

Concussed Transcript

When I was nine years old, I had my first and only concussion. While other kids got concussions on the sports field or in biking accidents, I managed to concuss myself in the stupidest, most trivial way possible. I remember being in the kitchen, standing on a basketball, and letting go of the countertop so I could drink a glass of milk. I came to several minutes later on the couch, discombobulated and scared. My grandmother, who was babysitting us at the time, wouldn't let me call my parents because, as parents of four young children, they rarely had a chance to go out together. We didn't even consider going to the doctor, so I spent that afternoon watching television and waiting for the headache to reside.

Though I'll never know the extent of my own concussion, I'm confident that I was lucky. After a few days, all the pain went away, and I've never had to think much about it since, except to tell it as a comic story about my idiotic childhood attempt to drink milk while standing on a basketball, surrounded by sharp cabinet corners. I'm also lucky because I've only ever had one concussion in my life. As we will soon see, repetition can be fatal.

Most of us are aware that concussions are dangerous to some extent- concussions have been a hot topic in the media with regards to the NFL, and the health concerns of professional football are trickling down into teenage sports as well. In fact, they just banned heading in soccer for children 11 and younger in California soccer leagues- my sister, who is ten, now gives the other team a free kick if she heads the ball. Today, I want to discuss the facts behind all of the hype around concussions, and what it is that made us suddenly realize how dangerous they are. What do concussions do to the brain, and is this different in teenagers? If you do think you've had a concussion, then what? How do you protect your brain without giving up sports or, for accident-prone people like nine-year-old-me, without wearing a helmet 24/7 for the rest of your life?

First, let's figure out what a concussion actually is, medically speaking. Growing up, I was always told that a concussion was when your brain hit the side of your skull, essentially bruising your brain tissue. In real medical circles, the term for concussion is actually "mild traumatic brain injury," or mTBI. A mild traumatic brain injury, despite its name, is not a mild type of brain damage- mild only means that the blow isn't fatal on impact. An mTBI is still a severe and serious injury to be taken seriously.

Your brain, under normal conditions, floats inside your skull in a substance called cerebral spinal fluid, which is about as dense as water. The outside of your brain is also covered in a spiderweb of veins, and the whole brain sits atop your spinal cord. When the skull receives a sudden force from outside, the skull often sharply rotates away from the force, or "snaps back" from the force.

This rotation causes the brain to move and twist in an unnatural manner, and can cause brain cells to get squeezed, stretched, or even torn apart. The brain can also collide with the rough interior surface of the skull, damaging neurons in the process. This type of damage is what we see with a concussion, or mTBI. Unfortunately, this kind of damage is hard to see using a CT scan or MRI, because those technologies cannot capture visuals of torn and stretched neurons. New technologies, like Positron Emission Tomography, or PET scanning, and Diffuse Tensor Imaging, or DTI, are showing promise for diagnosing concussions in the brain, but they are expensive and not widely available for public use yet.

So, in essence, the concussed brain is defined by stretched, squeezed, or torn brain cells. But what does this mean for our brain's functioning, in the short term and long term? If a concussion doesn't kill you, what does it do to your adolescent brain, and what makes it dangerous?

In the short term, a concussion might present a variety of different symptoms. It is often believed that a person must be unconscious after a head injury to have a concussion, but a person can maintain consciousness after the injury and still have an mTBI. Usually, a concussed person will either go unconscious or experience dizziness and confusion right after the injury, and few people can remember the moments leading up to and right after the concussive injury. A strong headache often follows a concussion, as do lightheadedness, fatigue, poor concentration, sensitivity to light and loud noise, and even anxiety and irritability.

Needless to say, if you experience any of these symptoms after a blow to the head, you should stop playing a sport immediately and consult a medical professional. Playing through a head injury is not only stupid, it's deadly. I try to be moderate on this podcast about risks, and I promise you that this is not an exaggeration. Studies on rats have shown that two minor concussions, 48 hours apart, combine to show the same level of damage as a severe traumatic brain injury, which can cause permanent disability or death. In rare cases, when two concussions follow each other in quick succession, something called second impact syndrome can happen, which causes the brain to swell, sending a sufferer into a coma and death, sometimes within minutes. And even if death and permanent disability are avoided, two concussions in succession can still lead to huge recovery times and cognitive deficits. The New York Times recently released an article about a high school football player who, instead of telling his coach that he felt concussed, continued to play. He received another blow to the head, and for three semesters he could not attend school without heavy doses of Ritalin (an ADHD medication) and a surrogate note-taker to transcribe lectures for him- he couldn't focus well enough to take his own notes. Anyway, I will end my diatribe here, but please, please, do not play through a head injury. If a second blow doesn't kill you, it will disable your cognitive functioning for months or years.

That aside, let's take a look at what happens in the brain itself in the moments, days, and weeks after a concussion. When the brain experiences a concussion, a flurry of chemicals are released and absorbed by neurons, and the whole brain goes into a sort of crisis mode. The physiology of a concussion is very complicated, with about a dozen chemicals involved and some of which I can't personally pronounce, but here's the gist: when our neurons get injured from a concussion, they release potassium, causing them to be out of chemical balance. The body, in response, then tries to pump potassium back into the neurons at a hyperactive rate. This pumping action takes up a huge amount of energy compared to normal brain functioning, and sends the brain into a sort of energy crisis. Once the cells are restored to chemical balance, the brain actually slows down its metabolism, or energy usage, to compensate for the huge amount of energy used to restore balance. The decreased metabolism of the brain can last up to four weeks after a concussion, during which time the brain is both vulnerable and cognitively impaired. During this whole process, calcium can also build up in our brain cells, often leading to cell death in the afflicted area.

So what does all of this mean for the way our brains work- the way we think and behave? Studies vary on the intensity and duration of cognitive impairments after adolescent concussions, but researchers seem to agree that working memory, attention, reaction time, and processing speed are all affected by a concussion. Research published in the *Journal of Neurosurgery* found that adolescents with concussions showed poorer speed-related brain functioning for a week after their concussion, in both reaction time and speed tasks. Another study, from the University of Oregon, tested both concussed and control teenage subjects on tasks of attention and cognitive flexibility, or the brain's ability to switch its focus from task to task. They tested their subjects after 72 hours, 1 week, 2 weeks, 1 month, and 2 months post-concussion. Even after two months of concussion recovery, the concussed teenagers still performed below their control counterparts. Finally, a study from the journal *Brain Injury* found that adolescents took up to 6 months to restore full memory capacity after a mild traumatic brain injury. It's important to recognize that these findings are all over the chronological map, and that we still have a lot to learn about the impact of concussions on the teenage brain. What's clear is that our cognitive functioning- our thinking and academic performance- are affected by concussions, perhaps for much longer than we would expect.

Interestingly, adolescents in high school also show longer recovery times for cognitive functioning than college students: a study at the University of Pittsburgh School of Medicine found that it took high school students an average of 7 days to recover critical memory functioning, while it took matched college students only 3 days to recover those capabilities. Concussions are dangerous in both cases, but it seems especially important to protect against concussions and repeated head injuries during the high school years. For a long time, scientists and doctors believed that adolescents could bounce back much more quickly from concussions

than adults because of brain plasticity. If our brains rewire so easily to absorb new information, then it followed that our brains should rewire to recover from concussion damage quickly as well. But neuroimaging has shown this to be false. If anyone should be cautious about concussions, it is my age group, the 15-19 year old range.

Obviously, concussions should be taken seriously. A concussion isn't just a bruise on your brain that heals itself up after a few days- it's a serious brain crisis, in which neurons are killed and whole areas of the brain go into energy crisis mode. Concussions impact our thinking and reasoning skills, and playing through an injury can result in exponentially more serious damage and even death. Ideally, we would all avoid concussions like the plague, but realistically, we can't. Many of us, myself included, are high school athletes that play contact sports. The prevalence of concussions is highest in boys' football, followed by girls' soccer, boys' lacrosse, boys' soccer, and girls' basketball. The reason why females get more concussions compared to boys in the same sports is somewhat unclear, but doctors believe it's probably a result of girls having weaker neck muscles and smaller skulls on average. About 300,000 sports-related concussions are reported among high school athletes each year, and this number is probably far smaller than the actual prevalence. Especially among male athletes, there is a tendency to deny or mask concussion symptoms and keep playing, so many male concussions go undiagnosed. And even if all concussions were diagnosed, 300,000 concussions a year is still a huge number. According to the National Federation of High School Associations, 7.8 million teenagers participated in high school sports in 2014. That means about 4 in 100 high school athletes is having a concussion each year, and that figure is probably closer to 15 in 100 for football players.

In a sports-dominated world, concussions happen. Getting rid of high school sports obviously isn't the answer; the benefits of exercise and team participation outweigh the dangers of head injuries. Nonetheless, as high school athletes, we do need to be aware of the risks and protective measures we can take with respect to head injuries. For all of us athletes, what questions should we be asking ourselves about the way we compete, and our futures as athletes?

First, let's talk about the safety equipment used to protect our skulls in sports. The most obvious example of such equipment is the football helmet, which has been a subject of huge debate in the last ten years. Football helmets were originally designed to protect the human skull from fractures and lesions, but not to protect the brain itself. You can think of it like this: imagine wrapping an egg in bubble wrap, and then tossing the egg around and letting it hit surfaces. The eggshell might not break, but that doesn't mean the yolk inside isn't getting scrambled. The same applies to the skull and brain; brain damage often happens in the absence of skull damage, and vice versa. A fractured skull doesn't imply a concussion, and an intact skull doesn't imply an uninjured brain. Even in recent years, as football helmet companies have become more aware of

concussions, helmets still aren't as safe as they are marketed to be. The STAR system, or Summation of Tests for the Analysis of Risk system, attempts to rate football helmets based on their efficacy in protecting the brain. Whole companies have marketed their products based on their STAR ratings for their helmets. However, while the STAR system does accurately measure the impact of a direct strike to the head, it fails to account for rotational acceleration- the speed at which someone's head whips around when struck. As we discussed before, rotation is a major cause of concussions, and we don't yet know how to measure the protection that helmets provide against rotation. While scientists work on figuring out how to make safer helmets, remember: just because you are wearing a top-of-the-line, STAR rated helmet does not mean that you are magically immune to concussions. If you get hit and start to feel any concussion symptoms, don't assume that you're in the clear just because you have a good helmet on.

More recently, soccer companies have started to release headgear to protect players from the impact of heading the ball. If you play soccer, especially girls' soccer, you've probably seen someone wearing headgear of this sort before- it's like a memory foam headband that goes around the forehead. Many players and coaches swear by the headgear, and some high schools are starting to require their players to wear it during practices and games. Though the makers of soccer headgear market the products as reducing the frequency and severity of concussions, there isn't much clinical evidence backing up their ability to prevent concussions. Nonetheless, the headgear does appear to reduce the force of impact when hit by a ball, and anecdotal evidence suggests that players experience less concussions when required to wear headgear. With more awareness about concussions and headgear, we will surely see more evidence about head protection in soccer in the future.

Finally, out of my own curiosity, I'd like to discuss the science behind many of the claims and accusations that have been circling in the media about professional football. As you probably know, the NFL has been ruthlessly attacked for its failure to protect players from concussion-induced brain damage. What's going on in the brains of professional athletes that makes head injury so catastrophic in the long term?

The medical condition that has plagued the NFL is not concussions themselves, but a degenerative brain disease called chronic traumatic encephalopathy, or CTE. CTE can develop in athletes who suffer from repeated concussions, or even repeated sub-concussive blows to the head over a period of years. Repeated head traumas cause a gradual buildup of a protein called tau in the brain, which is the same protein associated with Alzheimer's. CTE results in many of the same symptoms of Alzheimer's, including aggression, confusion, and eventual dementia and premature death. In 2015, the Department of Veterans Affairs conducted the largest-ever study on brain tissue of deceased football players. Thanks to the medical generosity of many retired NFL players, the Department was able to obtain the brains of 91 prior NFL players after they

passed away. 87 of those brains, or 96 percent of them, showed evidence of CTE. Though the people who donated their brains probably suspected damage, skewing the sample population, researchers believe this statistic is reflective of the NFL as a whole. That movie *Concussion* that came out a while ago was about the doctor who discovered this very same condition, and it came as a real blow to the NFL. Since then, the NFL has dedicated millions of dollars to brain and helmet research, amended rules about head-to-head contact, and settled a billion dollar lawsuit with families of affected players. We have certainly not seen the end of this story yet.

Concussions, and even sub-concussive hits to the head, are serious. Our brains are our most precious organ, and they are also one of the most difficult to treat, especially on a surgical table. Nonetheless, there are many important steps to take when healing from a concussion to ensure maximal recovery. The most important thing is to rest, both physically and mentally, and not to engage in any activities that could cause another blow to the head. Even riding a roller coaster, because of its acceleration, is considered too jolting during concussion recovery. The vast majority of concussion patients will recover enough to attend school and return to normal life, minus sports, after 7 to 10 days. Some individuals need longer to recover their cognitive skills, and you should speak to your teachers about extensions and easing back into school after a particularly nasty concussion. Otherwise, thankfully, the brain does heal at an incredibly rapid pace. Just avoid another concussion and you should be operating at full speed within two weeks, except for slight memory and attentional delays.

Despite the prevalence of concussions in our world, scientists are still figuring out how to accurately diagnose and treat concussions in adults and teens. The most important thing is, to put it bluntly, not to be stupid. If you get a blow to the head and feel even a bit of dizziness or confusion, get off the field and sit it out. Playing through an injury is a sign of being tough until the moment you get hit again, and your brain swells until you enter a coma and die. I'm being gruesome to prove a point, but I'm not exaggerating, either. Protect your head, be intelligent, and consult a doctor if you think you might be concussed. Going to the doctor sucks, but permanent memory and attention problems are infinitely worse. I didn't see a doctor after my concussion, and I'm lucky that I didn't hit my head again afterwards. If I had, I might not be writing the script for this podcast today.

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