# Headed for Trouble

**BU scientists are renowned for their research on concussions suffered by NFL veterans. Now their studies are raising alarming questions about the true dangers of high school football.** BY JASON SCHWARTZ

Wally Hilgenberg's brain sits beneath a microscope. It does not look good. What should be a clean, off-white layer of tissue is instead covered in brown splotches. Peering at it, Dr. Ann McKee points out a group of gnarled brown marks in the hippocampus, the part of the brain that controls memory and learning. "You see all these tangles?" McKee asks. "These are just tremendously abnormal nerve cells.... There's essentially no normal cell left."

McKee is actually looking at the remnants of the late Wally Hilgenberg's brain. The neuropathologist has dehydrated it, shrunk it, sliced it, and pressed it flat between two glass plates. It now looks like a piece of ginger, plucked from a sushi platter. A dye has been applied to highlight buildups of abnormal forms of tau, a protein that exists regularly in brain cells but, when mutated, may kill them. As McKee shifts the glass plates beneath the microscope, moving toward Hilgenberg's cortex and down to the brain's stem, all she finds is more brown, marking more dead cells. It looks almost as if somebody has spilled coffee on the slide.

Long before it landed in McKee's lab at the Bedford VA Hospital, Hilgenberg's brain had spent 16 years getting scrambled CONTINUED ON PAGE 64

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inside an NFL helmet. Its owner played linebacker for the Detroit Lions and the Minnesota Vikings in the '60s and '70s, and suffered for it later in life. Doctors believed ALS, known as Lou Gehrig's disease, was the cause of Hilgenberg's 2008 death. But McKee and her fellow researchers at the Boston University Center for the Study of Traumatic Encephalopathy, with which she is affiliated, now suspect that ALS was a misdiagnosis. Though Hilgenberg experienced the muscle weakness and atrophy consistent with ALS, McKee believes the true culprit was chronic traumatic encephalopathy, or CTE. Put simply, CTE results from too much banging of the head: Too much abnormal tau builds up, leading to too many dead brain cells, which can lead, finally, to a person's inability to properly control his muscles. McKee and her colleagues speculate that even the oft-concussed Lou Gehrig could actually have suffered not from his namesake disease, but from CTE.

McKee slides another brain sample under the microscope, that of Lou Creekmur, who played offensive line for the Lions during the '50s. Again, brown splotches all over, mottled like a smoker's lungs. Even to someone who doesn't know a hippocampus from a hippodrome, it's clear that something is wrong here. Like Hilgenberg, Creekmur's brain was battered throughout his 10-year NFL career. Later in life, he suffered memory loss, had difficulty focusing, and became prone to intense, angry outbursts. "He died in his eighties," McKee says, "but he was severely demented."

McKee inserts a final slide. This brain looks surprisingly normal. With its smooth, off-white surface, it's the model of health. But as McKee pushes the slide forward, moving it to reveal the frontal cortex, the telltale brown marks start to appear, seeping out from the corners like tributaries feeding a river. "You see areas like this where it's very distinctly abnormal," she says. "The damage isn't just restricted here; it's spreading all the way to neighboring parts of the brain." This brain, McKee says, did not belong to an NFL player. "This is a young kid."

**OVER THE PAST FEW YEARS, AMERICA** has fundamentally changed the way it thinks about concussions and football. McKee and CONTINUED ON PAGE 66

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her colleagues at BU are responsible for that. Thanks to them, it has become accepted fact that concussions and repeated blows to the head lead to CTE and problems later in life.

The key development has been the unique process McKee pioneered for looking at brain tissue. By dehydrating, slicing, and dyeing samples, researchers are able to look through a microscope at a shrunken-down version of one half of the brain, instead of just a small region. The method allows the brain to be seen from

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different angles and with greater clarity. The process is "very time consuming and very painstaking," McKee says. "But it enables a person who has never looked at brain sections before to say, 'Oh, God, this is like night and day!'"

That is almost exactly what Congress said when McKee presented her research on Capitol Hill just over a year ago. For decades, NFL officials had ignored or denied the brutal effect professional football has on its participants, all but insisting that repeated blows to the head didn't affect players' health later in life. The league had always allowed players to return to a game after suffering concussions. But the research conducted by McKee and her BU team changed that. Soon after her Congressional testimony, the NFL owned up to the damage the game can cause and issued a memo prohibiting players from returning to a game during which they suffered a concussion.

But for Chris Nowinski, the cofounder of the Waltham-based Sports Legacy Institute, which works alongside the BU Center, the research has never really been about the NFL. The former Harvard lineman and pro-wrestling star has suffered from many past concussions, and says that younger kids have always been his "number one" priority. "The tragedy is the children who have no CONTINUED ON PAGE 68

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comprehension of the risks [of] losing brain cells and losing [their] lives on the field," he says.

Nowinski, who has toured the country preaching concussion awareness at schools, says that focusing the spotlight on the NFL is part of a larger strategy. "The media writes about celebrities, so you have to change things at the top in football to change things in the middle," he says.

Here in Massachusetts, that middle is very large. There are currently more than 20,000 high school football players in the state. According to experts, 5 to 10 percent of them will suffer concussions this season. Many will go undiagnosed because, much like the professionals, kids steeped in football's warrior ethic often try to play through the pain. More than 40 percent of concussed high schoolers return to games too soon, according to a recent study by the Nationwide Children's Hospital in Columbus, Ohio. And because young athletes' brains are still developing, the dangers for them are elevated: According to one study, the brain trauma caused by a concussion can be three times more harmful for a child than it is for an adult.

The most serious risk is second-impact syndrome, an extremely rare but potentially fatal condition. If a concussed player returns to play too soon, a second hit to the head—even a light one—may cause death. Every year, a handful of kids die from second-impact syndrome nationwide, though there have been no recent fatalities in Massachusetts.

Much more common is post-concussive syndrome. Ordinarily, a concussion takes up to three weeks to clear. If, however, a second concussion follows the first too closely, recovery can take months. Post-concussive syndrome also exacerbates ADD, ADHD, and depression, says Robert Cantu, an SLI cofounder and neurosurgeon at BU's CSTE center. The condition is especially problematic for students, as mental rest is vital to recovering from a concussion. Even reading can set back the healing.

Take the case of Eric Budden, a senior at BC High. At 5-foot-11, 268 pounds, he's the football team's starting center. He suffered his first concussion in a preseason practice during his sophomore year, experiencing nausea and sensitivity to light and noise for about two weeks. When he suffered another in CONTINUED ON PAGE 70

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September of his junior year, his recovery took the same amount of time. But when he crashed his head into a teammate's facemask during practice about a month later—his doctors had declared him recovered—his symptoms lasted more than a month. "My grades kind of dipped a little bit," Budden says, noting that he had trouble focusing. "There was nothing I could do about it."

In a sense, Budden was lucky. If he had jumped back in sooner and been concussed again, his recovery could have taken most of the school year. This is something that Chris Nowinski is acutely aware of. "When we talk to the athletes and the coaches, we talk about fighting two fights," he says. The first is making sure students don't derail their academic career by going back in the game too soon and suffering post-concussive syndrome. "If you have to miss a semester and your grades drop, it's going to change what college you go to," Nowinski says. "It's going to change everything about your future."

The other fight is CTE, he says. Unlike post-concussive syndrome, which is the result of a specific incident, CTE represents the accumulation of hits to the head, whether concussive or not. The condition can lead to depression, mood swings, impulsive behavior, loss of memory, and general loss of brain function later in life. "The beginnings of CTE can start quite early," BU's McKee says. She's seen its early stages thus far in two young brains. The first belonged to an 18-year-old football player who died in an incident unrelated to the sport. The second is the brain she slid under the microscope after Hilgenberg's and Creekmur's. It belonged to Owen Thomas.

McKee says she hasn't seen enough brains yet to determine for sure the long-term impact of high school football on its players' minds. But the Owen Thomas case—which sparked national headlines—seems ominous. Thomas was a University of Pennsylvania junior lineman when he hanged himself in his apartment in April. Though Thomas's family said that they never knew him to have suffered a concussion, BU researchers found the early stages of CTE in his brain, suggesting that it may have played a role in his suicide. The most likely explanations are that Thomas either

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played through concussions without telling anyone or, perhaps more disturbingly, that all the run-of-the-mill hits to the head he absorbed between Pop Warner and Penn added up to CTE.

Nowinski draws his own conclusions. "I don't think the jury's out at all on whether high school exposure's enough for CTE," he says. "We've seen it in a kid who's just 18. We just haven't looked at a lot of 40- and 50-year-olds who just played high school football. If it starts in your teen years and it just progresses, some percentage of kids are walking out of high school football with CTE already in their brain. And probably the earlier they started, the higher their risk. If you played from 6 to 16, that's probably just as bad as someone who plays in the NFL [and plays from ages] 14 to 24. Maybe worse, because the young brain is, again, more sensitive."

**MCKEE AND NOWINSKI AGREE THAT THE** most important thing for high school athletes is to not play while concussed. But even in Massachusetts—where all this groundbreaking brain research is taking place—that has proven difficult.

For one, concussions are hard to diagnose. "Perhaps as high as 70 to 80 percent of mild concussions are missed in football because athletes can play through," says BU's Cantu. Contrary to popular belief, few concussions result in a player being knocked out. "I believe that the majority of physicians who are in practice today would not be qualified to manage athletic concussions," he says.

Special training is needed, notes Thomas Dodge, the president-elect of Athletic Trainers of Massachusetts. The standard checklist of concussion symptoms is 25 items long.

Many specialists believe athletic trainers are the key to handling concussions. But Dodge estimates that less than half the high schools in Massachusetts have them. In the city, and farther out into the state's rural areas, schools become less likely to employ trainers. Though Boston Public Schools has roughly 17,500 students enrolled across more than 30 high schools, for instance, the district employs just one athletic trainer for all of its facilities.

The issue in Boston, of course, is money. Through partnerships with BU and other medical providers, CONTINUED ON PAGE 74

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BPS is able to staff a doctor and emergency team at each district football game. But they don't know the kids as well as a trainer would, and aren't around the rest of the week. "I'm not saying that sports or a student's health aren't very important, but money is what it is," says Kenneth Still, the athletic director for BPS. "You can only spread it so far."

Perhaps the easiest—and cheapest—step for schools to take is to implement neurocognitive testing: memory and reflex exercises designed to show whether an athlete has suffered from a concussion. The most popular version is called the ImPACT test. It costs between $500 and $1,000 per year per school district, according to neuropsychologist Neal McGrath, who runs Sports Concussion New England, a clinic and consultancy in Brookline that helps some schools administer the test. It works simply enough: The healthy player takes it at the beginning of the season to serve as a baseline. Then, if the athlete takes a big knock to the head, he or she can be retested. If the results are significantly worse, it's likely a concussion. When testing levels return to normal, the athlete is ready to get back on the field. Because concussions may not show up in X-rays or CAT scans, ImPACT is viewed as a valuable tool for diagnosis. Nurses or school trainers can administer it, and its results show overly insistent players that they shouldn't return to play so quickly. Despite ImPACT testing's relatively low cost, however, only about 90 of the state's more than 500 public and private high schools utilize it. (Boston is not one of them.)

McGrath and Nowinski caution that concussions are just as likely to happen in practice as they are in games. "The trainers at the high school level have 20 sports to cover," says Nowinski. "So they're not at practice."

McGrath, who treats around 500 kids per year, says that there's a huge gap between how well small private schools monitor and treat concussions and how well public schools do—even the wealthiest public schools. It's a simple numbers game. For instance, Noble and Greenough, the Dedham private school, has two athletic trainers watching over nearly 600 students CONTINUED ON PAGE 76

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full time. Compare that with a school like Needham High, which has just one athletic trainer to care for more than 1,400 students. "The closer the athletic trainers are able to watch the kids, the more injuries we seem to get reported to us," McGrath says.

Even when schools have the resources, though, there's not always demand for them. Thanks to Boston Latin's Longwood location and generous alumni, the school's longtime football coach and athletic director, John McDonough, is able to staff an athletic trainer during both games and practices. Last spring, though, when McDonough arranged for ImPACT testing at Children's Hospital—working independently from the school district—just 65 to 70 of his school's 300 athletes paid the $20 to have it done. "Come on, let's do this," he vents. "I certainly wouldn't single out individuals, but there were a couple of our athletes who had suffered multiple concussions, and they weren't tested."

In the end, the onus must be on the players. Budden, the BC High lineman who suffered three concussions during practice, admits that if any of them had happened during the rush of a game, he likely would have stayed on the field. But he also says he knows that would have been foolish. When it comes to reforming football's intractable tough-guy culture, this counts as progress. BU is responsible for the shift in attitudes, and larger measures in the state, too. Last spring, McKee's team testified on Beacon Hill. The result was a new state law mandating that all concussed high school athletes get a doctor's okay before returning to play, and that players and coaches receive annual concussion education.

Nobody at BU is saying high schoolers should quit playing football yet. But each advance the researchers make moves the conversation away from the long-term dangers of concussions to the dangers of playing football, period. "It may be that human bodies are just not meant to run into each other at these speeds," Nowinski says. "We have to remember that before we invented helmets, the types of hits we have on the field would kill people. Just because we survive now and don't see any blood doesn't mean the body isn't dying on the inside." B