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Pay Now, Play Later?: Youth and Adolescent Collision Sports

Vivian E. Hamilton

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VIVIAN E. HAMILTON[†]

The routine and repeated head impacts experienced by athletes in a range of sports can inflict microscopic brain injuries that accumulate over time, even in the absence of concussion. Indeed, cumulative exposure to head impacts—not number of concussions—is the strongest predictor of sports-related degenerative brain disease in later life. The observable symptoms of disease appear years or decades after initial injury and resemble those of other mental-health conditions such as depression and dementia. The years-long interval between earlier, seemingly minor, head impacts and later brain disease has long obscured the connection between the two.

Risk of injury differs across demographics, implicating questions of social justice and complicating potential policy responses. For example, younger athletes, whose brains are still developing, are especially vulnerable to injury. Black boys and men participate in football at disproportionately high rates and are thus likely to suffer the effects of repeated head impacts at disproportionately high rates. Finally, female athletes have higher rates of injury and take longer to recover than do males in sports played by both sexes. It is unknown whether female athletes also have higher risk of long-term disease, because sex-related differences have received little attention.

Scholarship has addressed the legal implications of sports-related concussions suffered by young athletes, the overrepresentation of African-American boys and men in sport, and the underrepresentation of girls and women in sport. Legal scholars have not yet addressed the insidious effects of impacts that appear to cause no injury at all, or their disproportionate impact on groups already disadvantaged in other respects—the young, female athletes, and African-American male athletes. This Article addresses those issues, evaluates current reform measures, and concludes by suggesting a range of reforms including education, litigation, and law reform.

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INTRODUCTION

In what may be the first lawsuit of its kind, the estate of a former youth football player who committed suicide sued the organization that operated the youth league in which he played as a boy.[1] Joseph Chernach played youth tackle football for a Wisconsin team for four years beginning at age eleven.[2] After high school, he enrolled in college at Central Michigan University, but his mental health reportedly began to decline in his sophomore year.[3] Chernach left university and returned home where, at age twenty-five, he committed suicide by hanging.[4] An autopsy revealed that Chernach suffered from a degenerative brain disease, chronic traumatic encephalopathy (CTE), linked to repeated hits to the head.[5]

Chernach's mother, Debra Pyka, sued Pop Warner, the largest youth football organization in the nation, which operated the youth league in which her son had played. The complaint alleged that the head impacts Chernach sustained over four years of youth tackle football contributed to the neuropathology that ultimately led to his death.[6] Pyka sought $5 million in compensatory and punitive damages and asserted strict liability, negligence, and reckless conduct claims.[7] In February 2016, the youth league settled the lawsuit for an undisclosed sum.[8]

Apart from the tragedy of any premature death, two aspects of Chernach's story, and his mother's subsequent suit, are especially notable. First, unlike the athletes who obtained widely reported settlements with professional and collegiate athletic associations, Chernach did not participate in sport at an elite level. Instead, like millions of young athletes, he participated in a variety of sports through high school. Second, although his mother believed Chernach had experienced concussions, Chernach was never diagnosed with a concussion during his four years of youth football. Instead, Pyka's suit alleged that his death was the consequence of Pop Warner's negligently "allowing small children to play a violent pseudo warrior sport."[9]

A growing body of research supports the claim that repeated head impacts during the period when young people's brains are maturing—even in the

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1. Complaint, Pyka v. Pop Warner Little Scholars, Inc., No. 3:15-CV-00057 (W.D. Wis. 2016). Chernach continued playing football in high school, where he also wrestled and competed in track & field. *See* Ken Belson, *Pop Warner Settles Lawsuit over Player Who Had C.T.E.*, N.Y. TIMES (Mar. 9, 2016), https://www.nytimes.com/2016/03/10/sports/football/pop-warner-settles-lawsuit-over-player-who-had-cte.html.

2. Complaint, *supra* note 1, at 17.

3. *Id.* at 19.

4. *Id.* at 18.

5. *Id.* at 20.

6. *Id.* at 18.

7. *Id.* at 20–26.

8. Belson, *supra* note 1; *see also* Stipulation of Dismissal with Prejudice, *Pyka*, No. 3:15-CV-00057 (W.D. Wis. 2016).

9. Complaint, *supra* note 1, at 22.

absence of concussion—can lead to later-life neurologic disease and even death.[10]

Minor jolts to the head experienced by millions of athletes across a number of competitive sports—body-checking in ice hockey, heading a ball in soccer, and tackling in football, for example—typically cause no noticeable symptoms of traumatic injury or concussion. Each hit can nonetheless cause microscopic injuries within the brain, known as subconcussions.[11] The effects of these microscopic injuries accumulate over time and can lead to diffuse and crippling neurological damage.[12] Male and female athletes in a range of sports are vulnerable to brain injury. Recent national studies of high school and collegiate athletes, for example, found that male ice hockey players and wrestlers, and female ice hockey, field hockey, and soccer players all experience head impacts at rates similar to—or exceeding—those experienced by football players.[13]

Researchers have focused on the long-term effects of concussions. But recent studies suggest that concussion history is not the strongest predictor of later-life neurological consequences—instead, it is cumulative exposure to repeated head impacts over one's athletic career.[14] Thus, individuals who played football or other collision sport without ever suffering a diagnosed concussion are nonetheless at significant risk of later-life brain disease, depending on the number and types of impacts sustained.[15] Indeed, a 2017 study found that nearly one in three individuals who experienced repetitive head impacts eventually developed the degenerative brain injury known as chronic traumatic encephalopathy.[16] Yet until recently, this long-term brain injury caused by repeated head impacts has gone all but undetected as a public health concern, and has yet to be addressed by policymakers.

This Article gathers research from across disciplines—biomechanics, developmental neuroscience, law, and sociology—to describe sports-related

10. *See, e.g.*, Michael L. Alosco & Robert A. Stern, *Youth Exposure to Repetitive Head Impacts from Tackle Football and Long-term Neurologic Outcomes: A Review of the Literature, Knowledge Gaps and Future Directions, and Societal and Clinical Implications*, 30 SEMINARS IN PEDIATRIC NEUROLOGY 107 (2019); *see also* Sumra Bari et al., *Dependence on Subconcussive Impacts of Brain Metabolism in Collision Sport Athletes: An MR Spectroscopic Study*, 13 BRAIN IMAGING & BEHAV. 735, 736 (2018) (citing studies and observing that "a growing body of research has now demonstrated that asymptomatic athletes are also at the risk of functional and structural brain damage."); *infra* Subpart I.A.

11. Michael L. Lipton et al., *Soccer Heading Is Associated with White Matter Microstructural and Cognitive Abnormalities*, 268 RADIOLOGY 850, 851 (2013).

12. Julian E. Bailes et al., *Role of Subconcussion in Repetitive Mild Traumatic Brain Injury: A Review*, 119 J. NEUROSURGERY 1235, 1236 (2013).

13. *See infra* Tables 1 & 2; *see also infra* Subpart I.B.

14. Philip H. Montenigro et al., *Cumulative Head Impact Exposure Predicts Later-Life Depression, Apathy, Executive Dysfunction, and Cognitive Impairment in Former High School and College Football Players*, 34 J. NEUROTRAUMA 328, 329, 335–36 (2017). Researchers also considered a number of other potential variables, including age at first exposure to collision sport. *Id.* at 329.

15. *See infra* Subparts I.A. & I.B.

16. Breton M. Asken et al., *Research Gaps and Controversies in Chronic Traumatic Encephalopathy: A Review*, 74 JAMA NEUROLOGY 1255, 1257 (2017).

brain injuries and their negative effects on public health and social justice. It examines reform efforts to date, which have included league rule changes, litigation, and legal reform. It then identifies the different systems, such as family intervention, schools, and sports associations, that together constitute the environment in which young athletes participate in competitive sport in order to identify areas in which interventions or reforms might occur.

Like concussions, subconcussions occur when blows to the head or body transfer mechanical energy to the brain with enough force to damage brain cells and injure neural integrity.[17] Unlike concussions, subconcussions cause no immediately observable clinical symptoms.[18] Yet damaged cells wither then die, and tangles of detritus eventually litter the brain.[19] Symptoms can emerge years or decades after initial injury and can implicate mood, behavior, and cognitive function.[20] Traumatic brain disease is degenerative, eventually resulting in death.[21]

Several factors have combined to obscure the prevalence and severity of impact-related brain disease. First, the observed symptoms tend not to appear until adulthood or midlife—frequently decades after an individual has left sport.[22] The passage of time obscures the relationship between head impacts and the later pathology. Second, it is counterintuitive that a head impact that causes no discernible injury at the time of trauma might nonetheless be the cause of debilitating symptoms years or even decades later.[23] Third, the symptoms of sports-related brain injury mirror those of a host of other neurological conditions, including age-related disease unrelated to head trauma.[24] It is thus likely that individuals diagnosed with a number of illnesses, ranging from depression to dementia, are instead suffering the effects of

17. Concussion is also referred to by scientists as "mild traumatic brain injury" (mTBI) and is defined as "a clinical syndrome involving a disturbance in brain function that is generally time-limited and results from biomechanical forces, such as a bump, blow, or jolt to the head or body." COMM. ON SPORTS-RELATED CONCUSSIONS IN YOUTH, NAT'L RES. COUNCIL, SPORTS-RELATED CONCUSSIONS IN YOUTH: IMPROVING THE SCIENCE, CHANGING THE CULTURE 27 (Robert Graham et al. eds., 2014) [hereinafter SPORTS-RELATED CONCUSSIONS IN YOUTH].

18. Bailes et al., *supra* note 12, at 1235.

19. *Id.* at 1241.

20. *Id.*

21. *Id.*

22. Cyrus Safinia et al., *Chronic Traumatic Encephalopathy in Athletes Involved with High-Impact Sports*, 9 J. VASCULAR & INTERVENTIONAL NEUROLOGY 34, 37 (2016).

23. *See, e.g.*, Ann C. McKee, *Association Between Repetitive Head Impacts and Development of Chronic Traumatic Encephalopathy*, THE BRIDGE, Spring 2016, at 56.

24. Safinia et al., *supra* note 22, at 37 ("Clinical diagnosis of CTE remains challenging due to symptomatic overlap with other neurodegenerative diseases."); *see also id.* at 37 tbl.1 (including among the neurodegenerative diseases whose symptoms can mimic those of CTE: Alzheimer's disease, dementia, and Parkinson's Disease; in addition to clinical (symptomatic) overlap, researchers have also found pathological overlap between CTE and other neurodegenerative diseases); *see also* Douglas H. Smith, *Neuromechanics and Pathophysiology of Diffuse Axonal Injury in Concussion*, THE BRIDGE, Spring 2016, at 79, 80 (explaining that the two most prevalent characteristics of CTE pathology "are similar to tissue accumulations in other neurodegenerative diseases").

sports-related brain injuries.[25] And finally, the institutional actors with the greatest access to information—namely, large sports associations and the industries that exist in their orbit—also have financial and self-preservative incentives to play down the nature of the risk and to curtail the widespread dissemination of the accumulated research.[26]

The Article proceeds as follows: Part I describes the injuries and the athletes most susceptible to them. It begins by explaining the mechanisms by which seemingly minor injuries can, when accumulated, lead to degenerative neurological damage. It next describes the short-term and long-term effects of repeated head impacts and identifies the sports in which injuries are most likely to occur. Lastly, Part I identifies the groups at heightened risk of injury and the factors that render them vulnerable. They include youth and adolescents, female, and African-American/other racial minority male athletes.

Part II outlines the societal costs imposed by brain injuries resulting from repeated subconcussive head impacts and concludes that these injuries present a significant, albeit under-recognized, public health and policy challenge. Health care and caregiving expenses, insurance and litigation expenses, and lost productivity combine to easily reach billions of dollars annually. Moreover, those expenses do not capture the mental anguish and diminished quality of life experienced by affected former athletes and their families.

Part III describes reform efforts that have been implemented to date. It explains that rule changes and legal reforms targeting sports-related concussions (for example, "concussion protocols") will do little to reduce the incidence of later-life brain damage. To be effective, interventions must instead aim at preventing the sorts of head impacts that predictably lead to neural injury.

Part IV explores a range of possible reforms aimed at reducing the incidence of injurious head impacts. It draws on ecological systems theory, widely used by developmental psychologists to understand individuals within the various contexts that influence their lives in order to identify potential sites where various sorts of interventions might succeed.[27]

25. *See* Safinia et al., *supra* note 22, at 36, 38.

26. After committing $100 million to the National Institute of Health for brain research, for example, the National Football League (NFL) backed out of the partnership when the Institute funded a study by a researcher that the NFL considered to be overly critical of the league. *See* Laurel Wamsley, *NFL, NIH End Partnership for Concussion Research with $16M Unspent*, NPR (July 29, 2017), https://www.npr.org/sections/thetwo-way/2017/07/29/540238260/nfl-ends-partnership-with-nih-for-concussion-research-with-16m-unspent. *But cf.* Correspondence from Matthew Mitten, Professor of Law and Executive Director of the National Sports Law Institute at Marquette University Law School, to author (Jan. 30, 2019) (on file with author) (disputing this characterization of incentives with respect to the National Collegiate Athletic Association (NCAA)). As a member of the NCAA's Competitive Safeguards and Medical Aspects of Sports Committee from 1999-2005 (and its chair from 2002–05), Mitten noted that "[w]hen I was on [the] committee, we relied on best available medical/scientific evidence and recommended rules modifications and other precautions to protect [student-athlete] health and safety." *Id.*

27. Jennifer Watling Neal & Zachary P. Neal, *Nested or Networked? Future Directions for Ecological Systems Theory*, 22 SOC. DEV. 722, 722–23 (2013).

Youth participation in collision sports like football has already begun to decline, and the decline is likely to continue as public awareness of the risk of brain injury grows.[28] Yet in the absence of comprehensive reform, sports- related brain disease will continue at significant rates, disproportionately afflicting disadvantaged groups for decades to come.

I. THE EFFECT ON PUBLIC HEALTH OF CUMULATIVE BRAIN DAMAGE RESULTING FROM REPEATED HEAD IMPACTS

Nearly all sports and recreation activities carry some risk of injury, whether it be concussion or other head injury, and between 1.1 and 1.9 million youths aged eighteen and under experience sports and recreation-related concussions per year.[29] Millions more young people participate in sports whose rules permit the sorts of impacts that we now know are likely to cause immediate injury to cells in the brain.[30] The rules of a number of sports, moreover, make the sort of impacts likely to lead to brain injury—and long- term neurological damage—an intrinsic component of play.[31] Athletes participating in these organized sports experience higher rates of impact injury than others. The highest rates of reported concussion at both the high school and college levels correlate with football, ice hockey, wrestling, lacrosse, soccer, and basketball.[32]

Numerous studies have compared the incidence of reported *concussions* across different sports, but my research found no studies comparing the incidence of *head impacts overall* across different youth sports.[33] The difference between subconcussion and concussion appears to be one of degree, not kind. Indeed, researchers have argued that "the simple classification of 'concussive' (i.e., symptom-inducing) and 'subconcussive' (i.e. not producing symptoms) blows is inadequate and possibly misguided."[34] Instead, sports- related brain injury "should focus more on the cumulative effects of the mild, repetitive head trauma experienced on a regular basis by the majority of collision sport athletes."[35]

28. *See* Patrick Hruby, *As the Super Bowl Approaches, Is High School Football Dying a Slow Death?*, GUARDIAN (Jan. 30, 2019, 5:00 AM), https://www.theguardian.com/sport/2019/jan/30/high-school-football-numbers-drop-brain-trauma; *see also infra* Subpart II.C.

29. Mersine A. Bryan et al., *Sports- and Recreation-Related Concussions in U.S. Youth*, 138 PEDIATRICS, July 2016, at 1, 1.

30. *See infra* Subpart I.B.

31. *See infra* Subpart I.B.

32. *See* SPORTS-RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 34–35 tbls.1 & 2. Studies report concussions per "athletic exposure," or a single individual participating in a single practice or competition in which there is exposure to possible athletic injury). *Id.* at 28, n.2.

33. Researchers measure concussion rates through studies gathering data reported by athletes, athletic trainers, and other personnel. *Id.* at 60-61. They measure head impacts using technological devices attached to helmets or other headgear. *Id.*

34. Diana O. Svaldi et al., *Cerebrovascular Reactivity Changes in Asymptomatic Female Athletes Attributable to High School Soccer Participation*, 11 BRAIN IMAGING & BEHAV. 98, 99 (2017).

35. *Id.*

Studies have found direct evidence that repeated subconcussive impacts—those that do not cause symptoms or receive a diagnosis of concussion—can cause neuronal damage that accrues, causing lasting neurological injury and eventual symptoms of disease.[36] In a 2013 review of research published in the *Journal of Neurosurgery,* a multidisciplinary team of scientists noted "that subconcussion is a previously underrecognized phenomenon" and urged greater "appreciation of its ability to cause significant current and future detrimental neurological effects."[37]

Researchers have begun to understand the mechanisms by which repeated subconcussive blows to the head result in accrued damage to neurophysiologic function. The following Subparts describe the mechanisms of injury and resulting pathology, compare the injury risk posed by different sports, and examine demographic characteristics of different groups of athletes at heightened risk of sports-related brain injury.

A. Injury and the Delayed Onset of Disease

Researchers studying the effects of brain trauma have had to overcome (and indeed, continue to grapple with) a number of challenges.

First, unlike injuries that are visible to the naked eye or observable using x-ray, MRI, or other technologies, it is virtually impossible to observe brain injury using common imaging techniques. Instead, injury tends to occur at the cellular level, across different areas of the brain. There is no conclusive diagnostic test or biomarker that indicates concussion, much less subconcussion. The basis for diagnosis instead is the presence of a constellation of symptoms, usually self-reported by the athlete following a hit to the head or body.[38]

Second, the injuries incurred at the time of impact lead to a prolonged process of neurodegeneration, which unfolds over a period of years. While the neural injuries caused by concussive impacts lead to observable symptoms (for example, dizziness, loss of balance or consciousness), typical subconcussive impacts cause no immediate symptoms that might alert the athlete or others to the accumulating neural injuries.

Finally, it is easy for clinicians to overlook the potential link between sports injuries and brain disease, given that the clinical symptoms of sports- related neurodegenerative injury overlap with those of other mental illness or age-related brain disease.[39]

36. *See, e.g.*, Kausar Abbas et al., *Effects of Repetitive Sub-Concussive Brain Injury on the Functional Connectivity of Default Mode Network in High School Football Athletes*, 40 DEV. NEUROPSYCHOL. 51, 51–52 (2015).

37. Bailes et al., *supra* note 12, at 1236. The authors were comprised of neurosurgeons, a pathologist, and professors of mechanical, biomedical, and electrical and computer engineering. *Id.* at 1235.

38. SPORTS-RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 102–03. To assist in diagnosis, athletic and medical personnel typically use evaluation tools including symptom scales and checklists, balance testing, and neurocognitive assessments. *Id.*

39. *See* Safinia et al., *supra* note 22, at 38, 45.

The following subparts briefly describe the effects of impacts on the brain and subsequent development of disease.

1. *The Brain Following Impact*

Every body continues in . . . uniform motion . . . unless it is compelled to change that state by forces impressed upon it.[40]

The brain is a soft organ,[41] essentially floating in fluid within the skull. When an impact to the head or body, like a tackle, abruptly stops or changes the path of the skull's movement, the brain continues moving until it hits the inside of the skull. Researchers have used various methods to study the biomechanics of head impacts: helmet or mouthpiece sensors that measure the magnitude, direction and type (for example, linear, rotational, etc.) of head motion, computational models using laboratory-based studies and surrogates (for example, crash-test dummies), and laboratory-based experimental preparations using animals, tissues, cells, and cell matter.[42]

The effect any given impact has on the brain depends on a number of variables, including the magnitude and nature of the impact. Individual injury threshold varies as well; Subpart I.C. discusses some of the more significant of these factors (including size, developmental stage, and sex). Researchers believe a series of events, however, occur to greater or lesser degrees following mild through severe brain injuries.

Upon impact with the skull, the brain momentarily deforms, and the force can cause rapid stretching and shearing of brain tissue.[43] The brain's white matter is especially susceptible to injury caused by rapid stretching.[44] White matter comprises highly organized and directional bundles of axons—long, threadlike tracts emanating from neurons (the nerve cells in the brain).[45]

Axons transmit electrical impulses between neurons and to other parts of the central nervous system.[46] Stretch injury can disrupt the ability of membranes within the axon to regulate ion concentrations, which is necessary for the rapid transmission of impulses.[47] Rapid stretch can also lead to the physical breaking of microtubules, which are stiff cytoskeletal structures within axons that transport proteins and materials necessary for axonal functioning.[48]

40. SIR ISAAC NEWTON, MATHEMATICAL PRINCIPLES OF NATURAL PHILOSOPHY 83 (1846).

41. Christopher C. Giza et al., *It's Not All Fun and Games: Sports, Concussions, and Neuroscience*, 94 NEURON 1051, 1051 (2017).

42. SPORTS-RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 60–61.

43. Smith, *supra* note 24, at 79–80.

44. *Id.* at 80. Smith posits that the "highly organized, highly directional structure" of the brain's white matter may make it prone to damage from tensile and shear forces caused by rotational head acceleration. *Id.*

45. *Id.*

46. *The Neuron*, BrainFacts (Apr. 1, 2012), https://www.brainfacts.org/brain-anatomy-and-function/anatomy/2012/the-neuron.

47. Smith, *supra* note 24, at 81.

48. *Id.* at 80.

The brain works rapidly to reestablish normal ionic concentrations, requiring significant energy (in the form of glucose) to pump ions back to the correct side of cell membranes to reestablish brain cell function.[49]

Researchers theorize that a disruption of metabolic axonal function throughout the brain network causes the observed symptoms of concussion.[50] Symptoms can include confusion and slowed processing speed, dizziness, headache, and memory dysfunction.[51] More rarely, concussions can result in loss of consciousness.[52] It is only after brain enzymes reestablish membrane function that the brain network "resets."[53] The timing of recovery of basic brain function is highly variable—from one second to several days, in the case of coma.[54]

The abnormal concentrations of ions—calcium, in particular—that immediately follow injury also activate enzymes that break down proteins. Together with the mechanical damage to cytosketal structures, these enzymes contribute to neurochemical changes that degrade axonal structures and impair function.

Proteins that travel along the microtubule tracks can accumulate at sites where breakage has occurred, causing partial or complete transport interruption and swelling along the injured axon.[55] Thus, while axons themselves do not typically disconnect entirely at the moment of trauma, the accumulation of proteins caused by transport interruption can cause the eventual, secondary disconnection of axons.[56] Indeed, the accumulation of one of these proteins, amyloid precursor protein (APP), is used by scientists as a characteristic indicator of axonal injury.[57] The accumulation of another, the tau protein, which operates to stabilize the parallel arrangements of microtubules along axons, has been identified as an indicator of the neurodegenerative disease, CTE.[58]

Finally, some evidence suggests that brain injuries can also result in pituitary dysfunction.[59] Of children with mild to moderate brain injuries, forty-two percent (predominantly boys) had significantly lower-than-normal levels of growth hormone.[60] More research regarding pituitary and hormonal changes

49. SPORTS-RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 69–70.

50. Bailes et al., *supra* note 12, at 1239; Smith, *supra* note 24, at 81;

51. Bailes et al., *supra* note 12, at 1235; Thomas F. Budinger, Editor's Note, *An Overview of Concussion: History and Needed Research*, THE BRIDGE, Spring 2016, at 5, 13.

52. Bailes et al., *supra* note 12, at 1235. Loss of consciousness occurs in approximately ten percent of cases. *Id.*

53. Budinger, *supra* note 51, at 10.

54. *Id.*

55. Smith, *supra* note 24, at 80.

56. *Id.* at 81.

57. SPORTS-RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 76.

58. Smith, *supra* note 24, at 80–81.

59. SPORTS-RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 79.

60. *Id.* at 78.

that occur specifically after subconcussive and concussive impacts is required.[61]

2. *Short-Term Neurophysiological Changes*

The effects of repeated head impacts, even absent diagnosed concussion, can begin appearing after even a single season of play.[62] Studies of male and female athletes across various sports found that repetitive subconcussive blows, measured by helmet sensors, were associated with measurable cognitive and physiological changes in the brain.[63] Repeated impacts were associated with cognitive decline,[64] functional brain alterations,[65] and abnormalities in white matter microstructure.[66]

A 2017 study involving high school football players established "a linkage between the degree.......of exposure to repetitive subconcussive impacts and the degree of pathophysiological change in the brains of collision-sport athletes."[67]

In another study, an interdisciplinary team of scientists researched the head impacts of high school football players over two seasons.[68] The

61. *See id.* at 79.

62. Semyon M. Slobounov et al., *The Effect of Repetitive Subconcussive Collisions on Brain Integrity in Collegiate Football Players over a Single Football Season: A Multi-Modal Neuroimaging Study*, 14 NEUROIMAGE: CLINICAL 708, 708 (2017).

63. Kausar Abbas et al., *Alteration of Default Mode Network in High School Football Athletes Due to Repetitive Subconcussive Mild Traumatic Brain Injury: A Resting-State Functional Magnetic Resonance Imaging Study*, 5 BRAIN CONNECTIVTY 91, 93 (2015).

64. *See* Thomas M. Talavage et al., *Functionally-Detected Cognitive Impairment in High School Football Players Without Clinically-Diagnosed Concussion*, 31 J. NEUROTRAUMA 327, 327 (2014) (listing neurological conditions).

65. Abbas et al., *supra* note 36, at 55; Abbas et al., *supra* note 63, at 96; Katherine Morigaki Breedlove et al., *Detecting Neurocognitive & Neurophysiological Changes as a Result of Subconcussive Blows Among High School Football Athletes*, 6 ATHLETIC TRAINING & SPORTS HEALTH CARE 119, 119 (2014); Andrew R. Mayer et al., *A Longitudinal Assessment of Structural and Chemical Alterations in Mixed Martial Arts Fighters*, 32 J. NEUROTRAUMA 1759, 1759 (2015); Svaldi et al., *supra* note 34, at 108.

66. Jeffrey J. Bazarian et al., *Persistent, Long-Term Cerebral White Matter Changes After Sports-Related Repetitive Head Impacts*, 9 PLOS ONE, Apr. 2014, at 1, 2; I.Y. Chun et al., *DTI Detection of Longitudinal WM Abnormalities Due to Accumulated Head Impacts*, 40 DEV. NEUROPSYCHOL., 92, 93 (2015); Elizabeth M. Davenport et al., *Abnormalities in Diffusional Kurtosis Metrics Related to Head Impact Exposure in a Season of High School Varsity Football*, 33 J. NEUROTRAUMA 2133, 2142 (2016); Kian Merchant-Borna et al., *Novel Method of Weighting Cumulative Helmet Impacts Improves Correlation with Brain White Matter Changes After One Football Season of Sub-Concussive Head Blows*, 44 ANNALS BIOMED. ENGINEERING 3679, 3679 (2016).

67. Slobounov et al., *supra* note 62, at 709. The researchers quantified degree of exposure using number of impacts and average magnitude of impact. *Id.*

68. Evan L. Breedlove et al., *Biomechanical Correlates of Symptomatic and Asymptomatic Neurophysiological Impairment in High School Football*, 45 J. BIOMECHANICS 1265, 1265–66 (2012). Researchers have developed instruments that can be inserted into helmets and quantify the number, magnitude, and location of head impacts. *Id.* at 1266. In this study, the researchers installed Head Impact Telemetry System (HITS) instruments in the players' helmets and monitored head impacts at every contact practice and game over two seasons. *Id.* Head impact measurement devices not only quantify the linear and rotational acceleration of athletes' heads upon impact, but also track the number of impacts per player per season, and the location of each impact. Richelle M. Williams et al., *Head Impact Measurement Devices: A Clinical Review*, 8

researchers tracked the biomechanical history of each player, measuring impacts using instrumented helmets.[69] They also measured the players' neurophysiological function over time using functional magnetic resonance imaging (fMRI) and computer-based neuropsychological testing.[70] By measuring the athletes' functioning in the pre-season and then over the course of the football season, they were able to connect neurophysiological changes to blows sustained during practices and competition.[71]

The researchers found that total number of blows—not the magnitude of blows—correlated with progressive functional impairment.[72] They concluded that the "growing body of evidence indicates that the cumulative effect of repeated blows to the head is pathological," with the results of their study providing "direct evidence of this effect."[73]

3. *Long-Term Consequences and Neurodegenerative Disease*

Exposure to repeated head trauma correlates with subsequent development of the neurodegenenerative disease, CTE. The severity of the disease is associated with "[c]umulative exposure to trauma, not the number of concussions."[74] In other words, subconcussive impacts correlate with disease development and disease severity.[75]

Evidence suggests that occasional or infrequent impacts may not meaningfully increase the risk of later degenerative disease. Instead, risk appears to increase once the impacts experienced by an athlete exceed a threshold level. A team of researchers developed and validated a metric to estimate football players' total cumulative exposure to repeated head impacts.[76] The researchers found there to be a threshold number of impacts below which athletes showed no increased risk of neurological impairment.[77] But above a threshold number of impacts, the risk for an impairment increased linearly.[78]

The mean impact threshold varied for each type of neurological impairment. For example, the threshold number of impacts above which

SPORTS HEALTH 270, 270 tbl.1 (2016). HITS is the most widely used system and has been employed to measure impacts in football and ice hockey at all levels of play. *Id.*

69. Breedlove et al., *supra* note 68, at 1265–66.

70. *Id.* at 1266.

71. *Id.* at 1268.

72. *Id.* at 1267.

73. *Id.* at 1271.

74. McKee, *supra* note 23, at 59. Ann McKee is Director of the CTE Program and Professor of Neurology and Pathology at Boston University.

75. *See id.* at 59.

76. Montenigro, et al., *supra* note 14, at 329. The researchers termed the metric the "cumulative head impact index," or CHII. *Id.* They surveyed former high school and college football players, calculating the athletes' cumulative head exposure and identifying whether the athletes suffered one or more clinically meaningful neurological impairments. *Id.* at 329.

77. *Id.* at 335.

78. *Id.* at 334 fig.2.

athletes experienced a heightened risk of developing depression was approximately 1800 impacts.[79] For context, the average number of impacts per season was 545.[80] The threshold means for behavioral dysregulation, executive function impairment, and apathy were slightly higher, between 1850–2216.[81] The threshold for cognitive function was much higher, at 7251.[82] The authors of the study note that in individuals found to have had CTE, cognitive symptoms present later than behavioral impairments.[83]

In 2016, a panel of expert neuropathologists convened to define the microscopic diagnostic criteria for CTE.[84] The panel identified the condition as a unique pathology characterized by an accumulation of abnormal protein tangles distributed in an irregular pattern throughout the brain.[85] Once the disease has advanced, observable macroscopic changes include reduced brain weight and cerebral atrophy.[86]

CTE manifests in one or more of the following domains: mood disorder, behavior symptoms, cognitive deficits, and motor symptoms.[87]

Mood and behavior symptoms include depression, volatility, violence and rage, loss of control and impulsivity, and paranoia.[88] The most prominent cognitive deficits include deficits in memory, executive function, and attention.[89] Motor symptoms can include difficulty with speech, decreased coordination, and Parkinsonism (tremor, rigidity, and gait instability).[90] Nearly one-third of sufferers experience chronic headache.[91]

Because the damage tends to be distributed throughout the brain, it is difficult to identify with traditional screening methods. To make a definitive CTE diagnosis, pathologists must conduct a post-mortem examination of tissue taken from various regions of the brain for the distinct neuropathological markers.[92]

79. *Id.* at 334 tbl.6.

80. *Id.* at 333.

81. *Id.* at 334 tbl.6.

82. *Id.*

83. *Id.* at 335.

84. Ann C. McKee et al., *The First NINDS/NIBIB Consensus Meeting to Define Neuropathological Criteria for the Diagnosis of Chronic Traumatic Encephalopathy*, 131 ACTA NEUROPATHOL.75, 76 (2016). The panel was organized by the National Institute of Neurological Disorders and Stroke and the National Institute of Biomedical Imaging and Bioengineering (NNINDS-NBIB).

85. *Id.* at 84. Future panels will consider the contribution to the disease of other observed abnormalities, including other protein accumulations, axonal injury, and neuroinflammation. *Id.*

86. McKee et al., *supra* note 74, at 58.

87. *Id.* at 57.

88. *Id.*

89. *Id.*

90. *Id.*

91. *Id.*

92. Researchers are studying various possible diagnostic tools, including the use of biomarkers to highlight the presence of tau proteins in the blood, as well as the use of functional magnetic resonance imaging to study functional connectivity. *Id.* at 57–58.

B. WHICH SPORTS?: RISK, ACROSS AND WITHIN SPORTS

Evidence thus suggests that long-term neurological damage occurs above a threshold level of injury, measured by number of impacts.[93] In a review of research published in the *Journal of Neurosurgery,* a multidisciplinary team concluded that "[s]ubconcussion has its greatest effect through repetitive occurrences whereby cumulative exposure becomes deleterious."[94] It is thus reasonable to focus on those sports where the cumulative head impacts are most likely to cross the impact threshold.

Football, for example, can lead to "thousands of subconcussive impacts for a single player over the course of one season."[95] A number of other contact sports, however, including soccer, rugby, boxing, wrestling, and lacrosse, also result in high numbers of repetitive head impacts throughout a season and career.[96] Studies unfortunately do not capture the incidence of injuries incurred in a number of other high-impact sports, such as boxing or mixed martial arts, presumably because the less structured nature of those sports makes it more difficult to study those athletes.

Although few published studies have reported the number of total head impacts experienced by athletes in different sports, nationally representative data does exist for sports-related concussions, though more data is available for high school and college athletes than for younger athletes.[97] While concussion rates across sports might not represent a perfect analog to head-impact rates, they can serve as a rough proxy for head impacts and provide some insight into which sports present a higher risk of head injury overall.[98]

An eleven-year study of twenty-five high school sports found that boys' football accounted for nearly half—forty-seven percent—of all concussions.[99] The absolute number may overstate the risk, given that football teams are large, with more athletes participating on a team than in other sports.

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93. *See supra* text accompanying notes 75–80.

94. Bailes et al., *supra* note 12, at 1236. The authors were comprised of neurosurgeons, a pathologist, and professors of mechanical, biomedical, and electrical and computer engineering. *Id.* at 1235.

95. Slobounov et al., *supra* note 62, at 708.

96. *Id*.

97. *See* SPORTS-RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 29. Three surveillance systems provide most of the reported epidemiologic data on sports-related concussions: (1) National Electronic Injury Surveillance System—All Injury Program; (2) NCAA Injury Surveillance System; and (3) High School Reporting Information Online. *Id.*

98. Researchers who published a peer-reviewed retrospective study of the effects of subconcussive impacts used concussion rates to designate sports as high-contact or low-contact, and also reasoned that "[t]he degree of subconcussive contact . . . was presumed to vary according to the known prevalence rates of concussion in [] different sports." William T. Tsushima et al., *Are There Subconcussive Neuropsychological Effects in Youth Sports? An Exploratory Study of High- and Low-Contact Sports*, 5 APPLIED NEUROPSYCHOL. 149, 151 (2016) (reviewing only male sports and considering only football to be high contact, while classifying wrestling, soccer, judo, and baseball as low impact); *cf.* Mallika Marar et al., *Epidemiology of Concussions Among United States High School Athletes in 20 Sports*, 40 AM. J. SPORTS MED. 747, 748 (2012) (studying differences across sports using a more limited set of data).

99. Marmar, *supra* note 98, at 749.

Injury rates can provide a more accurate indication of risk. Data describes injury rates in terms of *athlete-exposures*, defined as "one individual participating in one practice or competition in which he or she is exposed to the possibility of athletic injury, regardless of the time associated with that participation."[100]

Risk of injury is highest for athletes involved in collision sports—those whose rules permit athlete collisions during play. These collisions can occur through tackling (football, wrestling), body-checking (ice hockey, men's lacrosse), other player-on-player collisions (women's lacrosse, basketball), or heading a ball (soccer). Athletes in collision sports can experience dozens, even hundreds, of subconcussive hits over the course of a single season.[101] Risk is lowest in sports where play involves few or no impacts, such as track & field, volleyball, and tennis.[102]

More studies have examined head impacts in American football than in any other sport, most likely because of the inherently physical nature of the game. Athletes playing different positions within the sport, moreover, experience different numbers and levels of impacts. Yet rates of concussion in other sports, particularly at the college level, approach the rate of concussion in football.

At the high school level, football players do have the highest reported rates of concussion injury.[103] At the collegiate level, however, women's ice hockey, field hockey, and soccer, as well as men's ice hockey and wrestling, all have slightly higher rates of concussion injury than football players.

Tables 1 and 2 below average the concussion rates reported by athletic trainers from 1997–2013 and published in nationally representative studies.

100. SPORTS-RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 35.

101. Abbas et al., *supra* note 36, at 52.

102. *See generally* LINDA CARROLL & DAVID ROSNER, THE CONCUSSION CRISIS: ANATOMY OF A SILENT EPIDEMIC (2011) (chronicling the long-term effects of concussion suffered by athletes in various collision sports, including boxing, ice hockey, football, and soccer).

103. Marar et al., *supra* note 98, at 749.

TABLE 1: AVERAGE RATES OF REPORTED CONCUSSION—HIGH SCHOOL ATHLETES[104]

Men's Football	7.08
Men's Lacrosse	4.63
Women's Soccer	4.30
Women's Lacrosse	3.57
Men's Wrestling	2.98
Women's Basketball	2.85
Men's Soccer	2.50
Women's Field Hockey	2.47
Men's Basketball	1.53
Volleyball	1.17
Softball	1.25
Baseball	0.70

*RATES PER 10,000 ATHLETIC-EXPOSURES

104. Table 1 presents averaged concussion rates from data published in SPORTS-RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 34 tbl.1–2. The data used was originally collected and/or published by the following: Datalys Center for Sports Injury Research and Prevention, Inc., NATA Nation Preliminary Concussion Rates, 2010-2012; Luke M. Gessel et al., *Concussions Among United States High School and Collegiate Athletes*, 42 J. ATHLETIC TRAINING 495, 479 tbl.1 (2007); Andrew E. Lincoln et al., *Trends in Concussion Incidence in High School Sports: A Prospective 11-Year Study*, 39 AM. J. SPORTS MED. 958, 960 tbl.1 (2011); Marar et al., *supra* note 99, at 750 tbl.1. With the exception of Marar et al., none of these studies included ice hockey. Marar et al. included the concussion rate only for boys' ice hockey—5.4. Marar et al., *supra* note 99, at 750 tbl.1. Gessel et al. did not report rates for either boys' or girls' lacrosse or girls' field hockey; Table 1 reports concussion rates for those sports averaged from Datalys, Marar et al., and Lincoln et al. Lincoln et al. did not report rates for girls' volleyball, so the table reports concussion rates averaged from Datalys, Marar et al., and Gessel et al.

TABLE 2: AVERAGE RATES OF REPORTED CONCUSSION—COLLEGE ATHLETES[105]

Women's Ice Hockey	7.33
Women's Field Hockey	6.77
Men's Ice Hockey	6.38
Men's Wrestling	6.0
Women's Soccer	5.9
Football	5.53
Women's Lacrosse	4.73
Women's Basketball	4.35
Men's Lacrosse	3.9
Men's Soccer	3.75
Men's Basketball	2.8
Softball	2.28
Volleyball	1.95
Baseball	0.85

*RATES PER 10,000 ATHLETIC-EXPOSURES

1. *Tackling and Body-Checking*

The rules of football, ice hockey, wrestling, and men's lacrosse all explicitly permit intentional contact. Unsurprisingly, these are also the sports with the highest rates of concussion for male athletes. For women, only ice hockey permits intentional contact, and it accounts for the highest concussion rates for female athletes as well (the data only reported data for women's collegiate ice hockey).

In ice hockey, for example, body-checking (or "checking") involves using the trunk (hips to shoulders) to physically impede the progress of an opponent with the (purported) aim of separating the opponent from the puck to gain competitive advantage.[106] In a given season, between ten and twelve percent of

105. Table 2 presents averaged concussion rates from data published in SPORTS-RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 35 tbl.1-2. The data used was originally collected and/or published by the following: Datalys Center for Sports Injury Research and Prevention, Inc., NCAA Concussion Rates, 2004– 2009 and 2009–2013; Jennifer M. Hootman et al., *Epidemiology of Collegiate Injuries for 15 Sports: Summary and Recommendations for Injury Prevention Initiatives*, 42 J. ATHLETIC TRAINING 311, 316 tbl.2 (2007).

106. *Standard of Play & Rule Emphasis—Body Checking*, USA HOCKEY, https://www.usahockeyrulebook.com/page/show/1015119-standard-of-play-and-rule-emphasis-body-checking (last visited Nov. 6, 2019); *Teaching Checking: A Progressive Approach*, HOCKEY CANADA, https://cdn.hockeycanada.ca/hockey-canada/Hockey-Programs/Coaching/Checking/Downloads/teaching_checking_progression_body_checking.pdf (last visited Nov. 6, 2019) (defining body-checking as

youth hockey players aged nine to seventeen report a head injury, the most common being concussion.[107] Most concussions, in turn, are therefore caused by body-checking.[108]

Among youth football players, both frequency and magnitude of impacts increase with age.[109] Researchers attribute the higher head impact frequencies to the increase in the number of practices and games at higher levels of play.[110] Also, at higher levels of play, player strength and speed increases, which in turn results in impact levels of higher magnitudes.

2. *Heading*

Heading in soccer involves an athlete attempting to play the ball in the air with his or her head. Many studies have associated heading with a range of neurological consequences, even in the absence of concussion.[111] Heading correlates with lower cognitive performance among athletes at levels from high school to professional soccer players, and studies have found cognitive decline even over the course of a single season.[112] Higher lifetime frequencies of heading correlated with neuropsychological deficits; players with greater histories of heading scored more poorly on tests measuring general intellectual function, cognitive flexibility, and concentration.[113]

Heading is also associated with microstructural injury to the brain's white matter,[114] as well as with changes in cerebral blood flow,[115] both typical of trauma-related brain injury pathology.

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using the "body for the purpose of stopping the attacking progress of the of the puck carrier and/or to separate the carrier from the puck").

107. Anthony Marchie & Michael D. Cusimano, *Bodychecking and Concussions in Ice Hockey: Should Our Youth Pay the Price*, 169 CAN. MED. ASS'N J. 124, 125 (2003) (reporting studies).

108. *See id.*

109. Thayne A. Munce et al., *Head Impact Exposure and Neurologic Function of Youth Football Players*, 47 MED. & SCI. SPORTS & EXERCISE 1567, 1572 (2015).

110. *Id.*

111. Walter F. Stewart et al., *Symptoms from Repeated Intentional and Unintentional Head Impact in Soccer Players*, 88 NEUROLOGY 901, 904–05 (2017) (citing studies). *But see* Anthony P. Kontos et al., *Systematic Review and Meta-Analysis of the Effects of Football Heading*, 51 BRIT. J. SPORTS MED. 1118, 1122–23 (2017) (conducting meta-analytical review of published studies analyzing effects of soccer heading and concluding that "[m]ost results . . . are not easily interpreted due to the few number of studies in the analysis," but that the "results of the current meta-analytical review of the literature . . . on neurocognitive performance and presence of concussion symptoms gives no conclusive evidence that heading is associated with adverse effects").

112. Marsha R. Zhang et al., *Evidence of Cognitive Dysfunction After Soccer Playing with Ball Heading Using a Novel Tablet-Based Approach*, PLOS ONE, Feb. 2013, at 1, 3 (finding "significant and specific cognitive changes in female high school soccer players who head the soccer ball during practice").

113. Adrienne D. Witol & Frank M. Webbe, *Soccer Heading Frequency Predicts Neuropsychological Deficits*, 18 ARCHIVES CLINICAL NEUROPSYCHOL. 397, 411–13 (2003).

114. Inga K. Koerte et al., *White Matter Integrity in the Brains of Professional Soccer Players Without a Symptomatic Concussion*, 308 JAMA 1859, 1859 (2012); Lipton et al., *supra* note 11, at 851.

115. Svaldi et al., *supra* note 34, at 107–09.

3. *Fewer Intentional Collisions*

In a number of sports whose rules do not explicitly contemplate intentional collisions, those sorts of collisions nonetheless occur with frequency. Play in soccer, basketball, and women's lacrosse regularly involves high-speed impacts—most frequently player-on-player, but also contact with the ground or other objects, like other players' sticks, goal posts, etc.

A 2015 study of high school soccer players found that contact with another player, rather than heading the ball, was the more common concussion mechanism for both girl and boy athletes.[116] Contact with another player was responsible for 68.8% of boys' concussions and 51.3% of girls' concussions.[117] Thus, it appears that heading the ball causes less observable but nonetheless cumulative brain injury. Player-to-player collisions, on the other hand, are more overt and appear to be the dominant cause of reported concussions.[118]

C. WHICH ATHLETES?: AN EPIDEMIOLOGY OF INJURY RISK

Some individuals are at heightened risk of suffering the effects of sports-related brain injury. Identified risk factors relate to brain development, physical characteristics (both development and sex-related), sociocultural influences, and socioeconomic conditions.

116. R. Dawn Comstock et al., *An Evidence-Based Discussion of Heading the Ball and Concussions in High School Soccer*, 169 JAMA PEDIATRICS 830 (2015). The study collected data from 2005-2014 from a large, nationally representative sample of U.S. high schools. *Id.* at 831. A 2017 study of adult amateur soccer players found that "players reported moderately severe and possibly concussive" symptoms—the equivalent of nearly six events per year—even in the absence of recognized concussion. Stewart et al., *supra* note 111, at 905. Consistent with the findings of Comstock et al., unintentional head impacts, rather than intentional heading, more strongly related to the experienced symptoms. *Id.*

117. Comstock et al., *supra* note 116, at 832 tbl.1.

118. Stewart et al., *supra* note 111, at 905.

1. *Young Athletes and the Developing Brain*

Sports-related injuries incurred during youth correlate with a range of later-life neurological pathologies. For example, a recent study found an association between participation in youth football and impaired mood and behavioral functioning in later life.[119] Among football players diagnosed with CTE, moreover, the age at which they began playing tackle football also correlated with the age at which they began experiencing symptoms of cognitive disease—for every year younger the athletes began to play tackle football corresponded with earlier symptom onset by two-and-a-half years.[120]

Young people experience more severe symptoms following head injury than adults, and they take longer to recover.[121] A number of differences between young athletes and adults may contribute to the former's heightened vulnerability to injury.[122]

Until they reach adolescence, children's heads are out of proportion to their bodies, and they have larger head-to-body ratios than adults.[123] As a result, the head is more susceptible to being whipsawed by impact forces. In addition, neck and shoulder muscles are still developing and less able to prevent the head's movement.[124] Thinner cranial bones, larger intracranial space in which the brain may move, and an immature central nervous system may contribute to higher injury risk as well.[125]

Brain development continues well into adolescence. In particular, the process in which existing neural connections are stabilized is incomplete during adolescence and continues into, and beyond, the teen years.[126] Researchers posit that the ongoing changes and relative instability of neural connections contribute to the vulnerability of injury.

119. *See generally* Michael L. Alosco et al., *Age of First Exposure to Tackle Football and Chronic Traumatic Encephalopathy*, 83 ANNALS NEUROLOGY 886 (2018) (finding a correlation between playing football during youth years and reported cognitive, behavioral, and mood disorders).

120. *Id.* at 896.

121. Typically, young people recover from injury more quickly than adults. In the case of sports-related head injury and concussion, however, the converse is true; mid-adolescents (ages thirteen through high school) recover more slowly from diagnosed sports-related concussions than do college-aged athletes. SPORTS- RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 81 (gathering studies); *see also* Michael P. McClincy et al., *Recovery from Sports Concussion in High School and Collegiate Athletes*, 20 BRAIN INJURY 33, 38 (2006).

122. SPORTS-RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 81. However, relatively few studies have included pre-high-school-age youth.

123. *Id.*

124. *Id.*

125. *Id.*

126. In myelination, axons become coated with a lipoprotein sheath that stabilizes and speeds the transmission of electrical signals throughout the brain. Tomáš Paus, *Growth of White Matter in the Adolescent Brain: Myelin or Axon?*, 72 BRAIN & COGNITION 26, 31 (2010).

2. *Female Athletes*[127]

Female athletes rarely participate in tackle football, the sport that young people experience the highest number and most severe impacts.[128] Yet, for every sport in which both female and male youth participate, female athletes have significantly higher concussion rates than their male counterparts.[129] High school girl soccer and basketball players, for example, experienced concussion rates seventy and fifty percent higher than that of boys.[130] At the collegiate level, women's ice hockey, field hockey, and soccer players all experienced reported concussions at rates higher than that of male football players.[131]

In addition to reporting concussions at higher rates than male athletes, the concussion symptoms experienced by female athletes, such as impaired memory, appear to be more severe and take longer to resolve.[132] One study found that concussions were associated with increases in abnormal menstrual patterns in adolescents and young women, suggesting disruption of the neuroendocrine system that governs the menstrual cycle.[133]

Researchers posit that girls and women are more susceptible to head injury for a number of reasons. First, their neck muscles tend to be less strong than those of male athletes. As a result, impacts of comparable magnitudes result in greater head and brain acceleration in female athletes.[134] Second, neuroanatomical differences between female and male brains may influence the incidence and severity of concussions in ways not yet well understood.[135] Female brains tend to have higher blood flow, differences in white matter, and higher levels of estrogen than male brains.[136]

Given the possibility that neuroanatomical differences influence injury risk, it is conceivable that for athletes assigned to one sex at birth but using hormone therapies to affirm a different gender identity will also be at altered (either heightened or reduced) risk of brain injury. My research found no published studies addressing injury risk for these athletes, however.

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127. "Female" here refers to biological sex, as opposed to socially constructed gender roles. *See generally* JUDITH BUTLER, UNDOING GENDER (2004) (exploring the connection and disconnection between biological sex and gender). The term is necessarily imprecise, as even biological sex is not binary. *See* EILEEN MCDONAGH & LAURA PAPPANO, PLAYING WITH THE BOYS: WHY SEPARATE IS NOT EQUAL IN SPORTS (2008) (arguing that conditioning participation in sports based on biological sex exposes inequality between men and women).

128. Rules of play in girls' lacrosse forbid the types of body-checking permitted by the rules governing boys' play.

129. Marar et al., *supra* note 98, at 754.

130. *See supra* Table 1.

131. *See supra* Table 2.

132. CARROLL & ROSNER, *supra* note 102, at 27.

133. Meredith L. Snook et al., *Association of Concussion with Abnormal Menstrual Patterns in Adolescent and Young Women*, 171 JAMA PEDIATRICS 879, 880 (2017).

134. Ryan T. Tierney et al., *Gender Differences in Head-Neck Segment Dynamic Stabilization During Head Acceleration*, 37 MED. & SCI. SPORTS & EXERCISE 272, 272 (2005).

135. CARROLL & ROSNER, *supra* note 102, at 27.

136. Tracey Covassin et al., *Sex Differences in Reported Concussion Injury Rates and Time Loss from Participation: An Update of the National Collegiate Athletic Association Injury Surveillance Program from 2004-2005 Through 2008-2009*, 51 J. ATHLETIC TRAINING 189, 193 (2016) (citing studies).

Some researchers have speculated that female athletes may more honestly report concussion symptoms than do male athletes, and/or male athletes may underreport their concussion symptoms, causing data to overstate female concussions relative to male concussions.[137] Others have suggested that the data may underreport female athletes' concussions relative to those experienced by male athletes, because the "popular misconception that girls don't play as hard as boys," increases the likelihood that girls' concussions will escape notice.[138] To date, neither theory has found definitive evidentiary support.[139]

Given that female athletes report higher rates of injury and experience more severe symptoms, it is also possible that women are at higher risk for long-term brain injury.[140] Yet, little attention has been paid to the disparate rate of concussion and brain injuries experienced by girls and women.[141] This elision likely reflects the tremendous popularity of men's high-impact sport, particularly football and ice hockey, compared with women's sport. The visibility of those athletes, and the highly physical nature of those sports heightens public awareness of brain injury within them. Despite the increases in girls' and women's athletic participation, largely due to the implementation of Title IX, neither collegiate nor professional women's athletics has traditionally attracted the audience or attention accorded to men's athletics.[142]

Researchers are increasingly focusing on female athletes. For example, a Boston University study will follow twenty former elite female soccer players to determine the effect that play and repeated headers may have on later-life cognitive ability and neurological disease.[143]

3. *Black and Socioeconomically Disadvantaged Athletes*

Black youth and men are overrepresented in certain sports—particularly tackle football and basketball. In academic year 2014–15, for example, black men were only 2.5% of all undergraduate students, but 56.3% of football teams and 60.8% of basketball teams.[144] And in 2016, 70% of National Football

137. *Id.*

138. CARROLL & ROSNER, *supra* note 102, at 27.

139. *Id.*; Covassin, *supra* note 136, at 193.

140. Svaldi et al., *supra* note 34, at 99.

141. *See* Kim Tingley, *Do Brain Injuries Affect Women Differently?* N.Y. TIMES MAG., June 26, 2019, https://www.nytimes.com/2019/06/26/magazine/do-brain-injuries-affect-women-differently-than-men.html (observing that "most of what scientists know about the potential prevalence and consequences of mild traumatic brain injury has come from studying contact sports, especially football—so, mostly men and boys").

142. *See* Nancy Leong, *Against Women's Sports*, 95 WASH. U. L. REV. 1249, 1279, 1280 (2018).

143. Matt Bonesteel, *Worried About All the Headers They Took, Former USWNT Stars to Participate in CTE Study*, WASH. POST (June 27, 2019), https://www.washingtonpost.com/sports/2019/06/27/worried-about-all-headers-they-took-former-uswnt-stars-participate-cte-study/.

144. SHAUN R. HARPER, BLACK MALE STUDENT-ATHLETES AND RACIAL INEQUITIES IN NCAA DIVISION I COLLEGE SPORTS 2 (2016), https://nepc.colorado.edu/sites/default/files/publications/Harper_Sports_2016.pdf.

League (NFL) players were African-American.[145] This overrepresentation also makes them disproportionately likely to suffer the effects of injury from head impact exposure.[146]

Scholars studying the disproportionate representation of African Americans in athletics have found that African-American boys as a group are "intensively" socialized into athletics.[147] Their families, peers, communities, and media all tend to encourage and reinforce athletic role aspirations.[148]

Black athletes have more pervasive athletic identities than their white counterparts. They are more likely to see themselves only as athletes, and to believe that others see them only as athletes, as well.[149] Black male athletes, moreover, have higher rates of "identity foreclosure," or a "commitment to an identity before one has meaningfully explored other options."[150] Identity foreclosure tends to occur when individuals have had little exposure to alternatives.[151] These findings are consistent with the limited economic and educational opportunities available in majority-black communities.

The income gap between black and white households is stark. In 2015, black median household income was just under $37,000, compared to just under $63,000 for whites.[152] The gap has proven to be persistent, "wide[ning] slightly since 2002 (from $23,500 to $26,000)."[153]

For many black athletes, their participation in sports provides them the ability to attend college. Many view college, however, primarily as a necessary step to achieving lucrative careers in professional leagues. Professional sports seem to promise financial security and social status, and many black athletes perceive athletic, rather than academic, success as their best chance to

145. RICHARD LAPCHICK & SAAHIL MARFATIA, THE 2017 RACIAL AND GENDER REPORT CARD: NATIONAL FOOTBALL LEAGUE 26 app.1 (2017), http://nebula.wsimg.com/63112e771048708d1b4213b554c6cd76?AccessKeyId=DAC3A56D8FB782449D2A&disposition=0&alloworigin=1.

146. Daniel S. Goldberg, *Mild Traumatic Brain Injury, the National Football League, and the Manufacture of Doubt: An Ethical, Legal, and Historical Analysis*, 34 J. LEGAL MED. 157, 161 (2013).

147. Krystal Beamon & Patricia A. Bell, *Academics Versus Athletics: An Examination of the Effects of Background and Socialization on African American Male Student Athletes*, 43 SOC. SCI. J. 393, 394 (2006). For a critical discussion of the role of race in the educational experiences of black football student-athletes, see Jamel K. Donnor, *Towards an Interest-Convergence in the Education of African-American Football Student Athletes in Major College Sports*, 8 RACE ETHNICITY & EDUC. 45 (2005).

148. Beamon & Bell, *supra* note 147, at 394; *see also* Kristen F. Benson, *Constructing Academic Inadequacy: African-American Athletes' Stories of Schooling*, 71 J. HIGHER EDUC. 223, 223–25 (2000).

149. Louis Harrison, Jr., et al., *Living the Dream or Awakening from the Nightmare: Race and Athletic Identity*, 14 RACE ETHNICITY & EDUC. 91, 95–96 (2011).

150. Krystal Beamon, *"I'm a Baller": Athletic Identity Foreclosure Among African-American Former Student-Athletes*, 16 J. AFR. AM. STUD. 195, 196 (2012).

151. Id.

152. Richard V. Reeves & Eduard Rodrigue, *The Century Gap: Low Economic Mobility for Black Men, 150 Years After the Civil War*, BROOKINGS INSTITUTION (Aug. 23, 2017), https://www.brookings.edu/research/the-century-gap-low-economic-mobility-for-black-men-150-years-after-the-civil-war/.

153. Id.

overcome socioeconomic disadvantage.[154] A range of sociocultural factors lead many black youth—especially black boys—to perceive that the surest way to achieve the financial success is through sport. Black athletes have higher expectations of professional sports careers than all other student athletes.[155] The odds of professional athletic success, however, are low—a mere one percent of collegiate athletes become professionals, and the average professional career ends after three-and-a-half years.[156]

To be sure, African-American youth are not the only racial/ethnic minorities to see in football a path to upward mobility and financial security. For decades, athletes have left the islands of American Samoa and Tonga, for example, to play football in American colleges and beyond.[157] Numerous camps on Tutuila, American Samoa's largest island, exist to train and facilitate the recruitment of local athletes.[158] These athletes, according to one scholar, "are stereotyped as genetically gifted with size, girth, and quickness suitable for football, as well as with a violent impulse that can be channeled into success on the field by virtue of their respect for authority, instilled by . . . hierarchical Samoan society."[159] A film documenting the lives of Polynesian athletes in the United States reported that while there are fewer than 250,000 in the country, Tongans and Samoans are "twenty-eight times more likely than any other ethnic group to play in the NFL."[160]

A gap in access to extracurricular sports has grown since the 1990s, with participation rates diverging between low-income and more affluent youth.[161] As school districts' budgets have decreased, schools have eliminated extracurricular programs, shifting the cost to parents.[162]

At the same time that access to extracurricular sports is decreasing in socioeconomically disadvantaged communities, the NFL funds a range of youth and scholastic programs, introducing millions of young people to the sport, and providing access to an extracurricular opportunity that might not otherwise exist. For example, the NFL Foundation funds "NFL FLAG-In- Schools," providing equipment and materials to some 8,500 schools, as well as

154. Beamon & Bell, *supra* note 147, at 394; *see also* Peter Benson, *Big Football: Corporate Social Responsibility and the Culture and Color of Injury in America's Most Popular Sport*, 41 J. SPORT & SOC. ISSUES 307, 311 (2017).

155. Beamon & Bell, *supra* note 147, at 394.

156. Beamon, *supra* note 150, at 195.

157. Fa'anofo Lisaclaire (Lisa) Uperesa, *Fabled Futures: Migration and Mobility for Samoans in American Football*, 26 CONTEMP. PACIFIC 281, 283–84 (2014).

158. *Id.* at 287.

159. *Id.* at 283.

160. Lea Lani Kinikini Kauvaka, Film Review, *In Football We Trust*, 28 CONTEMP. PACIFIC 526, 526 (2016).

161. Kaisa Snellman et al., *The Engagement Gap: Social Mobility and Extracurricular Participation Among American Youth*, 657 ANNALS AM. ACAD. POL. & SOC. SCI. 194, 196 (2015).

162. Alia Wong, *The Activity Gap*, ATLANTIC (Jan. 30, 2015), https://www.theatlantic.com/education/archive/2015/01/the-activity-gap/384961/.

a flag football-training curriculum for physical education teachers.[163] Flag football provides a non-contact introduction to the sport, and young athletes learn and play all positions. USA Football (amateur football's national governing body, funded by the NFL Foundation) characterizes flag football as "an entry point into the sport."[164]

Through USA Football, the NFL Foundation also provides need-based grants for youth leagues and scholastic teams to build fields, provide helmets, uniforms, and other equipment, and replace equipment.[165] The NFL also funds hundreds of free, non-contact youth summer football camps annually, introducing some 33,000 young people to the sport per year through its FUNdamentals and NFL Youth Football Camp Grant program.[166]

The overrepresentation of black boys and other boys of color in football leagues is unlikely to decrease. Parents with greater access to information about the risks of brain injury (and presumably, access to alternative activities in which to enroll their children) have already begun withdrawing their children from tackle football.[167] Professor emeritus Harry Edwards, a sociologist at the University of California-Berkeley, predicts:

> "[C]olleges and universities could be dealing with a diminishing number of athletes at the high school level and will dig deeper into the pool for athletes from socioeconomic backgrounds that do not have ready access to the information . . . that would [lead them to] restrict their sons' ability to participate in football."[168]

As a result, football teams will continue to become "blacker and browner."[169]

II. COSTS OF ACCUMULATED BRAIN INJURY

The benefits of participating in athletic activities are significant. Primarily, active play supports healthy development.[170] In the face of rising

163. *Youth Football*, NAT'L FOOTBALL LEAGUE FOUND., http://www.nflfoundation.org/youth-football (last visited Nov. 6, 2019).

164. *Id.*

165. *USA Football Grant Program*, USA FOOTBALL, https://usafootball.com/resources-tools/commissioner/grants/ (last visited Nov. 6, 2019).

166. NAT'L FOOTBALL LEAGUE FOUND, *supra* note 163.

167. *See* Lekan Oguntoyinbo, *Game Changer: Experts Say Health Risks to Put Football in Hands of Low-Income, Minority Players*, DIVERSE ISSUES IN HIGHER EDUC. (Jan. 26, 2014), http://diverseeducation.com/article/60354/; *see also infra* Subpart II.C. (discussing race and class inequalities in participation in American football).

168. Oguntoyinbo, *supra* note 167.

169. *Id.*

170. Dawn Anderson-Butcher et al., *Sports and Youth Development*, *in* 5 ENCYCLOPEDIA OF ADOLESCENCE 2846, 2847–49 (Roger J.R. Levesque ed., 2011) [hereinafter Anderson-Butcher et al., *Sports and Youth Development*]; NAT'L COUNCIL OF YOUTH SPORTS, REPORT ON TRENDS AND PARTICIPATION IN ORGANIZED YOUTH SPORTS 7 (2008). Studies of the benefits of sports participation define "sport" broadly, to include "recreational, skillful physical activity that has an element of competition and is organized in some manner." Anderson-Butcher et al., *Sports and Youth Development*, at 2847. Youth sports participation is also related to reductions in problem behaviors, delinquency, and substance abuse. *Id.* Some studies have found sport participation in some contexts linked to some negative outcomes, however, such as increased likelihood

childhood obesity and its related effects, children's health advocates have worked hard to educate the public about the importance of physical activity to children's health.[171] Further, structured play, such as organized sports, can positively influence a range of developmental outcomes, both physical and psychological.[172]

At the same time, every sport and recreation activity carries some risk of injury, including head injury or concussion.[173]

The costs of sports-related head injury—particularly those injuries resulting from cumulative impacts that result in no immediate symptoms— have until now been largely obfuscated. This Part considers those costs.

A. HEALTH CARE COSTS, LOST PRODUCTIVITY, DIMINISHED QUALITY OF LIFE

In a September 2017 study reported in the *N.Y. Times,* Yale economists estimated the annual cost savings if colleges and high schools eliminated boys'/men's contact sports or converted them to non-contact sports, where concussion rates are significantly lower.[174] They calculated that high schools would save between $5.1 billion and $18.4 billion per year, and colleges would save between $433 million and $1.5 billion per year.[175] Most of the savings are from football: over seventy percent of high school savings and just over fifty percent of college savings.[176] These costs, moreover, account only for the short-term expenses of concussion injury. The authors explain that the longer- term costs almost certainly exceed those borne at the time of injury by a significant amount.[177]

My research found no published studies seeking to estimate the incidence, much less quantify the cost, of treating the long-term neurological consequences of repeated head impacts.

The best available estimate has found that one in three athletes who experience repeated head impacts will eventually develop neurological disease.[178] We currently do not know what proportion of residents of assisted-living, memory care, and nursing home facilities are suffering long-term neurological damage caused by repeated head impacts or CTE, rather than merely suffering the effects of age-related dementia or Alzheimer's disease.

of engaging in risky behaviors. *See, e.g.*, Jacquelynne S. Eccles et al., *Extracurricular Activities and Adolescent Development*, 59 J. SOC. ISSUES 865, 870 (2003).

171. *See, e.g.*, Dawn Anderson-Butcher, *Recruitment and Retention in Youth Development Programming*, 12 PREVENTION RESEARCHER 3, 3–4 (2005).

172. Anderson-Butcher et al., *Sports and Youth Development*, *supra* note 170, at 2847.

173. Bryan et al., *supra* note 29, at 2 (2016).

174. Ray C. Fair & Christopher Champa, *Estimated Costs of Contact in College and High School Male Sports* 1 (Cowles Found. for Res. in Econ., Discussion Paper No. 2101, 2018).

175. *Id.* at 2.

176. *Id.*

177. *Id.*

178. Asken et al., *supra* note 16, at 1257.

Studies of former football players suggest that staggering numbers of former athletes may suffer from sports-related neurodegenerative disease, however. A 2017 study of the brains of 202 deceased football players diagnosed CTE in twenty-one percent of former high school players, ninety-one percent of former college players, and ninety-nine percent of former NFL players.[179] The degree of pathology correlated with number of years of play, with professional players having the most severe levels of pathology.[180] All of those diagnosed had cognitive symptoms and behavioral or mood symptoms, and among the symptoms experienced by a large majority were impulsivity, depression, violence, and suicidality.[181] One-third of those with milder CTE pathology also showed signs of dementia, while eighty-five percent of those with more severe pathology showed signs of dementia.[182]

Individuals with mood and behavioral challenges face additional barriers with respect to work and life functions, as well as additional treatment costs. Families that care for loved ones struggling with neurodegenerative disease frequently struggle to meet the emotional and financial burdens.

B. LITIGATION AND INSURANCE

Tort doctrine historically presumed that athletes participating in contact sports understood the risks of injury and consented to assuming the risks inherent in playing sport.[183] More recently, however, courts have allowed players to challenge the presumption of informed consent and employ other doctrines of liability in lawsuits seeking compensation for the effects of head trauma.[184] Between 2015 and 2018, the NFL, the NCAA, and the National Hockey League (NHL) agreed to pay a total of more than $2 billion to settle lawsuits by players suffering the effects of concussion and subconcussive head trauma.[185] Individual athletes in various sports have filed suits in some twenty- nine states, suing not only collegiate and professional sports associations, but also youth leagues, school districts, equipment manufacturers, coaches, and athletic trainers.[186] Insurance companies, who have had to pay legal fees and claims associated with players' claims, have become increasingly unwilling to

179. Jesse Mez et al., *Clinicopathological Evaluation of Chronic Traumatic Encephalopathy in Players of American Football*, 318 JAMA 360, 362 (2017).

180. *Id.*

181. *Id.* at 364–65.

182. *Id.* at 365.

183. *See* MATTHEW J. MITTEN ET AL., SPORTS LAW AND REGULATION: CASES, MATERIALS, AND PROBLEMS 929–30 (4th ed. 2017).

184. *Id.* at 930.

185. *See id.* at 930–31 (gathering cases). *See infra* notes 194–201 and accompanying text.

186. Steve Fainaru & Mark Fainaru-Wada, *For the NFL and All of Football, a New Threat: An Evaporating Insurance Market*, ESPN (Jan. 17, 2019), http://www.espn.com/espn/story/_/id/25776964/ insurance-market-football-evaporating-causing-major-threat-nfl-pop-warner-colleges-espn.

provide coverage to educational institutions and sports organizations for sports-related head trauma.[187]

1. *Liability of School Districts, Universities, and Their Employees*

The doctrine of sovereign immunity protects state entities such as public school districts from tort liability for acts performed as part of their governmental functions, which typically include the operation of athletic programs.[188] The related doctrine of qualified immunity protects state employees from liability when performing discretionary functions, though not ministerial tasks, in the course of their employment.[189] However, numerous exceptions to these immunity doctrines exist, along with state-by-state variations in the scope of immunity protections.[190]

In the absence of immunity, schools have been held liable for the negligent conduct of coaches and trainers, but typically only when the conduct is reckless or increases the risks inherent in a given athletic activity.[191] Schools have thus been held liable when coaches or athletic personnel have failed to recognize concussions or have required players to return to play following concussion.[192]

2. *Liability of Sports Associations*

Former football players suffering the effects of sports-related brain injury have received significant attention. A widely publicized 2017 study of the brains of 202 football players found that 177 of them suffered from CTE.[193] The same year, the resolution of the players' lawsuit against the NFL for $1 billion made national news.[194]

Collegiate athletes, too, have sought to hold the NCAA accountable for their injuries, reaching a $75 million settlement in 2016.[195] And after an autopsy confirmed CTE in a twenty-five-year-old man who committed suicide,

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187. *Id.*

188. *See* MITTEN ET AL., *supra* note 183, at 901 (gathering cases). Sovereign immunity does not extend, however, to state entities' proprietary functions. *Id.*

189. *Id.* at 901–02.

190. *Id.* at 901.

191. *Id.* at 901–02.

192. *Id.*

193. Mez, *supra* note 179, at 362. The study was not a randomized study; instead, individuals who played football at various levels prospectively donated their brains for study following their death, or family members donated the brains of deceased individuals for study. *Id.* at 361.

194. *In re* Nat'l Football League Players' Concussion Injury Litig., 821 F.3d 410, 447 (3d Cir. 2016) (affirming class action settlement), *cert. denied*, 137 S. Ct. 591 (2016); Jimmy Golen, *Supreme Court Leaves $1B NFL Settlement in Place*, ASSOCIATED PRESS (Dec. 12, 2016), https://www.apnews.com/249f93a0ce544de79a73cc71bda5ef69.

195. *In re* Nat'l Collegiate Athletic Ass'n Student-Athlete Concussion Injury Litig., 314 F.R.D. 580, 585–86 (N.D. Ill. 2016) (approving class action settlement agreement).

his family settled for an undisclosed sum with the youth football league in which he had participated.[196]

The best known, perhaps, is a lawsuit brought by former players against the NFL. The NFL settled the class action in 2015 by agreeing to compensate former players suffering the effects of "concussive and sub-concussive hits."[197] The League has paid out over $500 million in two years, with total payment expected to be $1.4 billion.[198] The NCAA settled a similar class action in 2016, agreeing to a $75 million settlement to fund concussion testing and diagnosis, as well as concussion-related research.[199]

Athletes in sports other than football have also sought recourse and reform through the courts. A class action suit recently filed by professional ice hockey players against the NHL settled in 2018 for $18.9 million.[200] The U.S. Soccer Federation resolved a threatened class action by adopting rules prohibiting players younger than eleven from heading the ball and restricting the practice of heading by players under thirteen.[201]

Sports associations have become increasingly vulnerable, not only to class actions brought by groups of former athletes, but also to suits brought by individual athletes and their families.

3. *Insurance*

As discussed above, litigation stemming from head-injury-related suits has cost sports organizations billions of dollars. As these costs have grown, so too has the cost of insuring the organizations against liability.

Insurance companies have adjusted to the increased legal and medical expenses associated with brain injury claims in a number of ways.

First, insurers have increased premiums and raised deductibles. The rising costs have led to the elimination of a number of football programs. One county community college system in Arizona eliminated football programs at four

196. Stipulation of Dismissal with Prejudice, *supra* note 8. Chernach played football in high school, where he also wrestled and competed in track and field. *See* Belson, *supra* note 1.

197. *In re Nat'l Collegiate Athletic Ass'n Student-Athlete*, 314 F.R.D. at 593.

198. *NFL Concussion Claims Hit $500 Million in Less Than 2* Years, ESPN (Jul. 30, 2018), http://www.espn.com/nfl/story/_/id/24235494/nfl-concussion-claims-hit-500-million-less-2-years.

199. *In re Nat'l Collegiate Athletic Ass'n Student-Athlete*, 314 F.R.D. at 585–86.

200. *NHL Concussion Lawsuit Reportedly Near Settlement*, REUTERS (Nov. 9, 2018, 8:23 PM), https://www.reuters.com/article/us-icehockey-nhl-concussions-lawsuit/nhl-concussion-lawsuit-reportedly-near-settlement-idUSKCN1NF057.

201. U.S. YOUTH SOCCER, POLICY ON PLAYERS AND PLAYING RULES, RULE 305 § 3 (2016), http://www.usyouthsoccer.org/assets/1/6/players_and_playing_rules_policy_rev_9-1-16_final_(2).pdf (explaining that players under the age of thirteen may head the ball during competition, but in practice may head the ball no more than twenty-five times per week); *see also* Christopher Clarey, *Soccer Without Headers? New Research Shows It's Worth Discussing*, N.Y. TIMES (Oct. 28, 2016), https://www.nytimes.com/2016/10/29/sports/soccer/soccer-without-headers-new-research-shows-its-worth-discussing.html; Ben Strauss, *U.S. Soccer, Resolving Lawsuit, Will Limit Headers for Youth Players*, N.Y. TIMES (Nov. 9, 2015), https://www.nytimes.com/2015/11/10/sports/soccer/us-soccer-resolving-lawsuit-will-limit-headers-for-youth-players.html.

schools, noting that the cost of insuring the football teams accounted for nearly one-third of all insurance costs for the system's 200,000 students.[202]

Second, insurers are excluding head trauma from coverage, or including restrictions that limit insurers' exposure.[203] For example, the NFL has no general liability insurance covering head trauma.[204] Pop Warner's insurance carrier insisted on an exclusion for any neurological injury, forcing the organization to seek an alternative provider.[205] Only one carrier was willing to provide coverage that included head trauma.[206]

Finally, most insurers have simply discontinued providing coverage for collision sports.[207] Explaining that the risk of eventual significant liability has simply become too great, one insurance executive wrote in a 2018 blog post that, "[f]or those in the business of insuring liabilities, brain trauma is an emerging latent exposure the likes of which the insurance industry has not seen in decades."[208]

C. INCREASING RACE AND CLASS INEQUALITY

The number of youth participating in tackle football has declined steadily over the past decade. The number of boys playing high school football dropped by more than 48,000 between 2009 and 2016.[209] Overall, the number of boys ages six through seventeen playing tackle football fell over eighteen percent, from just under 4 million to 3.2 million.[210] For the younger group of boys ages six through twelve, the decline was even larger—participation fell by nearly thirty percent between 2008 and 2016.[211]

There is little data studying racial differences among youth football players. One study found that the percentage of black boys playing football was only modestly higher than white boys—16.7% of black boys play football,

202. Fainaru & Fainaru-Wada, *supra* note 186.

203. Id.

204. Id.

205. Id.

206. Id.

207. Id.

208. Joe Cellura, *The Expanding Liability of Sports Concussions*, RISK & INS. (May 3, 2018), https://riskandinsurance.com/keep-head-trauma-in-mind-part-two/.

209. *High School Sports Participation Increases for 28th Straight Year, Nears 8 Million Mark*, NAT'L FED'N OF STATE HIGH SCH. ASS'NS (Sept. 6, 2017), https://www.nfhs.org/articles/high-school-sports- participation-increases-for-28th-straight-year-nears-8-million-mark/ (noting that, although sports participation overall had increased, participation in 11-player football had declined); *see also* Brian Murphy, "*I Don't Know That We Need Football As a Thing." Families Flee America's Favorite Sport*, THE NEWS & OBSERVER (Jan. 29, 2018, 1:50 PM), https://www.newsobserver.com/news/politics-government/politics-columns-blogs/under- the-dome/article197213314.html (reporting data gathered by the National Federation of State High School Associations).

210. Tod Leonard, *Youth Football Dilemma: Retaining Players Amid Constant Concussion Talk*, SAN DIEGO UNION-TRIB. (Nov. 26, 2017, 9:50 AM), http://www.sandiegouniontribune.com/sports/sd-sp-youth-football-declining-participation-and-concussions-20171123-story.html (reporting data gathered by the Sports and Fitness Industry Association).

211. Id.

compared to 14.2% of white boys.[212] Other anecdotal evidence suggests that African-American boys are more significantly overrepresented in youth football.[213]

By college, however, African-American players are significantly overrepresented on football teams. The NCAA reported that in 2009–2010, nearly forty-six percent of Division I football players were African-American.[214] Over the previous decade, from 1999–2009, the percentage of white players decreased annually, while the percentage of black players increased annually.[215]

Interviews with parents overwhelmingly suggests that those with access to information about the risks of brain injury—and who have access to alternative activities—have begun withdrawing their children from high- impact sports like tackle football.[216] For example, Jennifer Brown Lerner, a member of The Aspen Institute's National Commission on Social, Emotional and Academic Development, allows her eight-year-old son to play flag football, but stated, "I'm hesitant to have my son play tackle. I don't know that I would feel comfortable if he approached us."[217] When writer Tracy Hahn- Burkett's ten-year-old son asked her why she refused to allow him to play football, she recalled replying, "[b]ecause I like your brain the way it is."[218] Numerous prominent professional athletes, sportscasters, and even President Barack Obama have all either refused to allow their sons to play football, or stated that they would refuse, were they to have sons.[219]

As public knowledge of the risks of repeated head impacts grows, it is likely that the numbers of youth of all ages playing football will continue to decline. However, an important factor in youth sports participation is accessibility—a recent report in *The Atlantic,* for example, noted that certain sports are virtually inaccessible to lower-income youth, due to the costs of participation.[220]

Fewer sports activities are available in more socioeconomically depressed areas, which are also disproportionately populated by African-American families and other families of color. The NFL, however, in an effort to shore up the pipeline of future players, has invested tens of millions of dollars to support youth football programs. In areas where few alternatives are available,

212. Robert W. Turner et al., *Reported Sports Participation, Race, Sex, Ethnicity, and Obesity in US Adolescents from NHANES Physical Activity (PAQ_D)*, GLOBAL PEDIATRIC HEALTH, Jan.–Dec. 2015, at 1, 4 tbl.3.

213. Goldberg, *supra* note 146, at 184–85.

214. *Id.* at 184.

215. Id.

216. Murphy, *supra* note 209.

217. Id.

218. Tracy Hahn-Burkett, *Telling My Son, "No, You Can't Play Football,"* WASH. POST (Sept. 3, 2015), https://www.washingtonpost.com/news/parenting/wp/2015/09/03/telling-my-son-no-you-cant-play-football/?utm_term=.eac4c7a28fce.

219. *See* Patrick Findler, *Should Kids Play (American) Football?*, 42 J. PHIL. SPORT 443, 444 (2015).

220. Wong, *supra* note 162.

parents seeking the benefits of sports participation are more likely to permit their children to enroll in youth football programs.

III. REFORMS TO DATE: THE EFFECTIVE, THE INEFFECTIVE, AND THE DECEPTIVE

The last century has seen a range of reforms aimed at making sports safer. In response to pressure to support concussion research and modify rules to improve athlete safety, sports associations and legislatures in nearly every state have enacted "concussion protocols." These protocols require teams to implement best practices to identify and treat concussions.

A. LEGISLATIVE REFORMS

Zachary Lystedt, a middle-school football player, suffered a severe brain injury after returning to a football game in which he had earlier sustained a concussion.[221] His family then initiated a successful lobbying effort to persuade state legislatures to enact what became known as "Lystedt Laws"— laws that mandate removal from play after a suspected concussion and require some form of medical clearance before the athlete may return to play.[222] Lystedt Laws also typically include some educational component, aimed at informing athletes and their parents about the risks of concussion.[223] By 2015, every state and the District of Columbia had enacted some version of the Lystedt Law.[224]

Because the brain is more vulnerable to repeat injury in the aftermath of traumatic brain injury (TBI), the sorts of concussion protocols mandated by Lystedt Laws may shield players from the increased risk of injury. Preliminary data suggest that Lystedt Laws are increasing awareness of concussion risks.[225] However, it is unclear the level of influence these laws will have on a sports culture in which a significant percentage of athletes ignore or hide their concussion symptoms.

Finally, because concussion protocols only apply once a player has suffered an impact severe enough to cause observable symptoms, they do nothing to protect athletes from the cumulative deleterious effects of repeated subconcussive impacts.

221. Kerri McGowan Lowrey, *State Laws Addressing Youth Sports-Related Traumatic Brain Injury and the Future of Concussion Law and Policy*, 10 J. BUS. & TECH. L. 61, 63 (2015).

222. *Id*. at 63–64.

223. *Traumatic Brain Injuries Among Youth Athletes*, NAT'L CONF. OF ST. LEGISLATURES (Nov. 18, 2015), http://www.ncsl.org/research/health/traumatic-brain-injuries-among-youth-athletes.aspx; *see also Traumatic Brain Injury Legislation*, NAT'L CONF. OF ST. LEGISLATURES (Oct. 11, 2018), http://www.ncsl.org/research/health/traumatic-brain-injury-legislation.aspx (providing summaries of and citations to legislation adopted by each state).

224. NAT'L CONF. OF ST. LEGISLATURES, *supra* note 223.

225. Viviana Bompadre et al., *Washington State's Lystedt Law in Concussion Documentation in Seattle Public High Schools*, 49 J. ATHLETIC TRAINING 486, 486 (2014).

B. LEAGUE RULE CHANGES

The NCAA and the NFL both have adopted concussion protocols along the lines of the Lystedt Laws.[226] And in response to growing concern over the effects of concussions, sports associations have taken a number of steps aimed at lowering the incidence of brain injury. These steps have included: (1) changing rules to alter or eliminate the more hazardous aspects of play; (2) restricting the level of player-to-player contact during practices; (3) restricting various types of contact by athletes under a certain age; and (4) encouraging coaches to teach athletes various safer techniques of play.

Modifying or eliminating hazardous components of contact-collision sports can reduce the incidence of impacts and related head injury. In 1976, the NCAA amended rules of play to prohibit "spearing," or leading with the head when blocking or tackling.[227] Following the amendment, there was a decrease in the rates of cervical spine injuries.[228]

Studies evaluating the effects of policy changes that eliminated body-checking in youth ice hockey found a nearly threefold reduction in concussions, compared with youth leagues that continued to permit body- checking.[229] USA Hockey prohibits youth players aged twelve and under from body-checking.[230] Hockey Canada, which governs youth hockey in that country, followed suit in 2013, banning body-checking in its Peewee leagues, for ages thirteen and under.[231] Several Canadian cities and provinces impose higher age thresholds, ranging from ages fourteen to seventeen.[232]

Proponents of both tackling and body-checking claim that youth exposed to the practices earlier in their athletic careers can learn proper technique, enabling them to avoid injury. Later exposure, proponents claim, leaves athletes poorly equipped to avoid injury.[233] They argue that educating coaches to teach proper technique is a better way to improve player safety.[234] However,

226. The NCAA adopted its "Concussion Plan" in 2010. 2015–2016 NCAA DIVISION I MANUAL, ART. 3.2.4.17 (2015).

227. Joseph S. Torg et al., *The National Football Head and Neck Injury Registry: 14-Year Report on Cervical Quadriplegia, 1971 through 1984*, 254 JAMA 3439, 3440 (1985).

228. *Id.* at 3441.

229. Amanda M. Black, et al., *Policy Change Eliminating Body Checking in Non-Elite Ice Hockey Leads to a Threefold Reduction in Injury and Concussion Risk in 11- and 12-Year-Old Players*, 50 BRIT. J. SPORTS MED. 55, 55 (2016).

230. USA HOCKEY OFFICIATING RULEBOOK, RULE 604: BODY CHECKING, https://www.usahockeyrulebook.com/page/show/1084648-rule-604-body-checking.

231. *Hockey Canada's 94th Annual General Meeting Concludes in Charlottetown, P.E.I.; Body-Checking Rule Change Approved; Jim Hornell Elected Chair of Hockey Canada Board of Directors*, HOCKEY CAN. (May 25, 2013), https://www.hockeycanada.ca/en-ca/news/agm-concludes-in-charlottetown.

232. *See, e.g.*, Marchie & Cusimano, *supra* note 107, at 124 (noting that some provinces, including British Columbia, have imposed a threshold of 14-15 years); Emily Mertz, *Hockey Edmonton Bans Body Checking at Many Levels of Bantam and Midget Hockey*, GLOBAL NEWS (Apr. 20, 2016, 1:29 PM) (reporting rule to take effect 2016–2017 season).

233. Marchie & Cusimano, *supra* note 107, at 124.

234. Id.

research suggests coaches can be resistant to education, so it is unclear whether this strategy will be effective in order to prevent youth injury.[235]

Pop Warner, the largest youth football organization, recently began encouraging coaches to teach players "heads-up" style of tackling, which entails the tackling athlete initiating contact with the shoulder while keeping his head up. The organization claims that heads-up tackling makes play safer and thus requires its coaches to attend Heads Up Football training.[236] While head-first tackling, or spearing, is uniquely dangerous, no research supports the assertion that tackling with the head up is safe.[237]

Moreover, research has found that side impacts, rather than headfirst impacts, are the most likely to result in concussion, because they cause not only linear acceleration, but also rotational acceleration of the head.[238] Recall that brain stem fibers are aligned linearly; this alignment renders them particularly susceptible to injury when impact includes a rotational component.[239]

Some sports associations have adopted rules limiting the number of contact practice sessions per week. Pop Warner adopted rule changes limiting contact during practices in 2012.[240] And more recently, in 2016, the Ivy League adopted a policy banning all contact during practices.[241]

Like rules eliminating the most dangerous types of tackling, limiting contact during practices ought to limit both the number of reported concussions and the total number of head impacts experienced by athletes. At the same time, because competition tends to be more intense than practice, the incidence of concussions is twice as high during competition (12%) than in practice (5.9%).[242] Thus, the incidence of the impacts will be reduced, but by no means eliminated.

As noted above, in 2015, the U.S. Soccer Federation adopted rules prohibiting players younger than eleven from heading the ball and restricting

235. *Id.* at 126.

236. *See Heads Up Football Coach Training*, POP WARNER LITTLE SCHOLARS, https://www.popwarner.com/Default.aspx?tabid=1476163 (last visited Nov. 6, 2019).

237. Kathleen E. Bachynski, *Tolerable Risks? Physicians and Youth Tackle Football*, 374 NEW ENG. J. MED. 405, 405 (2016).

238. Arash A. Sabet et al., *Deformation of the Human Brain Induced by Mild Angular Head Acceleration*, 41 J. BIOMECHANICS, 307, 310 (2008); Steven P. Broglio et al., *Biomechanical Properties of Concussion in High School Football*, 42 MED. & SCI. SPORTS EXERCISE, 2064, 2068–69 (2010).

239. Broglio, *supra* note 238, at 2069.

240. *Limited Contact in Practice Rule*, POP WARNER LITTLE SCHOLARS, https://www.popwarner.com/Default.aspx?tabid=1476228 (last visited Nov. 6, 2019).

241. Ken Belson, *The Ivy League Moves to Eliminate Tackling at Football Practices*, N.Y. TIMES (Mar. 1, 2016), https://www.nytimes.com/2016/03/02/sports/ncaafootball/ivy-league-moves-to-eliminate-tackling-at-practices.html.

242. Julie A. Rechel et al., *An Epidemiologic Comparison of High School Sports Injuries Sustained in Practice and Competition*, 43 J. ATHLETIC TRAINING 197, 200 (2008).

the practice of heading by players under thirteen.[243] The policy will likely have some nontrivial effect on head injury for those groups of players.[244] As with the elimination of tackling during practices, however, it is likely that the most intense contact occurs during games—not practice. Thus, the policy change can only reduce some of the risk of injury caused by contact.

C. THE TECHNOLOGICAL IMPERATIVE: THE FALSE PROMISE OF HIGH-TECH PROTECTIVE GEAR

"There is no good clinical evidence that currently available protective equipment will prevent concussion."[245] Technology has contributed to human progress, and many technological innovations have improved population health. The belief that technical innovation can resolve our most significant problems, sometimes referred to as the "technological imperative," is particularly pronounced in the health sector.[246] In the highest-risk sports, it is evident in the narrative that the development and use of proper technology can make play significantly safer.[247] The NFL, for example, announced its "Play Smart, Play Safe" initiative, which will spend more than $50 million with the aim of creating a safer helmet to reduce concussions.[248]

Prior to the adoption of helmets, catastrophic head injuries, including skull fractures and massive brain bleeding, led to the deaths of dozens of collegiate football players. The dangers of the sport were well known by the turn of the century—in 1905 alone, for example, twenty-five players died from on-field injuries.[249] The predecessor organization to the NCAA was founded in 1910 at the urging of President Theodore Roosevelt with the central goal of making the game safer.[250] Yet, although the NCAA adopted various changes to the rules of play towards that end, and although leather helmets were available

243. U.S. YOUTH SOCCER, *supra* note 201, Rule 305 § 3, at 7; Strauss, *supra* note 201; *see also* Clarey, *supra* note 201 (discussing how players under thirteen may head the ball during competition, but in practice may head the ball no more than twenty-five times per week).

244. Both heading the ball and player-to-player contact (frequently occurring when two or more players simultaneously try to the head the ball) cause head injury. Stewart et al., *supra* note 111, at 904.

245. Paul McCrory et al., *Consensus Statement on Concussion in Sport: The 4th International Conference on Concussion in Sport Held in Zurich, November 2012*, 47 BRIT. J. SPORTS MED. 250, 254 (2013); *see also* Rodolfo R. Navarro, *Protective Equipment and the Prevention of Concussion—What Is the Evidence?,* 10 CURRENT SPORTS MED. REP. 27, 30 (2011) (gathering studies showing that certain types of protective equipment can reduce somewhat the risk of head injury and concussion, but that no equipment has been shown effective at preventing concussion).

246. Kathleen E. Bachynski & Daniel S. Goldberg, *Youth Sports & Public Health: Framing Risks of Mild Traumatic Brain Injury in American Football and Ice Hockey*, 42 J.L. MED. & ETHICS 323, 328–30 (2014).

247. *Id.* at 328.

248. Mark Fainaru-Wada & Steve Fainaru, *NFL Retakes Control of Brain Research as Touted Alliance Ends*, ESPN (Aug. 31, 2017), http://www.espn.com/espn/otl/story/_/id/20509977/nfl-takes-control-brain-research-100-million-donation-all-ending-partnerships-entities.

249. CARROLL & ROSNER, *supra* note 102, at 50.

250. *Id.* at 51; *Concussion Timeline: A History of NCAA Decisions Intended to Help Protect College Athletes from Serious Injuries, Including Those that Can Cause a Concussion*, NCAA SPORT SCI. INST., http://www.ncaa.org/sport-science-institute/concussion-timeline (last visited Nov. 6, 2019).

by the 1890s, the Association would not mandate helmet use until 1939.[251] Canadian and American ice hockey associations began requiring amateur athletes to wear helmets in the 1960s. [252]

Early helmets varied widely in effectiveness, and athletes continued to suffer catastrophic injuries. After two young ice hockey players died from injuries incurred while wearing helmets, a physician writing in the *Canadian Medical Association Journal* observed that "the so-called protective helmet of amateur hockey players gives only limited protection, even in minor accidents."[253]

The need for standardization of protective helmets prompted the founding of the National Operating Committee on Standards for Athletic Equipment (NOCSAE), which adopted safety standards on football helmets in 1978.[254] It later promulgated standards for helmets and protective equipment used in other sports, including lacrosse.[255] In 1975, the Canadian Standards Association adopted the first national hockey helmet standard.[256] The adoption of standards increased transparency and improved the overall effectiveness of helmets.[257] The standards do not specifically address concussion or subconcussion, nor is their intent to evaluate protection against concussive injury.[258]

Helmets are now very effective at preventing skull fractures and intracranial hemorrhages that result from high-magnitude direct impacts.[259] The outer shell, one of the two primary helmet components, resists penetration and dissipates the impact pressure.[260] At the same time, the shell deforms partially, allowing it to absorb a portion of the mechanical energy.[261] The helmet's second primary component, a relatively softer liner, further absorbs impact energy and increases the duration of the pressure impulse, reducing peak value of the impact force to the head.[262]

251. NCAA SPORT SCI. INST., *supra* note 250.

252. Nicola Biasca et al., *The Avoidability of Head and Neck Injuries in Ice Hockey: An Historical Review*, 36 BRITISH J. SPORTS MED. 410, 411 (2002).

253. John F. Fekete, *Severe Brain Injury and Death Following Minor Hockey Accidents: The Effectiveness of the "Safety Helmets" of Amateur Hockey Players*, 99 CAN. MED. ASS'N J. 1234, 1238 (1968).

254. Voight R. Hodgson, *National Operating Committee on Standards for Athletic Equipment Football Helmet Certification Program*, 7 MED. & SCI. IN SPORTS 225, 225 (1975).

255. *See, e.g.*, *Standard Performance Specification for Newly Manufactured Lacrosse Helmets with Faceguard*, NAT'L OPERATING COMM. ON STANDARDS FOR ATHLETIC EQUIP. (2018), https://nocsae.org/wp-content/uploads/2018/05/ND041-15m18-Mfrd-Lacrosse-Helmets-perf-std.pdf.

256. Bachynski & Goldberg, *supra* note 246, at 326.

257. *See* Michael L. Levy et al., *Birth and Evolution of the Football Helmet*, 55 NEUROSURGERY 656, 661 (2004).

258. Katherine M. Breedlove et al., *Impact Attenuation Capabilities of Football and Lacrosse Helmets*, 49 J. BIOMECHANICS 2838, 2838 (2016).

259. Levy et al., *supra* note 257, at 659.

260. Yunhua Luo & Zhaoyang Liang, *Understanding How a Sport-Helmet Protects the Head from Closed Injury by Virtual Impact Tests*, 28 BIO-MED. MATERIALS & ENGINEERING 279, 280 (2017) (analyzing the efficacy of various helmet materials at absorbing and diffusing mechanical energy from direct impacts).

261. *Id.*

262. *Id.*

As discussed above, however, impacts to the head or body can cause linear head acceleration/deceleration, where the brain hits one side of the skull then rebounds and hits the opposite side, resulting in what scientists refer to as "coup/countercoup trauma".[263] As a result, the brain tissue can stretch and become distorted.[264] Impacts can also cause rotation of the head with velocity exceeding that of the initial impact.[265] The strain caused by rotational acceleration can rupture blood vessels and strain axons in white matter, leading to cascading axonal injury.[266] Helmets can do relatively little to protect the brain from these injuries.

Technological development will also do little to improve helmet efficacy, according to physics professor and helmet industry consultant Timothy Gay:

> [H]elmets are 85% as good as they're ever going to get .... The optimal football helmet won't be much better than the helmet you can buy right now because there are just physics restraints on the kind of padding you can use. We have a pretty good micro, nanotechnological understanding of how materials work. And basically, there are limits on what padding materials can do for a given thickness.[267]

Both sports associations and helmet manufacturers continue to suggest that helmet technology has advanced (or can advance) to protect players' brains from the harmful effects of impacts. Lawsuits brought against Riddell, the largest producer of football helmets (which provided helmets to the NFL from 1989–2014), have alleged that the company falsely advertised its helmets' ability to reduce the incidence of concussion compared to other helmets. A class action brought by former NFL players was incorporated into the players' concussion litigation against the League.[268] Riddell did not participate in the settlement agreement between the players and the League, and the suit is ongoing at the time of this writing.[269] A class action brought by individuals and school districts in New Jersey was voluntarily dismissed (and presumably settled) in 2017 after the district court permitted the suit to go forward.[270]

As part of what some scholars identify as the "technological imperative," however, industry personnel continue to propound the notion that

263. Budinger, *supra* note 51, at 9.

264. *Id.*

265. *Id.* at 8.

266. *Id.* at 9.

267. Mark Wilson, *Why NFL Helmets Will Never Be Concussion-Proof*, FAST COMPANY (Jan. 5, 2016), https://www.fastcompany.com/1671752/why-nfl-helmets-will-never-be-concussion-proof.

268. *In re* Nat'l Football League Concussion Player Litig., 307 F.R.D. 351, 361 n.2 (E.D. Pa. 2015) (noting consolidation of claims against Riddell into the class action).

269. Bob Hohler, *The 342 Former Patriots Who Have Sued the NFL and Helmet Maker Riddell*, BOS. GLOBE (Mar. 10, 2018), https://www.boston.com/sports/new-england-patriots/2018/03/10/patriots-sue-nfl- helmet-maker-riddell.

270. *In re* Riddell Concussion Reduction Litig., 77 F. Supp. 3d 422, 440 (D.N.J. 2015) (No. 13–7585) (granting in part and denying in part Defendants' Motion to Dismiss); Stipulation of Dismissal with Prejudice, *In re Riddell*, 77 F. Supp. 3d 442 (D.N.J. 2017) (No. 13–7585).

technological improvements can eventually guarantee protection from injury. The NFL, for example, funds numerous research projects, including a $60 million program to "improve the understanding of the biomechanics of head injuries in professional football and to create incentives for helmet manufacturers, small businesses, entrepreneurs, universities and others to develop and commercialize new and improved protective equipment, including helmets."[271]

IV. USING A SOCIAL ECOLOGY OF YOUTH ATHLETICS TO TARGET INTERVENTION STRATEGIES

In the 1970s, developmental psychologist Urie Bronfenbrenner formulated what has become a widely used theory to identify the various environmental systems with which individuals interact.[272] Known as "ecological systems theory," Bronfenbrenner's framework helps illustrate individuals' relationships within their immediate communities and broader society. In the public health context, understanding the interactions of different levels of society can help clarify the causes of—and point towards possible contexts in which to address—specific health-related concerns.

Bronfenbrenner described the ecological environment as "a nested arrangement of concentric structures, each contained within the next" and which were interdependent forces surrounding the developing individual.[273] The child is thus nested within the different structures, like a Russian doll, or the center of a group of concentric circles. The first level, termed "microsystem" by Bronfenbrenner, represents the settings in which the individual engages in direct social interactions—for example, the family, school, or athletic team.[274] Microsystems interact with each other and are themselves nested within "exosystems," with which the child does not directly participate or wield influence over, but that still directly influence the child.[275] These can include school administrations and sports associations. Finally, macrosystems are the broad legal rules and cultural ideologies that influence the child.[276]

In the context of youth sports, we can identify the different systems that surround and influence children. The most immediate system is the child's family, coaches, and teammates—these are nested within broader community institutions such as sports associations or youth leagues. Finally, networks of

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271. NFL, HEALTH AND SAFETY REPORT 5 (2017), https://annualreport2017.playsmartplaysafe.com/files/NFL-2017_Health-and-Safety-Report.pdf.

272. URIE BRONFENBRENNER, THE ECOLOGY OF HUMAN DEVELOPMENT: EXPERIMENTS BY NATURE AND DESIGN (1979) (developing what is called the ecological systems theory).

273. *Id.* at 22.

274. *Id.*

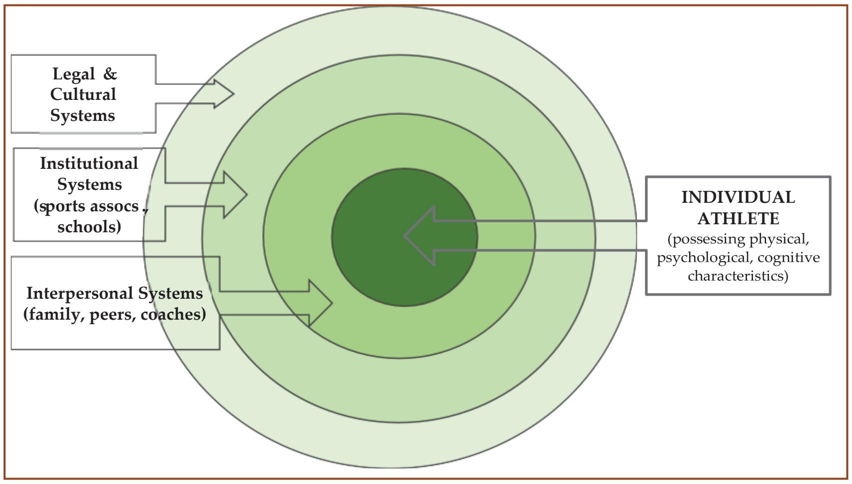
275. *Id.* at 25.

276. *Id.* at 26.

legal rules and cultural beliefs will shape the context in which children participate in sports.

A graphic representation is below:

TABLE 3. SOCIAL ECOLOGY OF THE YOUTH ATHLETE



Having identified different systems that influence the context of youth sport participation, we might consider possible interventions aimed at each, with the goal of decreasing risk of brain injury.

A. YOUTH ATHLETES AND THEIR FAMILIES, AND EDUCATORS

It is critical to recognize sports-related brain injury as a public-health challenge. Responsibility to address the challenge cannot rest, solely or principally, at the individual level. Some efforts to mitigate the incidence and effects of concussions, for example, have done just that. The Concussion Policy adopted by the NCAA, for example, imposes on athletes the obligation to self-report concussion symptoms.[277] While it is desirable that athletes feel they can, and should, self-report symptoms, requiring them to do so in the face of current sports culture, when the risk of doing so might lead to repercussions ranging from coaches' displeasure to losing a scholarship, is misguided.[278]

Instead, interventions targeting youth and adolescent athletes and the adults who interact most closely with them should aim more fundamentally to ensure that they have the best information available when making decisions

277. *See* Whitney Johnson, Note, *Deception, Degeneration, and the Delegation of Duty: Contracting Safety Obligations Between the NCAA, Member Institutions, and Student-Athletes*, 49 VAL. U. L. REV. 1045, 1067–68 (2015).

278. *Id.* at 1068.

about the risks of participation in contact sports, particularly the long-term neurological effects of concussions and subconcussive, repeated head impacts.

1. *Athletes*

On the one hand, it is essential that athletes understand the risks they undertake when participating in various competitive sports. This sort of information might be made part of physical education or science curricula in schools. In a 2004 study, sixty-six percent of high school football players admitted to not reporting a possible concussion because they believed their injury was not serious enough to warrant medical attention.[279] Ensuring that athletes understand the seriousness of concussions and head injuries causing any concussive symptoms is an important component of addressing concussion injuries. Education efforts and curricula should also include information about the dangers of head impacts, even when minor.

On the other hand, education efforts directly targeted at athletes themselves will likely have only limited effect, for a number of reasons.

First, for much of the time during which they are vulnerable to sport-related injury, it is young athletes' parents and guardians, rather than the athletes themselves, who have decision-making abilities.

Second, athletes, like most individuals, are susceptible to cognitive biases that tend to lead them to discount factual information about risk. The first is optimism bias: the belief that they are less likely than average persons to experience the negative consequences that attend a given risk.[280] Second, time discounting results in individuals placing less value on future consequences relative to immediate utility or gratification.[281] Consistent with this theory, the majority of high school football players surveyed in 2012 who were knowledgeable about both the symptoms and risks of concussion nonetheless reported they felt it was "okay" to play with a concussion, and indeed, that they were willing to "play through any injury to win a game."[282]

2. *Parents and Guardians*

Society presumes that parents will endeavor to make decisions consistent with the best interests of their children. In the context of youth sports, parents can only do so if they possess full information about the benefits and risks inherent in different activities. Currently, parents receive relatively limited information, frequently part of large packets of materials when they enroll their children in an athletic activity.

279. SPORTS-RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 100–01; Michael McCrea et al., *Unreported Concussion in High School Football Players: Implications for Prevention*, 14 CLINICAL J. SPORT MED. 13, 15 tbl.2 (2004).

280. *See* SPORTS-RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 100–01 (explaining some athletes' apathy toward reporting).

281. *See* Benson, *supra* note 154, at 315.

282. SPORTS-RELATED CONCUSSIONS IN YOUTH, *supra* note 17, at 101.

Lystedt Laws generally provide for education centered around recognizing concussion and the heightened risk of subsequent injury.[283] They do not, however, focus on the risks posed by subconcussive, repeated head impacts. Comprehensive education programs should provide parents and caregivers with information about the risks posed by these injuries, in addition to the risks of injuries accompanied by observable symptoms.

Ensuring that information about the risk of head injury is widely available and visible in locations and at times that parents are likely to encounter them—at schools, through public service announcements, in hospitals and pediatricians' offices, etc.—will entail outlay of public monies. However, given the high cost imposed by these injuries, there will almost certainly be a positive return on the investment in public health interventions, particularly those that effectively target the parents and caregivers who decide which activities their children will participate in.[284]

B. YOUTH LEAGUES AND ATHLETIC ASSOCIATIONS

Youth and scholastic leagues, from Pop Warner to the NCAA, govern the teams through which millions of youth and adolescents participate in sport. They are better positioned than individuals and families both to comprehend and address the impact-injury risks that attend different activities within their respective sports. Leagues have the capacity to gather relevant information and data and to establish the rules and protocols that govern practices and competitions.

Leagues have—perhaps unsurprisingly—been resistant to adopt significant policy or rule changes in order to increase player safety. Like most large, established institutions, the organizations are hesitant to implement changes that might decrease their relevance or ability to attract member- participants. Instead, despite overwhelming scientific evidence, leagues continue to manufacture doubt with respect to the risks of injury.[285] Pop Warner, for example, has issued communications affirming its commitment to "educate the public about the facts around head injuries."[286] Its statement goes on to insist, however, that "there is no proven connection between youth

283. NAT'L CONF. OF ST. LEGISLATURES, *supra* note 223.

284. Aaron E. Carroll & Austin Frakt, *It Saves Lives. It Can Save Money. So Why Aren't We Spending More on Public Health?*, N.Y. TIMES (May 28, 2018), https://www.nytimes.com/2018/05/28/upshot/it-saves- lives-it-can-save-money-so-why-arent-we-spending-more-on-public-health.html (reporting on data published in Rebecca Masters et al., *Return on Investment of Public Health Interventions: A Systematic Review*, 71 J. EPIDEMIOLOGY & COMMUNITY HEALTH 827 (2017)).

285. The term "manufacture of doubt" was coined by epidemiologist David Michaels to describe the legal and political strategies adopted by industries accused of exposing workers and the public to health risks. DAVID MICHAELS, DOUBT IS THEIR PRODUCT: HOW INDUSTRY'S ASSAULT ON SCIENCE THREATENS YOUR HEALTH (2008); *see also* GERALD MARKOWITZ & DAVID ROSNER, DECEIT AND DENIAL: THE DEADLY POLITICS OF INDUSTRIAL POLLUTION (2002).

286. *Player Safety Communication*, POP WARNER LITTLE SCHOLARS, https://www.popwarner.com/Default.aspx?tabid=2159476 (last visited Nov. 6, 2019).

football and CTE," and that "we encourage more advanced, unbiased research into this issue."[287] It also suggests, despite lacking evidence, that costless modifications to style of play reduce risks to what is an acceptable level.[288]

Faced with growing evidence of risk, leagues will voluntarily implement incremental reforms but continue to resist more costly or far-reaching ones. Reforms that will produce meaningful reduction of impact-injury risk will require some level of compulsion. Perhaps the most effective is litigation.

Litigation has the potential to hold leagues accountable for failing to inform athletes and their families of risk and failing to avoid known risk. Suits create indirect pressure on leagues to change rules, as entities will implement reforms to avoid liability.

Litigation can also force change more directly. The suit brought by families against the U.S. Soccer Federation is an example. Despite the uncertain likelihood of ultimate success on the merits, the athlete representatives were nonetheless able to secure rule change in exchange for dismissing their suit.[289]

Professional sports leagues, particularly the NFL and NHL, have come under scrutiny for their handling of sports-related injuries. Professional athletic leagues exist (at the risk of stating the obvious) to generate profit. Professional sports leagues do not directly employ youth athletes but can have such pervasive popular presence that they are able to shape culture. Some writers have argued that the NFL, and football more broadly, expresses essential aspects of American culture and consciousness.[290] Other scholars more recently have drawn attention to the ways in which the league carefully shapes and packages the nature of its media identity.[291] It is, in the words of former commissioner Paul Tagliabue, "truly an entertainment business."[292] The NCAA also increasingly operates like a large profit-focused organization, as colleges and universities seek the visibility, prestige, and income that revenue- generating sports can provide.

The NFL aggressively cultivates future players and fans. Indeed, in 2012, a league executive described it as "laser-focused for the last five years trying to connect kids to the NFL."[293] For example, from 2010 through 2015, it partnered with Nickelodeon, a cable and satellite television network targeted at

287. *Id.*
288. *Id.*
289. *See supra* Subpart II.B.
290. *See, e.g.*, SAL PAOLANTONIO, HOW FOOTBALL EXPLAINS AMERICA 17 (2008).
291. Thomas P. Oates, *Shifting Formations: The NFL in Uncertain Times*, 14 POPULAR COMM. 1, 1 (2016).
292. *Id*.
293. Joe Flint, *NFL and Nicktoons Hope to Score Touchdown with Cartoon*, L.A. TIMES (Sept. 5, 2012, 12:00 AM), http://articles.latimes.com/2012/sep/05/entertainment/la-et-ct-nfl-nicktoons-20120905 (quoting Peter O'Reilly, Vice President of Fan Strategy and Marketing for the NFL).

children, to produce the television series *NFL Rush Zone*.[294] The show featured a group of children who play youth football and develop superpowers when protected by their "power armor"—football uniforms with full helmets.[295] The children protect the sport of football "from an evil force trying to capture the essence of the NFL."[296]

More than one scholar has likened the NFL to "Big Tobacco," analogizing its efforts to suppress growing evidence about the risks of the game to the efforts of tobacco corporations in earlier decades to suppress the evidence about the health risks posed by consumption of its product.[297] Indeed, like the tobacco corporations, the NFL and NCAA have resisted efforts to publicize the risks inherent in certain sports, employing their own marketing professionals and scientists to cast doubt on emerging knowledge. Like the tobacco corporations, those injured by sport were compelled to seek recourse through litigation. And finally, like the tobacco corporations, the NFL and NCAA have begun looking abroad to both recruit players and expand their fan and consumer bases.

Given the financial stakes involved, it is unlikely that the large sports organizations will become full, willing partners in efforts to address the injuries caused by high-impact sport. To the extent that making some efforts (for example, supporting research) contributes to the positive image the associations wish to promote, they will do so. It is unrealistic, however, to expect much more, particularly when the steps required to do so risk denaturing what many view as essential aspects of their sports.

C. LAW

Concerted lobbying efforts initiated by families affected by sports-related brain injury led to the adoption of laws aimed at ensuring the health and welfare of young athletes.[298]

Legislative efforts, especially at the state level, could go farther. Legislation might, for example, impose age restrictions on certain sports, prohibiting individuals under a certain age from participating. There have been numerous calls to prohibit youth younger than twelve (or even all minors) from participating in tackle football.[299] Younger athletes interested in football would instead be limited to playing a safer version of the sport, such as flag

294. *See NFL Rush Zone: Guardians of the Core*, FANDOM, https://nickelodeon.fandom.com/wiki/NFL_Rush_Zone:_Guardians_of_the_Core (last visited Nov. 6, 2019); *see also* Jeffrey Montez de Oca et al., *Reaching the Kids: NFL Youth Marketing and Media*, 14 POPULAR COMM. 3, 4–5 (2016).

295. Flint, *supra* note 293; *NFL Rush Zone*, WIKIPEDIA.COM, https://en.wikipedia.org/wiki/NFL_Rush_Zone (last visited Nov. 6, 2019).

296. Flint, *supra* note 293.

297. *See, e.g.*, Goldberg, *supra* note 146, at 167–68; MICHAELS, *supra* note 285, at 3.

298. *See, e.g.*, Lowrey, *supra* note 221, at 63 (adopting the Lystedt Law in Washington following lobbying by Zachary Lystedt's family).

299. *See, e.g.*, Bachynski, *supra* note 237, at 406; Findler, *supra* note 219, at 445.

football.[300] Similarly, the prohibition on heading the ball in soccer might be expanded to prohibit heading altogether for youth younger than twelve. Wrestling, since it is difficult to imagine rule changes that could eliminate the more dangerous aspects of the sport, might be prohibited altogether for younger athletes.

The federal government, of course, is more limited with respect to the types of restrictions or policy changes it might be able to impose directly. It could, however, use its spending power to withhold certain education-related funding from states that failed to enact measures to improve the safety of youth sports.[301]

The state's principal obligations to its young citizens are to (1) safeguard their well-being during their youth and (2) preserve their future life- determining liberties.[302] It delegates these duties to parents, who are generally motivated to act in their children's best interests.

The short-term risks of high-impact sports are arguably comparable to or only slightly higher than the risks of other sports and activities. Instead, high-impact sports, by significantly increasing the likelihood of later-life brain disease, threaten individuals' future well-being. The profound mental and emotional symptoms of brain disease—depression, cognitive deficits, anxiety, emotional dysregulation—can altogether deprive an individual of the ability to live an autonomous, self-determining life. Indeed, numerous former athletes suffering the effects of traumatic brain disease end their own lives. The number of former athletes who did so without ever receiving a diagnosis of the cause of their illness remains unknown.

Prohibiting young people from participating in certain activities temporarily denies them and their parents the liberty of making those choices. Arguably, however, the threat to individuals' long-term autonomy justifies policy changes aimed at avoiding these risks.

D. CULTURE: MASCULINE IDENTITY, VIOLENCE, AND COLLISION SPORTS

Participation in competitive sports can yield both physical and social benefits. Athletics can help students develop physical and social competence and correlate with increased self-esteem and academic achievement.[303] Sports tend to be a visible and predominant aspect of the school life of adolescents and play a central role in structuring friendship networks.[304]

Other aspects of sports culture are more fraught. United States' sports culture—particularly football—has long been criticized as reifying a culture

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300. Indeed, as discussed above, the NFL already supports hundreds of flag football programs in schools. NAT'L FOOTBALL LEAGUE FOUND, *supra* note 163.

301. U.S. CONST. art. I, § 8.

302. Vivian E. Hamilton, *Immature Citizens and the State*, 2010 BYU L. REV. 1055, 1060–62 (2010).

303. Derek A. Kreager, *Unnecessary Roughness?: School Sports, Peer Networks, and Male Adolescent Violence*, 72 AM. SOC. REV. 705, 706 (2007) (gathering studies).

304. *Id.* at 705.

that valorizes hypermasculinity and aggression, and denigrating women as inferior to men.[305]

Team sports participation helps create status hierarchies within schools. Star male athletes enjoy elevated social status among their peer groups.[306] Female athletes, however, tend to be marginalized. Critical theorists have argued, moreover, that by prioritizing male sports and venerating male athletes, sports can contribute to a gendered regime within schools.

The realm of sport, despite advances in equality facilitated by Title IX, remains a gendered one.[307] The centering of male athletes occurs not only within the context of athletic competition itself, but also within the context of research and academic attention. While some researchers have begun studying the effects of repeated head impacts on female athletes' health, more researchers will ideally include female athletes in their work. However, only if funding is available, of course, can research expand and allow for better understanding of the long-term effects of high-impact sports on women's health outcomes.

Marketing and media coverage of collegiate and professional sports also tend to glorify violence within sports. In the most high-impact sports, "on-the-field violence is intertwined with success, prestige, and essentialist images of 'maleness.'"[308] Male athletes who adhere to norms of toughness and restrictive emotionality are more likely than other male athletes, moreover, to believe also that head injury and concussions are not serious.[309]

Aggression and dominance can become part of athletes' identities and extend to informal, non-sport settings. One study of nearly 6,400 males in grades seven through twelve found that male athletes participating in contact sports (particularly football, but also wrestling) are significantly more likely to be involved in serious violence or fights than athletes in other sports (such as baseball and tennis) and non-athletes.[310]

High-impact sports like football and ice hockey also tend to valorize what scholars have referred to as a "warrior narrative," in which athletes are likened to modern-day gladiators. The narrative, amplified by media coverage,

305. *See* Zack Furness, *Reframing Concussions, Masculinity, and NFL Mythology in* League of Denial, 14 POPULAR COMM. 49, 50 (2016).

306. Kreager, *supra* note 303, at 705.

307. *See* Leong, *supra* note 142, at 11–12.

308. Kreager, *supra* note 303, at 709.

309. Allyssa Jean Schlosser, Concussion Knowledge and Attitudes: The Impact of Hegemonic Masculinity 27–29 (Jan. 2016) (unpublished M.A. Thesis, University of North Dakota) (on file with the University of North Dakota Scholarly Commons).

310. Kreager, *supra* note 303, at 716–17. The author examined the influence of selection effects, considering whether more aggressive boys are more likely to select high-contact sports. *Id.* at 711. Indeed, these variables (including measures of prior fighting and minor delinquency) accounted for nearly all of the effect in wrestling, but did not account for the entire relationship between football and off-field violence. *Id.* at 719. Instead, football "remain[ed] a strong and significant predictor of violence." *Id.* at 718. Playing tennis was associated with a 35% decreased risk of fighting, compared to nonathletes. *Id.* at 717.

normalizes violence and the view of bodies as weapons.[311] Even the language of many sports, but football in particular, derives from military vocabulary.[312] Military displays are now common at collegiate and professional games. The relationship between the military, militarism, and football is neither incidental nor accidental. The U.S. Department of Defense and Pentagon contracts with the NFL and other sports teams, spending in excess of $15 million to market various branches of the military, according to 2015 reports.[313]

To the extent that cultural norms that embrace violence correlate with increased likelihood of engaging in sports-related violence (or the more violent aspects of sports), efforts to replace those norms with more socially desirable (and physically safer) norms may help reduce the incidence of sports-related injury caused by intentional contact.

To change cultural commitments that normalize activities leading to brain injury is complex. Cultural change, even in the contemporary milieu of rapid information-spreading, takes time. In the case of sport-related brain injury, moreover, cultural change will require dissemination of information about the risks as well as displacing norms that associate masculinity with violence. The task is further complicated by the counter-narratives aggressively promulgated by many sports associations.

CONCLUSION

This Article has described the dimensions of an under-recognized, yet wide-ranging challenge. The internal nature of brain injury and the delay between injury and disease make sports-related brain disease and CTE difficult to study, and it is only recently that researchers have come to understand the mechanisms by which routine head impacts can have long-term, devastating consequences. Researchers continue working to further our understanding of the consequences of collision sports, with the goal of developing treatment protocols that might limit or prevent the long-term effects of head trauma. Even while research continues, lawmakers and advocates possess sufficient knowledge to appreciate the magnitude of the health risk, and can begin to work to reduce it.

311. Sue Curry Jansen & Don Sabo, *The Sport/War Metaphor: Hegemonic Masculinity, the Persian Gulf War, and the New World Order*, 11 SOC. SPORT J. 1, 11 (1994).

312. Michael L. Butterworth, *Everybody's All-Americans: High School Football and the U.S. Military*, *in* FOOTBALL, CULTURE AND POWER 139, 142 (David J. Leonard et al. eds., 2017).

313. *Id.* at 139–40.