

Blowing the Whistle on Concussions

A photograph of a San Francisco 49ers player, Steve Young, lying on the field. He is wearing a white jersey with "YOUNG" and the number "80" on the back. His gold helmet with the 49ers logo is on the ground next to him. The background is a blurred green field.

YOUNG

SACKED:
San Francisco 49ers
quarterback Steve Young retired
in June after six career concussions
dealt by opposing players.

Raps to the head can debilitate or even kill athletes. Yet concussions are often misdiagnosed and mistreated

by Polly Shulman

Immediately after being elbowed in the jaw by Boston Bruin Hal Gill during a March 4 hockey game, Eric Lindros's world went yellow. The star center of the Philadelphia Flyers fell to the ice. He was helped into the locker room by the team's trainer, then vomited. He complained of a bad headache and strangely colored vision. Team doctors gave him heat packs and ibuprofen and then put him back in the lineup for another four games. "I wanted to keep playing," despite the telltale signs of a concussion, Lindros told report-

ers. "That's the mentality of a player—'Everything's going to be fine, it's going to go away,' and you just keep on playing." He added, "I knew that things were not good, and I tried to convey that through my symptoms. But I was not going to pull myself out of the game. I wanted the team to pull me out. I was hoping as the week went on that they would do that."

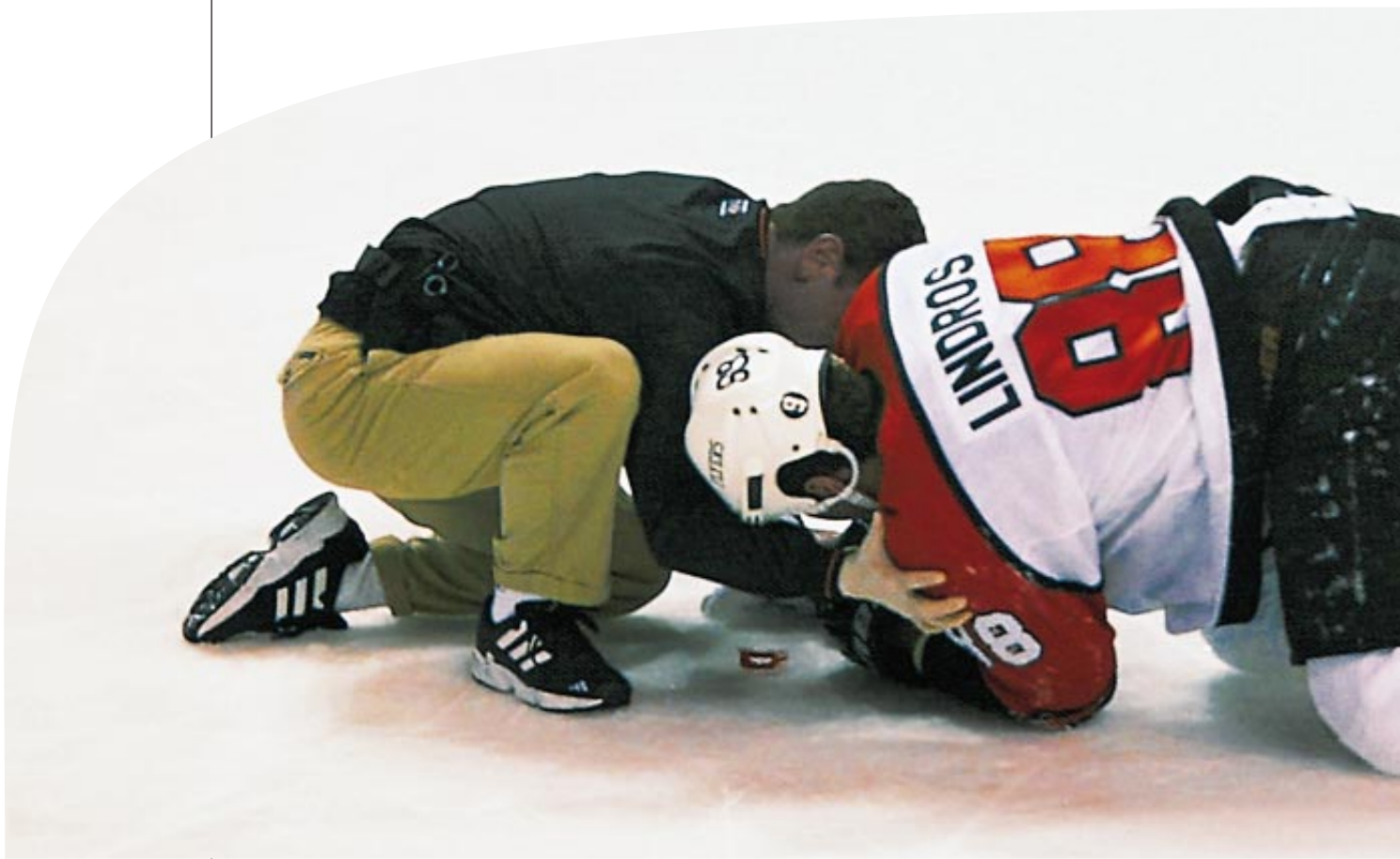
It was nine days before team doctors sent Lindros to a headache specialist, who referred him to James P. Kelly, an expert in sports-related concussions who is based at Northwestern University Medical School. Kelly diagnosed Lindros with a moderate concussion. Playing in subsequent games would put the athlete at serious risk: a second concussive hit sustained before the first one had healed could cause permanent brain damage or even death.

Lindros did not recover well. He sat out for 10 weeks, returning only for the crucial last two games of the Eastern Conference finals in May. He had played just eight minutes of Game 7 when he was elbowed again, this time by New Jersey Devil Scott Stevens. Lindros went down hard. It was his fourth concussion of the season and his sixth in two years. In the following days doctors said that Lindros should hang up his skates, and the sports media conjectured widely about the 27-year-old's premature retirement. And yet in July rumors arose that he might be traded, with several teams said to be interested.

Lindros is a perfect example of the dangers that sports-related concussions pose. According to the Centers for Disease Control and Prevention, 20 percent of the brain injuries that occur yearly in the U.S. can be attributed to athletics. That's more than 300,000 concussions. High school, college and amateur athletes receive most of these injuries, because there are so many more of these players than there are pros. "This is a major public health issue that's been given short shrift," says Michael W. Collins of the Henry Ford Hospital in Detroit. "It's underrecognized, underdiagnosed and misdiagnosed. It's happening with alarming frequency at the high school, college and professional levels."



SCOTT TROVANDS AP Photo



COLD AS ICE: Relations between Eric Lindros and Philadelphia Flyers management chilled this spring after he accused the team doctors of mistreating his many concussions.

A single blow to the head can cause a whole range of symptoms, from problems with balance and coordination to impaired decision making, failing memory and personality changes. Unless the injury is severe, patients generally recover with time. But most athletes return to games or practices far too soon. A second blow before a concussion is fully healed has a far greater chance of imposing more serious, longer-lasting harm. There is also the risk of death from “second impact syndrome,” a rare condition in which the brain swells fatally. Furthermore, “there’s growing evidence that not only are you more likely to have another concussion if you’ve had one, but the problems accumulate,” Kelly says.

Although the professional-athlete cases get the media attention, the thousands of kids playing youth hockey, football and soccer, the thousands of high school and college athletes, and the thousands of weekend jocks are in even greater danger, because it is far less probable that they, their coaches or their parents will recognize the symptoms of concussion. Scientists are trying to develop guidelines to help amateurs as well as pros recognize the signs and severities of concussions, but it is an inexact science. And there are currently no treatments that make concussions heal faster.

Lindros’s sad string of concussions threatened not only his health but his image. His dissatisfaction with the way the team’s staff handled his ongoing injury has caused bad blood with team general

manager Bob Clarke, who stripped Lindros of his captaincy. “When a guy like Lindros comes out and criticizes the doctors and trainers, he’s thinking of himself and not the team,” Clarke said at the time. If concussions end the hockey star’s career, he will be the second Lindros knocked out by brain injury. His younger brother, Brett, had to retire from the National Hockey League at the ripe old age of 20, after suffering three concussions with the New York Islanders and an unknown number before joining the league.

The list of elite athletes whose careers have been curtailed by brain injury is long: hockey players such as Pat LaFontaine, who retired from the New York Rangers, Paul Kariya of the Anaheim Mighty Ducks and James Patrick of the Buffalo Sabres; and football players including New York Giants linebacker Harry Carson, New York Jets receiver Al Toon, Dallas Cowboys quarterback Roger Staubach and San Francisco 49ers star quarterback Steve Young, who announced in June that he would retire early, having sustained six concussions.

HARD TO DIAGNOSE

And yet “for every Steve Young or Eric Lindros, every Muhammad Ali or Merrill Hoge, there are clearly thousands of high school kids who have had some of the same problems,” neuropsychologist Collins says. Part of the trouble in diagnosing concussion is that the symptoms can be very subtle.

EZRA SHAW/Allsport



People might dismiss a headache or altered vision as signs of stress or fatigue. “People joke, ‘I got my bell rung,’ but getting your bell rung means there’s been some neurological change in the brain,” Collins explains. People commonly think that concussion results from a knockout blow, but most concussions don’t involve loss of consciousness. The primary symptoms that often go unrecognized include balance trouble, headaches, dizziness, subtle personality change and cognitive problems. Sometimes injured athletes will have difficulty calling up old memories or forming new ones.

Complicating the subjective recognition of symptoms is the athlete’s desire to underemphasize injury. Young athletes are taught to “play through the pain.” Few players want to sit out a stretch of important games, much less an entire season. One of the hardest challenges, Kelly says, “is getting the athletes to honestly report their symptoms and pull in the reins on themselves a bit. As much as it’s admirable that the athletes are serious about getting back at it, they have to understand that these problems are very serious.”

Collins agrees. Brain injuries demand more caution than orthopedic injuries do, he says; because there are no pain receptors in the brain, an individual doesn’t experience direct pain with a concussion. This adds to the confusion when trying to judge symptoms. Doctors maintain that to be safe, athletes who are symptomatic following a blow to

the head should be kept off the playing field and return only after the symptoms have disappeared. For more severe concussions, players should be free of symptoms for up to two weeks before resuming play [see box on page 50].

Because concussions can be hard to recognize for nonneurologists (including amateur coaches and trainers) and because multiple injuries are so dangerous, Collins and his colleague Mark R. Lovell of Henry Ford Hospital have devised a system of neuropsychological testing. In their scheme, each team member spends half an hour with a doctor at the beginning of the season and takes tests that measure various brain functions—repeating numbers backward, putting pegs in a pegboard, recalling words heard several minutes earlier, and so on. If they are subsequently injured, they take the tests again. “We determine when their scores are back to preinjury levels before allowing them to return to play,” Lovell says. It’s important to have the baseline for comparison, he emphasizes, because everyone starts out with different abilities.

Few school-level coaches are experienced at administering neuropsychological tests, however, so Lovell and Collins have developed a computerized version of the exam, which resembles a computer game. They are testing the software in schools across the country and envision placing it in the offices of pediatricians and primary care physicians. “It’s like giving the brain a physical,” Collins says. “If you give the rest of the body a physical, why not the brain, which is the most important organ we have?”

WHAT EXACTLY IS A CONCUSSION?

There is great misconception among the public about what a concussion actually is. It is not a bruise to the brain. It is a harsh chemical imbalance within the gray matter. A brain inside a skull is like a person riding inside a car with no seat belt, explains David A. Hovda, a neuroscientist at the University of California at Los Angeles School of Medicine. If the skull halts or spins suddenly as a result of a collision, abrupt stop or whiplash motion, the unrestrained brain mass will slam up against the inside of the skull. The brain tissue is not physically damaged, except in the worst cases. But a devastating cascade of chemical reactions is unleashed.

The slam causes all the brain cells, or neurons, to fire at once, for several milliseconds. This extreme mass-firing sends the brain into a panic. Neurons across the brain release neurotransmitters—the chemicals that carry signals between them. “It’s like a very brief seizure,” Hovda says. A sinister wave of electrical activity spreads across the brain as the flood of neurotransmitters, especially glutamate, tells neurons everywhere to fire even more. The cells scramble in vain to regain a normal, neutral state so they can be ready to fire again.

This scrambling consumes a lot of energy. But the neurons can’t regenerate the energy they lose. The frantic firing causes the neurons to absorb excess electrically charged calcium and sodium and to spit



out potassium. The calcium clogs the mitochondria—the cell structures that make energy—preventing them from doing their job. So just when the neurons most need energy, they can't produce it.

Meanwhile the wash of calcium and potassium causes the brain's blood vessels to constrict, right when the neurons need more glucose from blood to fuel their attempts to recover. "We call this an energy crisis," Hovda says. A prolonged energy crisis can kill cells, resulting in permanent brain damage.

The extra sodium entering the brain cells can create more trouble, too. It makes them take in water—the way eating salty potato chips makes you thirsty. The water swells the cells, pushing them up against the skull. If the swelling is extreme, the expanding

brain will start to crush itself against the skull; neurons, or even the entire brain, can die.

The cascade of chemical events peaks rapidly, but it takes a long time for the cascade to tail off and for the brain to settle neurons back to normal. Although no one knows quite how long is needed for the self-correction in humans, Hovda and his colleagues have done some suggestive studies in rats. Potassium, they found, rushes out of the cells for minutes, calcium rushes in for days, and sodium rushes in for hours to days. The constriction of blood vessels can also last for days. There is a damning after-effect as well: once the brain manages to increase metabolism to meet the cells' high energy demands, it goes into a state of metabolic depression. The

JOE PATRONITE The Image Bank

A HEADS UP ON HEADERS

Concern about concussions in youth soccer has surged as rapidly as the sport's popularity has. Some scientists are now questioning the wisdom of "heading" the ball, at least for players under 12 years old. Others disagree, citing one study that found that by far the most concussions in soccer come from collisions with other players, especially when more than one are trying to head the ball.

"All of us suspect that the momentum of a ball on a young child's head, especially if it hits them when they're not ready, is a possible concussion scenario," says James P. Kelly, an expert in sports-related concussions who is based at Northwestern University Medical School. "But we have very little evidence that heading the ball per se is dangerous."

Also under debate is the long-lasting effect of years of headers. A 1999 study of amateur adult soccer players, swimmers and runners in the Netherlands (the average age was 25) found that on tests of memory and planning soccer players performed the least well. Some of the researchers concluded that the soccer players were suffering from chronic traumatic brain injury, or "punch-drunk syndrome," and oppose heading the ball on the basis of this study. Other scientists, however, think that factors such as head collisions and regular drinking could account for the lower scores.

Most physicians say that more testing is needed before concluding that headers should be banned, at a minimum for young players. But some concerned parents are clamoring for protective headgear, and entrepreneurial operations have surfaced to offer it. The armor varies from glorified cloth headbands to neoprene helmets. Whether they work, or are needed, is up in the air. —P.S.

brain "sort of gets exhausted," as Hovda describes it. The exhaustion lasts longer than the other chemical effects do.

The more severe the concussion, the longer the cascade continues. If a second concussion interrupts the brain's quest for equilibrium, Hovda says, a new cascade starts on top of the first one. The resulting damage is not just additive but multiplicative.

The chemical cascade helps explain the symptoms of concussion. "The cells in the brain have to fire in order for you to learn or remember something," Hovda says. "If they can't fire because they can't pump the chemicals where they have to go, or are exhausted, then you can't learn." Learning and retrieving information also require your cells to pro-

duce certain proteins. Protein synthesis takes energy—exactly what the concussed brain is short of. "It's not that the information isn't there," Hovda says. "It's that you can't access it."

Blows that twist the head—such as the elbow to Lindros's jaw or a right cross in boxing—cause worse harm than head-on hits. While setting off the chemical cascade, the wrenching action can also stretch or even sever neuronal pathways, adding permanent, local damage to the trauma.

Physicians try to treat certain symptoms of concussion by administering painkillers for headaches or antidepressants for some personality problems. But so far there's no effective treatment for the concussion itself except time. "I find it very depressing," Hovda says. "In the last 10 to 20 years there have been more than 25 clinical trials of treatments for head injury, and none of them have been successful. The problem is that the treatments target a particular part of the cascade. But no one knows how long these cascades last, so a drug given at one point may be beneficial but may be detrimental later."

THE MOST DANGEROUS SPORTS

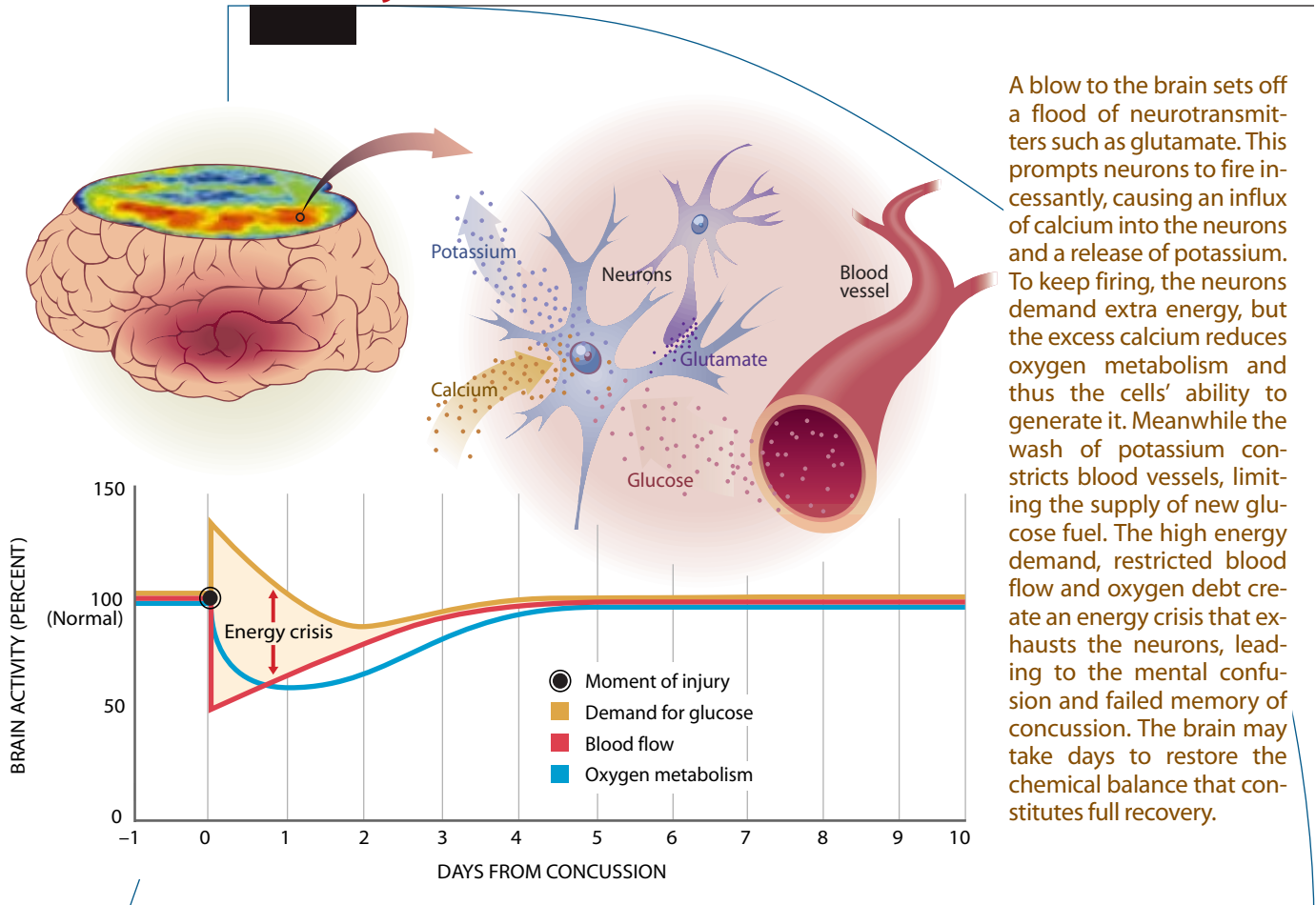
The consequences of a concussion vary greatly from individual to individual. In their neuropsychological tests, Collins and Lovell found that athletes with learning disabilities such as dyslexia had greater cognitive deficits following concussions than their teammates did. Genes may also play a part. Barry D. Jordan, a neurologist at the Burke Rehabilitation Hospital in White Plains, N.Y., and his colleagues compared boxers who have *APOE*ε4, a gene associated with Alzheimer's disease, with boxers who have more common versions of the same gene. The *APOE*ε4 fighters were more likely to suffer from chronic traumatic brain injury, sometimes called dementia pugilistica or punch-drunk syndrome.

Hovda says that pregnant women may take a blow harder because they have extra blood circulating in their brains. And young people may react differently than adults. Some animal studies suggest that injury may lessen the brain's plasticity—its ability to learn new things and change—at least temporarily, especially in adults.

The threat varies from sport to sport, of course. In a three-year study published in September 1999, John W. Powell and Kim D. Barber-Foss, then at Med Sports Systems in Iowa City, studied concussions in varsity athletes from 235 high schools. Of the 10 sports they tracked, boys' football accounted for the most brain injuries by far—63.4 percent of 1,219 reported concussions. Boys' wrestling ranked second, with 10.5 percent. Soccer and basketball for both sexes were the next most dangerous. At the bottom was girls' volleyball, with only six concussions, or 0.5 percent. (The study didn't look at girls' football, girls' wrestling or boys' volleyball.)

Equally interesting are the patterns of brain injury within a sport. Football is hardest on quarterbacks; their concussion rate was nearly twice that of run-

Anatomy of a Concussion



SOURCE: David A. Hovda, UCLA School of Medicine

SAMUEL VELASCO

HOW SERIOUS A BLOW?

The American Academy of Neurology has issued the following guidelines for recognizing and managing sports-related concussions:

GRADE 1

Symptoms: No loss of consciousness; transient confusion; mental-status abnormalities last less than 15 minutes.

Management: Remove the athlete from the activity; examine immediately and at five-minute intervals. Allow to return to sports that day only if symptoms resolve within 15 minutes. Any athlete who incurs a second Grade 1 concussion the same day should be removed from sports until symptom-free for one week.

GRADE 2

Symptoms: No loss of consciousness; transient confusion; mental-status abnormalities last longer than 15 minutes.

Management: Remove the athlete from the activity; examine frequently to assess the evolution of symptoms. Get more extensive, diagnostic evaluation if symptoms persist or worsen for longer than one week. Remove

from sports activity until symptom-free for one week. Any athlete who incurs a Grade 2 concussion subsequent to a Grade 1 concussion on the same day should be removed from sports until symptom-free for two weeks.

GRADE 3

Symptoms: Loss of consciousness, either brief (seconds) or prolonged (minutes or longer).

Management: Remove the athlete from sports until symptom-free for one week if the loss of consciousness is brief, for two weeks if the loss of consciousness is prolonged. If still unconscious or if abnormal neurological signs are present at the time of initial evaluation, the athlete should be transported by ambulance to the nearest emergency department. If a subsequent brain scan shows brain swelling, contusion or other intracranial pathology, the athlete should be removed from sports for the season and be discouraged from returning to contact sports.



ning backs and more than twice that of linebackers. Most concussions in soccer came from collisions with other players, especially when more than one tried to head the ball. For all the sports except volleyball, the injury rate was up to 14 times greater during games than during practice. That makes sense, because players go at it harder and may be less likely to worry about protecting themselves when the score is at stake. And athletes who sustained more than one concussion tended to get their second in the same season as the first, rather than later—perhaps because of impairment from the first concussion.

High on everyone's list of treacherous sports is boxing. "I'm certainly on board with the American Medical Association, the American Academy of Neurology and various other physician groups that for 20 years have called for a ban on boxing," Kelly says. "The goal is to produce brain injury in your opponent before he produces it in you. We don't think that's a sport." But Jordan counters that "if boxing is banned it'll go underground, and the potential for injury will be horrendous. The general public has no idea how destructive that would be. In New York State, [unlicensed] boxing was banned during the 1920s. There was boxing going on in basements and in bars, with no safety rules or controls, and people gambling on the outcome. We don't want to go back to that."

Doctors agree that the benefits of playing most sports far outweigh the risks. "Most of us are interested in making sports safer and elevating the level of competition so that it is not just one step away from a brawl," Kelly says. Equipment can help.

Helmets should fit properly and be hard, so that blows bounce off rather than twist the head. Mouth guards can absorb force and reduce it from the joint of the jaw. Training can help, too; athletes should work on their neck muscles, because a strong neck can carry the force of a blow away from the head into the torso.

Leagues should also impose rules that emphasize head safety, and referees should enforce them. But most of all, doctors, coaches, trainers, parents and athletes themselves need to understand the symptoms of concussion so that they can guard against the dangers posed by repeat blows to the head. After all, we're not like cartoon characters who can survive any number of anvils dropped on the head. For thousands of sports enthusiasts as well as pros, paying close attention to those seemingly minor symptoms will help protect the athlete's most important piece of gear: the brain.

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FURTHER INFORMATION

A collection of articles on brain injury in high school, college and professional athletes can be found in the *Journal of the American Medical Association*, Vol. 22, No. 22; September 8, 1999.

The Brain Injury Association's Web site on concussion is available at www.biausa.org/sportsfs.htm, and the American Association of Neurology concussion Web site can be found at www.aan.com/public/concussionsportsindex/sportsconcussion.htm

BLURRY CHOICE: A ban on boxing could reduce cases of brain damage—or send the sport underground, where fighters would be even less protected than they are now.