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Brainstorm: Head Injuries and the NFL, Part 4: The Physics of Head Trauma

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One fine afternoon in the autumn of 2010, Minnesota Vikings defensive end Ray Edwards executed one of the most dangerous acts you can do in football: He *speared* another player.

The target in this case was Cowboys running back Marion Barber, who suddenly became laid out like one of T.S. Eliot’s etherized evenings.

I was horrified. Edwards had done other rough stuff that season, too, spear ing Seattle’s quarterback Matt Hasselbeck, Detroit’s Shaun Hill, and a few others. Edwards received a $20,000 fine for his hit on Barber.

What is *spearing*, and why did I react so strongly?

For the uninitiated, spearing is the act of hitting another player with the crown of one’s helmet. This can be hazardous, especially if that crown hits in the vicinity of another player’s skull. The head of the target receives the blow, bends back, snaps forward, bobbles.

Spearing can be excruciating to watch when cameras do instant slow-motion replays, especially if you are a brain scientist. Excruciating. And also instructive. In our quest to explain the biology of CTE (chronic traumatic encephalopathy), we are going to use spearing to describe the physics of closed-head injuries. We will start with the brain at rest. We will end with its owner on the sidelines, and maybe in the emergency room.

The brain at rest is normally “floating” comfortably in a salty sea of liquid we call cerebrospinal fluid. That’s good for our survival. The brain is a relatively vulnerable organ to outside forces, the consistency of gelatin. The fluid is there to cushion the brain from light trauma, the normal bumps and bounces of everyday life.

Being speared is not a normal part of everyday life, however. If a stationary player is suddenly, forcefully, hit from the left, the brain slams into the inner right side of the skull, then rapidly ricochets, crashing back against the inner
left. Two injuries are thus sustained, but on opposing sides of the brain, something we call a coutrecoup injury.

Sudden accelerations/decelerations are capable of generating forces potent enough to cause neural damage. Science recognizes three dangerous categories — linear, rotational, and angular — which on the football field usually occur in combination. The spearing example above describes a perfect linear injury, where the head is not rotating about an axis, but simply banging like a bell from one inner side of the head to the other. Most sports-related head injuries are not perfectly linear, however, and as such cause the brain to turn — to rotate — within the skull during the hit. With standard rotational injuries, the head spins around an axis through its center of gravity. Angular injuries are also rotational in nature too, but here the turning does not occur perfectly through the brains’ center of gravity, but at a contorted angle. These tend to be the most severe.

This means that not all head injuries are created equal. If we measure simple recovery time, that’s exactly what we see. The hits that usually take the shortest time to heal are somewhat linear front-to-back hits, usually called sagittal injuries. The hits that take the longest time are the side-to-side variety, called lateral injuries. The amount of damage may be subject to the severity of the generating force, though some researchers have called this seemingly obvious insight into question.

How does brain movement inside the skull result in brain damage? And why is everyone concentrating on repeated hits and CTE? Though this might be odd to say, the answers to both of these questions are not necessarily intuitive. But it does lie in our next installment, where we consider the more intimate consequences of Ray Edward’s behavior toward talented running backs.

Maybe you’ll be horrified, too.

Comments