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Game Changer: Linking computational brain injury metrics and concussion symptoms in American college football

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The escalating concerns surrounding head impacts and concussions in contact sports have spurred a multitude of research initiatives focused on building computational models to interpret the brain's response to an impact. A crucial aspect of our study involved calculating brain injury metrics, mainly focused on the tissue strain, to ascertain the severity of a head impact. We employ custom fit mouthguards to obtain kinematics of the skull and then use the kinematics as boundary conditions in personalized computational models of the brain. Using Penn State's Brain Simulation Research Platform, we can efficiently run large scale jobs and generate an array of injury metrics such as strain and strain rate for each impact.

Our study, primarily focused on the football team at Western Carolina University, has delved into the relationship between these computational metrics and real-world concussion symptoms. We establish baseline cognitive measurements for each player using ImPACT, an FDA-approved tool, before tracking them through games and practices. Each identified head impact over 30Gs was followed by an immediate cognitive test using ImPACT again, to detect any changes in cognitive abilities. Parallel to these tests, the recorded acceleration traces from the mouthguard were incorporated into our brain simulation to compute metrics for that impact.

The brain simulation research platform is a brain modeling service capable of computing results for thousands of head impacts parallelly. The platform is built on Amazon Web Services (AWS) and uses a custom nonlinear finite element code. This code is written in C and employs Message Passing Interface (MPI) to facilitate parallel computing. The code is open source and available on Github. The verification and validation results of this code have been presented at last year's conference and are openly available on the website.

The meshes used for the impact simulations are based on dimensions of a 50th percentile male or female head model. The brain models use a hyper-viscoelastic material formulation, while the surrounding skull was treated rigid. The metrics computed for each impact were various versions and combinations of strains and strain rates as they have been suggested to have some association with brain injury.

In correlating the results from the cognitive tests and the computational metrics, our study seeks to reveal any substantive associations that may exist between them. Our findings may suggest potential applications of computational models for diagnosing concussions in contact sports. We will present our preliminary results, providing a glimpse into how this research may shape concussion diagnosis and management in the future.