling the brain. These human body models were validated using a combination of cadaveric and animal studies. In this study, the football helmet was validated by laboratory testing using drop tests on the crown of the helmet. By coupling the two models into one finite element model, the brain response to impact loads caused by helmet design features can be investigated. In the present research, LS-DYNA is used to study a helmet crown impact with a rigid steel plate so as to obtain the strain-rate, strain, and stress experienced in the corpus callosum, midbrain, and brain stem as these anatomical regions are areas of concern with respect to mTBI.

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