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We have many playful euphemisms for hitting our heads, but concussions are no joke.

> As doctors learn more about their consequences, sufferers of this invisible disability are finding renewed hope.

BY MICHAEL DREGNI

More than three

years later, Amy Zellmer can still recall the sound of her head hitting the frozen concrete. She slipped on ice near her St. Paul, Minn., home in February 2014, and that noise signaled a change in her life that resonates even today.

"It happened just like *that!*" she says, snapping her fingers. "I imagine I looked like Charlie Brown."

Zellmer landed on the back of her head and estimates she was knocked out for a minute or two. When she stood up, she realized something wasn't right. She was dizzy, wobbly, sick to her stomach. "It was like little lightning bolts going off in the corners of my eyes — the proverbial 'seeing stars."

She realized she needed to go to the ER, but when she tried to locate the nearest hospital on her computer, she couldn't read the screen: "That's when I knew I had a problem."

So she telephoned a neighbor, who

soon arrived and soothed the bump on Zellmer's head with a package of frozen peas. The neighbor then asked the time-tested question, "Who's the president?" Zellmer answered "Bill Clinton" — two presidents off. A friend's husband happened to be a chiropractic neurologist and he immediately made time to see her at his office. He told Zellmer she had suffered a concussion and major whiplash, including torn muscles and a dislocated sternum.

The stars disappeared in a couple of days, but effects of the fall lingered. Zellmer experienced aphasia and short-term memory lapses. She got lost while driving. She struggled to concentrate and tired easily. Dizziness made her head spin. Strange mood swings disrupted her days.

"It was like I had been on a boat for a long time, or had just taken off roller skates, and I still felt like I was moving. It was constant, like I was drunk all the time." Other days, it seemed she had an evil head cold and was lost in a never-ending fog.

Zellmer, now 43, saw several doctors, ophthalmologists, and other specialists over the next two years. Nothing seemed to help. She was finally referred to a craniosacral therapist, who gently massaged her scalp. After a couple of treatments, she remembers hearing a distinct noise in her head and feeling a huge sense of relief. That sound signaled a release of pressure, which instantly cleared her fogginess. (For more on craniosacral therapy, see ELmag.com/ seeingstars.)

Still, Zellmer's cognitive issues endured. She consulted a neurologist, who referred her for a four-hour exam: She scored worse than a dementia patient. A neuropsychologist prescribed Ritalin and antidepressants, but Zellmer refused to take them, viewing the pills as Band-Aids for the real problem. Whatever that real problem was.

THE INVISIBLE DISABILITY

Seeing stars. Getting your bell rung. A knock on the noggin. In the notso-distant past, we shrugged off head injuries with quaint euphemisms — a cute way of skirting the seriousness of a traumatic brain injury, or TBI.

These days, the medical world takes TBIs seriously, as we now know that seeing birdies is more dangerous than we ever imagined. The far-reaching and seemingly disparate health effects of TBIs can include cognitive problems, coordination dysfunction, hormonal disruption, digestive issues, and mood disorders. At the same time, we're learning more about how to treat TBIs and their repercussions.

TBIs cover a spectrum of severity, from subconcussive to concussive (which account for 70 to 90 percent of all cases) to fractured skulls and worse, explains Vani Rao, MD, a Johns Hopkins University School of Medicine neuropsychiatrist, in *The Traumatized Brain*.

The brain is jarred in a concussion. It accelerates forward, crashing into the skull (known as a coup injury), then it often bounces back and hits the rear of the skull (contrecoup). Sometimes, it twists atop the brain stem as well.

Contrary to common perception, you don't actually have to hit your head to get a concussion: It can result from whiplash, or even from the shock waves of an explosion, like those that troops experience in combat. This can lead to or exacerbate PTSD, according to a recent study.

A TBI can harm the brain in numerous ways. It may cause bleeding (an intracranial hemorrhage) or create a blood pool or clot (a hematoma); the brain tissue itself may be bruised or torn. These injuries can then put pressure on the brain, resulting in harmful inflammation.

It can also cause oxygen deprivation, leading to the death of brain cells, and twisting on the brain stem might result in vestibular or endocrine issues. In addition, a TBI can damage the axon fibers that carry messages between different parts of the brain.

The effects might be subtle or dramatic, singular or myriad:

• **Physical conditions,** such as headaches, seizures, hearing loss, and vision issues, including seeing double, blurriness, eyestrain, light sensitivity, and depth-perception dysfunction.

• Hormonal disruption resulting in blood-sugar dysregulation and emotional problems, such as depression, anxiety, mania, or apathy.

• **Digestive issues**, including microbial changes, motility problems, and increased gut permeability.

• **Behavioral upsets** like sleep disturbances, impulsivity, aggression, even psychosis.

• **Cognitive issues** including problems with attention, memory, language, and executive functions, such

> There's no such thing as a safe blow to the head."

as organizing, planning, sequencing, and monitoring or modifying behavior.

"Most people with mild TBI make a spontaneous recovery within the first few months of injury," Rao explains. "But mild brain injuries are not always benign.

"Traumatic brain injuries are, in a sense, a silent epidemic, because often, after persons with TBI have been treated in the emergency department or released from the hospital, family members or friends may assume that they are now 'fixed.' There may be no physical evidence of injury, so it is easy for others to believe that everything is back to normal. Unfortunately, that is often not the case, especially with more severe injuries."

Accurately determining how many head injuries Americans sustain each year is difficult because many of us don't visit a doctor after hitting our heads. Still, the Centers for Disease Control and Prevention (CDC) estimates that Americans suffer between 1.6 million and 3.8 million sports- and recreation-related concussions annually. This discrepancy is huge because so many TBIs are never reported.

But those statistics don't reveal the true scope of the issue for one crucial reason: While sports-related TBIs get the spotlight, they account for a minority of all head injuries. Forty-seven percent of all TBIs are the result of everyday falls, according to the CDC. These incidents are especially prevalent among the elderly; a new CDC study finds that one in 45 people age 75 and older suffers a fall and TBI.

Innocuous falls happen to all of us in daily life as we slip on stairs, trip over rugs, tumble from ladders, or stumble while carrying items when we can't see where we're going.

Because of these everyday head injuries, an estimated 5.3 million Americans are currently living with a lifelong disability — that's roughly one in every 60 people. TBIs also account for 30 percent of all injury-related deaths.

The fact that there's no clear count of head injuries suggests we're still largely in the dark concerning their dangers. Public awareness is growing, however, thanks — ironically, as it turns out — to one source: The National Football League (NFL).

"SHAKEN UP ON THE PLAY"

Football players wear helmets exhaustively engineered, thoroughly tested, incredibly expensive helmets — that are supposed to protect them from TBIs, even after the uncountable

Head Injuries by the Numbers

2,500,000

Number of Americans treated in emergency rooms for TBIs each year, according to the Centers for Disease Control and Prevention. Experts speculate that perhaps just as many — or more — hit their heads and never have it checked out. Number of Americans who die every day due to a TBI-related injury, according to the Brain Injury Association of America (BIAA).



33%-52%

Percentage of people who suffered major depressive disorders in the first year after a TBI, according to various studies. Ten percent consider suicide and 15 percent try to kill themselves, a study in the *Journal of Neurotrauma* reports.



Number of seconds between TBIs in the United States, according to the BIAA.

Percentage of former NFL players expected to develop long-term cognitive problems — Alzheimer's or other forms of dementia — as a result of concussions or chronic traumatic encephalopathy (CTE), according to the NFL's own study.

Changing Mindset: A TBI-Recovery Story

Brent Porter can't count the number of head injuries he's suffered — 20 to 30 is his best guess. He was a child daredevil and received his first head-banging at age 8 with help from a trampoline.

From there, Porter graduated to ever-moreextreme sports — skateboarding ("We built a halfpipe in our backyard, so I had 24-hour access to ramps when I was *really* young"), snowboarding, motorcycle road racing, mountain-bike racing, and more.

He suffered TBIs doing all of them.

When Porter was a kid, he rarely wore a helmet — no one did, as he remembers. And he rarely saw a doctor after hitting his head. "It's like this need for adrenaline almost overrides any concerns about the injuries. It just drives you to want to continue doing it," says Porter, now 46 and an IT specialist in Minneapolis. "Growing up, we thought you just had to power through injuries. You shook it off. You tried to get back up and continue riding or snowboarding or whatever."

He says he learned his lesson the hard way in 2013 after his worst crash yet. He was downhill racing his mountain bike when he bottomed out the fork suspension and got thrown over the handlebars. As he landed, his shoulder was pushed into his neck, causing him to black out. He never really even hit his head; afterward, his helmet looked as good as new.

Porter tried to shrug it off and get back on his bike. "But I kept on crashing because I had no coordination. You're not thinking clearly, and it's all very confusing."

Friends took him home, where he rested. But the next day, his girlfriend realized his coordination was askew, his attention was lacking, and he couldn't sleep. "I was struggling," he says. "It almost feels like you have a really bad hangover."

Two days after the crash, he went to the TRIA Sport Concussion Program in Bloomington, Minn. Over time, he met with a neurologist, physical therapist, and speech therapist, who provided support and, ultimately, helped him overcome his injuries.

"The more I hit my head, the worse the effects seemed to get. The longterm effects are especially hard to deal with.

"I suffered through some pretty heavy depression after the 2013 crash, and when I look back at all the concussions I've had, I realize that I was having depression and anxiety issues after them, too.

"The recovery and treatment lasted six months. Doing that makes you realize that there's something going on that you wouldn't have noticed without the specialists' help." instances of head contact many sustain during every practice and game.

But in 2002 a young forensic pathologist named Bennet Omalu, MD, in the county coroner's office in Pittsburgh, performed an autopsy of "Iron Mike" Webster, the legendary Pittsburgh Steelers lineman who died at age 50. A Hall of Famer, Webster was known for his durability, never missing a game during a 10-year stretch between 1976 and 1985. He spent the last decades of his life struggling with dementia, delusions, paranoia, and explosive moods. Though Webster was believed to have died of a heart attack. Omalu sensed something else.

CT and MRI scans of Webster's brain found nothing abnormal. So Omalu did a specialized proteinstain test; the results were startling. Webster's brain was clouded with massive accumulations of tau, one of the proteins that causes Alzheimer's.

Omalu believed that Webster's brain had been rattled by the cumulative effect of all the subconcussive head injuries he suffered over his 17 NFL seasons. His report on Webster's autopsy was published in the peerreviewed journal Neurosurgery, where Omalu coined a name for the syndrome - chronic traumatic encephalopathy, or CTE. Encephalopathy is a broad term for a disease that alters the brain's structure or function.

Omalu's report garnered wide attention for CTE, and for TBIs generally, prompting a slew of studies. Among the more notable is an ongoing study at Johns Hopkins School of Medicine that began in 2014, in which researchers are examining a group of retired pro football players; their findings to date suggest that repeated brain trauma causes molecular changes to brain tissue that can have consequences for decades after.

Notably, some brain injuries happen without a concussion: They can result from a single blow to the head or repetitive hits over time. "There's no such thing as a safe blow to the head," says Omalu.

Fearing for football's very existence, the NFL went on the offensive. League lawyers and doctors took a page from Big Tobacco's playbook to obscure the link between cigarettes and lung cancer and worked to discredit Omalu and downplay CTE. At the time, the NFL didn't even have concussion guidelines for assessing players — as sports commentators like to say, they were merely "shaken up on the play."

The NFL seemed to be winning the game in dismissing CTE. But after Omalu found CTE in autopsies of four more NFL players, the media, and soon the public, took notice. Head injuries became big news.

BRAIN GAMES

Head injuries are not limited to football, of course: They happen in hockey, cycling, soccer — most any sport. Nor are they limited to the pros.

In a study published in Radiology in 2016, researchers examined the potential effects of subconcussive head blows on the 3 million U.S. kids playing organized youth football. They studied 25 players age 8 to 13 over a single football season, conducting advanced neuroimaging using MRI with diffusion tensor imaging (DTI) scans both pre- and postseason. The players' helmets were fitted with Head Impact Telemetry System (HITS) sensors to assess frequency and magnitude of impact.

The kids were "hitting their heads hundreds of times over the approximately three-month season" without suffering actual concussions, says lead study author Christopher Whitlow, MD, PhD, chief of neuroradiology at Wake Forest School of Medicine in Winston-Salem, N.C. He was interested in understanding the cumulative effect of these subconcussive hits.

Whitlow's team found "measurable brain changes" to the white matter in the youths' brains: "When you look at these players, they don't look any different; they're not behaving any differently. Do these changes mean anything at all? Perhaps not. Maybe these changes all go away like their bruises after the season and this is just another manifestation of a physical sport.

"But the issue is that we don't know," he says. "What happens after two seasons? And ultimately, is your lifetime cumulative head-impact exposure the thing that makes a difference?"

In a 2016 study of amateur soccer players published in EBioMedicine, researchers found that heading a soccer ball - just once - causes instant changes to the brain. They did transcranial magnetic stimulation (TMS) and electromyographic (EMG) recordings followed by cognitive tests of 19 players age 19 to 25 before and after routinely heading balls. They discovered alterations in brain corticomotor inhibition and cognitive function — in particular, memory-test performance was reduced by up to 67 percent.

"The good news is that these changes in brain function were transient, with effects normalizing within 24 hours," explains lead study author Magdalena Ietswaart, PhD, professor of psychology at Scotland's University of Stirling.

"The bad news is that we do not know whether there is an accumulative effect when this biochemical disruption is repeated over and over again through weekly heading-practice drills, or what the long-term consequences of heading on brain health are."



Head Cases: Top 10 Sports for Concussions

These sports and recreational activities result in the most head injuries treated in emergency rooms, according to a study by the U.S. Consumer Product Safety Commission.

1. Bicycling

- 2. Football
- 3. Baseball and softball
- 4. Basketball
- 5. Water sports, such as diving, surfing, water skiing, and others
- 6. Off-road sports on powered recreational vehicles such as ATVs and go-karts
- 7. Soccer
- 8. Skateboarding and scootering
- 9. Accidents in gyms and health clubs
- 10. Winter sports (skiing, sledding, snowboarding, snowmobiling, and others)



Will a Helmet Protect You?

The answer is no — and yes. Whether you're playing football or hockey; riding a horse, bicycle, or motorcycle; or skiing or snowboarding, a helmet is not fail-safe protection from a concussion.

A study presented at the American Academy of Neurology's 2014 annual meeting found that pro-level football helmets reduced the risk of traumatic brain injuries (TBIs) by only 20 percent compared with wearing no helmet.

But a helmet *can* cushion your head in sports or recreational activities — and even that 20 percent might be a lifesaver.

"Helmets work like a brake or shock absorber," the Snell Memorial Foundation, which sets industry standards for testing helmets of all sorts, states on its website. "A helmet will effectively reduce the speed of the head by breaking and crushing, which reduces the amount of energy transferred to the brain. The whole process takes only milliseconds to turn a potentially lethal blow into a survivable one."

And to some degree, a helmet can protect your head from worse injuries than TBIs, such as skull fractures and penetration.

When buying a helmet, invest in a good one. The best new helmets have two-layer Multi-directional Impact Protection System (MIPS) tech. Look for testing approval from organizations like Snell or the Institute for Critical Technology and Applied Science at Virginia Tech. For bicycling helmets, Helmets .org compiles the latest safety research and reviews.

While helmets are not yet popular for soccer, you can wear protective headbands that may mitigate head contact.

THE ROAD BACK

As doctors learn more about the consequence of TBIs, their knowledge is leading to new treatments. Given the range of seemingly disconnected symptoms, protocols are often individualized based on the results of sophisticated tests.

"Treating head injury requires a multifaceted approach," explains functional neurologist Brandon Brock, DC, of Cerebrum Health Centers in Dallas–Fort Worth. "Sometimes it requires medication to control symptoms. Sometimes it requires diet and nutrition to allow appropriate healing. Sometimes it requires the appropriate neurological exercises to give the brain harmony and symmetric function.

"We need to make sure there are no underlying triggers that were there beforehand that would keep the person from healing, like diabetes, thyroid problems, or infectious disease that can make the inflammation so sustained that people can't recover."

Receiving treatment soon after an injury is preferable, because the brain remains plastic and responsive for days or weeks, Brock says. The longer you wait, the more likely the brain gets set in new, problematic patterns. But if an injury is months or even years old, a new battery of functional-neurology tests can still detect symptoms, and treatment remains possible.

For Amy Zellmer, it wasn't until two and a half years after hitting her head that she found hope for recovery. She connected with functional neurologist Jeremy Schmoe, DC, of Minnesota Functional Neurology and Chiropractic in Minneapolis in August 2016. By this point, she was begging for help. She described her many symptoms — and, for the first time in all her consultations with specialists, Schmoe validated them. "I was like, *Hallelujah, somebody understands!*" Zellmer remembers.

Using a platform posturography test, Schmoe examined her balance. He conducted video analysis of her gait. He checked her autonomic nervous system, since concussions often skew heart rates and blood pressures; the combination of a higher resting heart rate and uncertain spatial awareness can result in an overactive startle response and hyperanxiety. He used videonystagmography (VNG) to check her eye tracking. Then he outlined a course of vestibular rehab to improve her balance and dizziness, and manual therapy to treat the effects of her whiplash.

Schmoe prescribed neuroorthopedic rehabilitative exercises to help Zellmer restore her eye-brain coordination. And he recommends yoga — in particular, TBI survivor Kevin Pearce's Love Your Brain program (www.loveyourbrain.com).

The nervous system is amazing. It's elastic: You can make changes to it. You just have to give it the right stimulation."

"We challenge the nervous system with different types of sensory inputs to activate the brain to make changes to the objective findings that we identify during examination," Schmoe explains. "If we see that you're off balance to the left, we might do an exercise to stimulate the left side of your body to give your brain better awareness of where you are in space.

"The nervous system is amazing. It's elastic: You can make changes to it with repetition, intensity, and frequency. You just have to give it the right stimulation to help build plasticity."

He next ran blood labs to check Zellmer for anemia, infection, inflammation, thyroid and hormonal imbalances, autoimmune disorders, and vitamin D or magnesium deficiencies — all of which can affect recovery.

Hormonal disruption can cause issues ranging from emotional imbalance to mood disorders, as well as blood-sugar dysregulation, says Schmoe. "When you hit your head, the midline areas of your brain get torsion, which can injure the areas that affect your pituitary output. This can affect the adrenals and thyroid. We see people develop a whole metabolic cascade of symptoms after a brain injury."

There's an axis between the brain and gut, he explains, and "literally within a couple of days after a brain injury, your gut lining could start to be affected." Schmoe explains that this can cause recurrences of past gut issues, including infections and insulin dysregulation.

"If you can address the brain and you can improve the circuits in the brain, you can make changes to the gut — it's a bidirectional pathway," he says. "By improving the brain, you can improve the gut. Then if you loop back around and improve the gut even more, your brain's going to heal faster. You have to look at everything when it comes to brain injuries."

For Zellmer, the improvements were swift.

"Within two weeks, my dizziness went from a nine out of 10, to a two. Once I got the dizziness under control, it freed up so much energy."

Today, she continues her therapy and is improving. She runs her own business as a photographer, but has also started new work: raising TBI awareness. She lobbies state and national legislatures, serves on the advisory council of the Brain Injury Association of America, and has selfpublished two books on the subject.

Her recovery is still in progress, but Zellmer is optimistic. She says she is now on "the road back to normal." \bullet

Michael Dregni is an *Experience Life* deputy editor.

What to Do After a Head Injury

Brandon Brock was working as a professional stuntman during summer months in college when he suffered a major concussion, temporarily losing his vision. The incident inspired him to become a functional neurologist and doctor of chiropractics at Cerebrum Health Centers in Dallas-Fort Worth. helping others recover from traumatic brain injuries (TBIs). His advice on what to do after suffering a head injury: Get checked out by a professional sooner than later — it's better to be safe than sorry.

 If there is loss of consciousness: Brock advises immediately calling 911. "If someone forgets where they're at or has amnesia, retrograde or anterograde - meaning they don't know what happened before or there's a period of time after they don't remember — they need to go to the hospital," he says. He recommends not driving someone who has lost consciousness to the ER: rely on an ambulance instead. "If the person who's been injured has a seizure or something like that, you don't want to be driving while you're dealing with the seizure at the same time."

• If there is a major laceration or contusion: Call 911 and go to the ER, Brock says. "If there are any skull deformities, you need to get the person to the hospital."

• If there is any display of bizarre behavior: Call 911 and go to the ER. Brock recommends that if the person who's hurt is acting different, disoriented, or just not like themselves, he or she should be checked out.

"If the injury doesn't break the skin or doesn't damage the skull, there's no change in behavior, there's no amnesia, and there was no knockout, then you need to watch the person for 24 hours or so," Brock says. The person needs rest and no mental or physical strain for at least three or four days. "If they're doing OK, that's great. If they're not doing OK, then they need to see a practitioner."

EMTs and ER personnel will do several kinds of tests for concussions. The most basic is asking several simple questions to test your cognitive response, including your name, the date, and so on. Next, they will check your eyes' responsiveness and tracking, a test known by the acronym PERL (for "*pupils* are equal and *r*eactive to *light*").

At the hospital, there are more in-depth tests for concussions, including cranial computerized tomography (CT) x-rays, magnetic resonance imaging (MRI), and immediate postconcussion assessment and cognitive testing, or ImPACT.

If you have further questions about head-injury symptoms, refer to the handy table from the Centers for Disease Control and Prevention at www.cdc.gov/ traumaticbraininjury/ symptoms.html.

