Although it does not account for the majority of sports-related concussions, American football is certainly responsible for the heightened public awareness of this condition. News stories of spectacular—sometimes fatal—head injuries on the field, as well as new research into a condition recently coined “chronic traumatic encephalopathy” (CTE), has focused public attention on the dangers of football. As a result, there is renewed interest in mitigating the potential neural trauma related to contact sports. Protecting the players in the face of an intrinsically violent sport has been a significant challenge for both those who officiate these games and the manufacturers of the equipment being used.

In 1938, the original “leatherhead” helmets were replaced by more rigid helmets to reduce the potential for head injury. These “crash helmets,” which were popular for over 2 decades, contained no internal padding but rather had a web suspension system that did little to dissipate the kinetic energy of a direct blow to the head. Recognition that these plastic enclosures provided insufficient protection against injury prompted neurosurgeon Richard Schneider to redesign the football helmet, with an eye to protecting both the brain and the cervical spine. Acknowledging the importance of impact duration and deceleration forces, Dr. Schneider strongly advocated the use of material within the helmet that would permit more deformation and more gradual deceleration of the head. In addition, Schneider recommended equipping the back of the helmet with a “skirt” of sponge rubber that would prevent a knife-like blow to the cervical spine during hyperextension. Even years before the description of diffuse axonal injury, Dr. Schneider recognized the importance of reducing the suddenness of impact and worked tirelessly to design a helmet that would mitigate the effects of sudden deceleration. Schneider’s experimental work on the mechanisms of brain and spine injury resulted in the creation of a helmet equipped with air-filled bladders that cushioned the skull from direct impact (Fig. 1). However, the design of this helmet—which became the standard in the 1970s—was principally geared toward cushioning the blow and decreasing direct impact forces. Although Schneider and others clearly recognized the importance of reducing direct impact forces and lengthening the period of impact, a clear understanding of traumatic brain injury was in its infancy at the time. Consequently, the testing of protective gear was fairly elementary and did not include the modeling of rotational acceleration forces. Our understanding of sports-related concussion has greatly improved over the subsequent 4 decades, and we are now in the position to examine protective gear with far better models and metrics.

In the accompanying article, Lloyd and Conidi examined football helmet design in detail by using a more sophisticated model, with specific attention to how well different designs protect the brain from traumatic forces. They utilized a phantom model and several testing paradigms to gauge how well these helmets shield their wearers from concussive forces as well as rotational acceleration injuries. Importantly, the authors look at both modern helmets and older, retired models. This type of broad comparison allows us to gain insight into not only individual manufacturing differences, but also the effect of changes in design concepts. Moreover, the analysis allows us to deconstruct the components of sports-related head injury, separating out parameters such as linear acceleration, rotational acceleration, and impact duration—each of which can lead to brain injury but can be differentially mitigated by the various helmets. Among the 21 helmets tested, the Schutt Vengeance was found to be the most protective overall, although in individual metrics it did not necessarily lead the pack (for example, it was eclipsed by the 1930s MacGregor-Goldsmith leatherhead in angular acceleration, and had less concussion protection than the Rawlings Quantum helmet). Importantly, the authors found that
none of the helmets provided absolute protection from significant head injury in game conditions.

This study showcases the advances made in biomechanical testing in the years since Schneider’s seminal experimental work. However, it is sobering to note that even the best helmet tested could not provide adequate protection in the face of game conditions. In fact, there is evidence that suggests that improvements in helmet design may have actually increased the risk of catastrophic head injury in football, as competitive players attempt to use the helmet as a weapon. The mitigation of direct impact forces afforded by the helmet and facemask have emboldened players to tackle their opponents using their heads. Despite attempts by officials to discourage players from hitting opposing players with their helmets, the “weaponization” of the football helmet has compromised efforts made by physicians, engineers, and equipment manufacturers to protect the players from injury. Richard Schneider campaigned vigorously against the use of the helmet as a tackling tool because of the dangers of both head and cervical cord injuries.

Helmet designs will continue to improve over time, with improvements in materials and in our understanding of the forces responsible for brain injury. As they have in the past, neurosurgeons should lead studies on brain injury, protecting our athletes from sports-related brain and spine injuries. However, it is clear that this effort will not be sufficient to eliminate the risk of sports-related brain injury and its long-term sequelae. We must also redouble efforts to recognize and eliminate the type of contact that puts the player at risk not only for immediate brain injury, but also for the chronic effects of repetitive minor injury.

And that is a tall order in a popular sport that has always prided itself on physicality and toughness.


References

Disclosure
The authors report no conflict of interest.

Response
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We thank Drs. Sagher and McGillicuddy for their thorough review of and positive comments regarding our article. Considering the current epidemic of sports-related concussions and traumatic brain injuries (TBIs), we believe our article is particularly timely and hope that our contributions will fuel additional research toward the development of advanced headgear to provide better protection against TBI for sports participants of all ages.

In the meantime, we concur with Drs. Sagher and McGillicuddy that steps must be taken to eliminate the type of contact that puts players at risk for not only immediate brain injury, but also the chronic effects of repetitive minor injury. Furthering our research in the area, we look forward to expanding upon current testing to evaluate sports helmets for various applications, including motorcycling, hockey, lacrosse, and horse riding. Additionally, we propose developing testing protocols that evaluate protective headgear at impact velocities associated with typical concussive events.