Helmet-to-helmet collisions: Scientists model how vibrations from football hits wobble the brain

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It's fall football season, when fight songs and shouted play calls fill stadiums across the country. Another less rousing sound sometimes accompanies football games: the sharp crack of helmet-to-helmet collisions. Hard collisions can lead to player concussions, but the physics of how the impact of a helmet hit transfers to the brain are not well understood. A research team from the U.S. Naval Academy in Annapolis, Md., has created a simplified experimental model of the brain and skull inside a helmet during a helmet-to-helmet collision. The model illustrates how the fast vibrational motion of the hit translates into a sloshing motion of the brain inside the skull. The researchers will present their findings at the 164th meeting of the Acoustical Society of America (ASA), held Oct. 22 – 26 in Kansas City, Missouri.

Murray Korman, a professor in the physics department at the U.S. Naval Academy, worked with his student Duncan Miller during the course of a semester to develop the experimental model. To simulate a side collision, the researchers hung one helmet from the ceiling with clothesline and swung the second helmet into the first, like a pendulum. Accelerometers mounted on the helmets recorded the vibrations before, during, and after the hit.

Figuring out simple ways to model a human head inside the helmets was a challenge, Korman notes. Human cadavers were out, and crash test mannequins were too expensive. After reading up on skull vibrations, the team settled on a wide plastic hoop, shaped like the skirt of a bell. "They say that when you get hit, you get your bell rung. No pun intended, but your skull does kind of ring like a bell," Korman says.

The researchers modeled the brain as a brass cylinder cushioned in a slot carved out of open-cell foam that mimicked fluid within the brain cavity. By choosing simple materials the researchers minimized the complexity of their set-up while retaining those elements needed to capture the essential motions of the brain and the skull. They found that their brass cylinder brain sloshed back and forth within the skull much more slowly than the rate of vibration of the initial hit. Building a model is important, Korman notes, because it can help determine how a measurable parameter, like the acceleration of a helmet during a hit, would translate into potentially damaging brain motion. "The ultimate damage comes when the brain hits the side of the skull," Korman says.

Korman says there is still a lot of work to do to improve the model. He hopes in the future to collaborate with biophysicists to incorporate more detailed knowledge of the material properties of the brain and skull. Ultimately, the model might be used to test new helmets designed to better protect the brain from hits. Korman describes futuristic helmets that might crumple on impact like plastic car bumpers, leaving the only bell ringing on the field to be done by the marching band.

More information: asa.aip.org/asasearch.html

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