

A White Paper Review on Common Head and Neck Injury Research in Football

Submitted to the Oyster River Cooperative School District

By

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To whatever extent safety or risk of injury is considered for the question of establishing access for Oyster River High School students to participate in football, we submit a white-paper review from recent and relevant literature related to the topic. Public dialog concerning football is often influenced by anecdotal experience prone to hyperbole and consumer media garnished with sensationalism.¹ Thus, objectivity can be sought in the scientific literature, but only when the data are taken within context and recognized for its generalizability and limitations. Below is a sampling of summative statements derived from one or more peer-reviewed publications, organized under general themes, often taking conclusion statements directly from authors. Articles are limited to being published within the past three years, where possible, or include earlier publications considered to be seminal works. This is not intended to take the place of a true systematic review or meta-analysis.

1. **Head Impact-Exposure, Concussions, and Spine Injury:** American football is described categorically as a 'collision' sport. Tackling, blocking and incidental contact result in head impacts and acceleration forces that transmit through the helmet to the brain and/or spinal cord posing risk for acute injury.² Head-impact exposure is a phrase encouraged by the National Institutes of Health to capture the concern surrounding impacts sustained to the head, irrespective of whether there are immediate signs or symptoms (i.e., concussion). This is especially important in the pediatric brain given its vulnerability and ongoing developmental trajectory.
 - a. Due to the contact nature of tackling and blocking, ample research supports that football typically ranks highest among other collision and contact sports for the number of head impacts sustained in a given time frame (i.e., season).
 - i. Collegiate and high school football players can sustain over 1,000 impacts in a season^{3,4}
 - ii. High school football players can sustain over 1,000 impacts in a season⁵, with a study across four seasons of play reporting an average of 652 head-impacts per season.⁶
 - iii. Youth football players sustain a median number of head impacts per season of 252⁷, with an average of 210⁸ in middle school football players, and 161 per season in 7-8 year olds⁹.
 - iv. A pilot study quantified and compared head impacts from four different types of sports teams: college football, high school football, college soccer, and college lacrosse. In the four teams under study, college football players experienced a categorically higher burden of head impact. However, the high school football cohort was not significantly different from the college soccer cohort.¹⁰
 - v. In separate studies, high school girls lacrosse had fewer than 2 impacts per season,¹¹ under-11 rugby players sustained an average of 116 impacts¹², collegiate ice hockey frequency of impacts for males was 287 per season and females was 170,¹³ and an average of 140 per season in 13-14 year old ice hockey players.¹⁴
 - b. Concussion incidence in football has been shown to be highest, or among the highest, of collision and contact sports. Incidence is influenced by participation rates, of which, football also has the highest.¹⁵
 - i. Collegiate men's wrestling and men's and women's ice hockey have the highest reported concussion rates. Men's collegiate football had the highest annual national estimate of reported SRCs, although the annual participation count was also the highest.¹⁶
 - ii. In high school, football had the highest sport-related concussion (SRC) rate (9.21/10 000 AEs), followed by boys' lacrosse (6.65/10 000 AEs) and girls' soccer (6.11/10 000 AEs).¹⁷

- iii. A large systematic review and meta-analysis of 23 articles including international sports pooled overall and sport-specific concussion incidence rates per 1000 athlete exposures (AEs) for youth sports. The three sports with the highest incidence rates were rugby, hockey and American football at 4.18, 1.20 and 0.53, respectively.¹⁸
 - c. Catastrophic head and neck injury and fatality are organized into 'Direct' or 'Indirect' causation by the National Center for Catastrophic Sport Injury Research and University of North Carolina-Chapel Hill. Football has lead the nation in catastrophic head and neck injuries and fatalities since data were first collected. However, as with concussions, prevalence of an event does not take into account the participation rates in a sport, and is why incidence is important to measure for more accurate comparisons across sports.
 - i. Catastrophic head and neck 'Direct' injuries from the "All Sport Report (1982-2016)" for "high school sports shows football had the highest number of direct catastrophic events, followed by female cheerleading, baseball, wrestling, and male track and field. However, when accounting for the number of participants in the sport (incidence), cheerleading, male gymnastics, football, and ice hockey had the highest rates per 100,000 participants. Similar results were observed when restricted to fatal events".¹⁹
 - ii. "During 2005-2014, a total of 28 deaths (2.8 deaths per year) from traumatic brain and spinal cord injuries occurred among high school (24 deaths) and college football players (four deaths) combined. Most deaths occurred during competitions and resulted from tackling or being tackled. All four of the college deaths and 14 (58%) of the 24 high school deaths occurred during the last 5 years (2010-2014) of the 10-year study period. These findings support the need for continued surveillance and safety efforts (particularly during competition) to ensure proper tackling techniques, emergency planning for severe injuries, availability of medical care onsite during competitions, and assessment that it is safe to return to play following a concussion".²⁰
2. **Neurologic and Cognitive Effects:** Accumulation of sub-symptom and/or mTBI (i.e., concussion) events over a span of time while participating in sports is theorized to contribute to later life neurological deficits. Chronic Traumatic Encephalopathy (CTE) is a real concern, originally associated with sports through boxing²¹, with diagnostic pathological criteria recently defined during an NIH workshop with leading experts.²² Repetitive head impacts from sports are recognized as a risk factor for CTE²³, however, it is not known what "the true aetiology/mechanisms are; how many will develop or have the disease; if there are other relevant comorbid factors at play including genetics, cardiovascular health and substance abuse; or even the clinical presentation of this disease".^{1,22}
- a. In convenience samples of deceased football players whose families donated their brains for research, a high proportion had neuropathological evidence of CTE, suggesting that CTE may be related to prior participation in football. These studies are limited, among other factors, to having selection-bias, but the high rates of positive identification of CTE is undeniable.^{24,25}
 - b. A recent prospective study analyzed plasma tau levels in collegiate football players during pre-season practices. While plasma tau increased, it was not associated with increased head impact exposure.²⁶ A similar study using non-contact sport controls found no differences in tau concentrations following periods of contact throughout a season.²⁷ Separately, greater head-impact exposure predicted higher later-life plasma t-tau concentrations in former professional players, but plasma t-tau did not predict clinical function.²⁸
 - c. A recent study based on self-report measures in former football players suggested the earlier age one started, the increased risk for later-life cognitive and behavioral impairments.²⁹ In contrast, a large study using 3904 older men from The Wisconsin Longitudinal study found no significant harmful association of playing football with a cognition score, a depression score, or the likelihood of heavy alcohol use at 65 years of age.³⁰ However, a recent systematic review³¹ of multiple studies focused on research pertaining to long-term effects of concussions in retired athletes, and concluded that some research showed modest evidence of neurodegenerative disease in retired professional football players, but not in former high school players. Authors concluded: "More research is needed to better understand the prevalence of chronic traumatic encephalopathy and other neurological conditions and diseases, and the extent to which they are related to concussions and/or repetitive neurotrauma sustained in sports".

- d. Another recent systematic review of mental health measures associated with concussive and sub-concussive history identified a consistent positive association between a history of concussion and depression among former athletes, although the underlying causation remains unclear. Limited and inconsistent findings were observed in studies that evaluated subconcussive impacts.³²
 - e. Serum neurofilament light polypeptide, a marker of axonal nerve injury and potential biomarker of concussion³³, increased in starting football players over baseline and when compared with 'non-starters' suggesting evident brain trauma due to head-impact exposure.³⁴
 - f. Mounting brain imaging studies of physiologic and biochemical measures, often compared with controls, show evidence of physiologic changes due to head impacts and football³⁵⁻³⁸, however it is unknown whether these changes result in permanent or later-life neurological deficits. Limited research is available in other sports, but some exists, such as in women's collegiate soccer³⁹.
3. **Improved Football helmets:** Design and materials innovation in football helmets are reaching new platitudes for impact force mitigation^{40,41}, but helmets cannot eliminate impact forces translated to the brain or prevent concussions outright. Helmets have increased in size, which increases the surface area available to contact opposing players.⁴⁰ Wearing a helmet may provide a false sense of security and reduce 'head protective' behaviors.^{42,43} A recent prospective study reported collegiate football players who practiced regularly without helmets decreased head-impact exposure throughout a season.⁴⁴ Some have advocated adding soft exterior padding to helmets to further mitigate forces, such as the Guardian Cap, but independent research found it failed to significantly improve the helmets' ability to mitigate impact forces at most locations.⁴⁵
4. **Improved Rules, Coaching Education, and Tackling Training:** The increasing trajectory in impact exposure with age evident from section #1.a contradicts typical skill improvement that should come with experience. Policies aimed at reducing contact in practices have merit for lowering head impact risk^{46,47}, but fall short in addressing the head-initiated behavior. For example, 'Pop Warner' (PW) leagues developed practice policies limiting full contact practice time, but these policies fail to address game situations where most concussions occur⁴⁸. USA Football implemented an un-validated 'Heads Up' Football (HUF) tackling program that was unable to reduce game concussion incidence comparing HUF PW teams to non-HUF teams⁴⁹. Such results suggest that reducing tackling in practice and/or adopting an unverified tackling technique has limited effect in games. Questions also arise as to whether limiting opportunity for training may inadvertently place athletes at greater risk for injury by delaying their skill development as previously observed in hockey.⁵⁰

In summary, it is appropriate to acknowledge at this stage that football warrants concern for its safety and the need for continued research and rigorous injury prevention strategies. This is in light of the of data pointing to football as carrying a combination of high risk for both acute and catastrophic injury, as well as emerging evidence for developing long-term neurodegenerative deficits. This appears to differentiate it from other contact and collision sports. Indeed, the NFL's Executive Vice President for Health and Safety, Jeffrey Miller, conceded in March, 2016, that there was a link between football and degenerative brain disorders before the U.S. House of Representatives' Committee on Energy and Commerce.⁵¹ However, because prospective, longitudinal studies are lacking, it is also premature to conclude that all players, on any level, in any playing position, is at any more risk for acute or chronic injury than any other contact or collision sport.

Regardless, lowering the overall and relative risk of injury in football is dependent on effective teaching of head-safe techniques by the coaching staff, proper execution of said techniques by players, proper fit of protective equipment⁵², and following rules designed to enhance safety; all areas deficient in rigorous, scientific study. In addition, it is paramount to have qualified personnel in place to enforce rules for safe-play (game staff) and to provide administrative and health-care oversight that decreases injury severity and liabilities (athletic trainers, athletic directors, team physicians).

Finally, it important to acknowledge that inactivity is a risk factor to an overweight and obese condition, with 40% of American adults and over 18% of youth being obese.⁵³ Football may be the only recreational outlet for some youth and their only opportunity to participate in an activity to reinforce an active and healthy lifestyle.

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