


Is Youth Football Safe? An Analysis of Youth Football Head Impact Data

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BACKGROUND: The issue of whether sports-related head trauma at the youth level can result in long-term sequelae that may negatively impact the participant has been widely debated.

OBJECTIVE: To investigate head impacts in the Summit Youth Football League equipped with helmets using the Riddell InSite impact monitoring system. The monitoring system allowed for analysis of the number of impacts and severity of impacts by player.

METHODS: Data were obtained for all 20 members of the youth football team. Impacts were recorded as “low,” “medium,” and “high” intensity.

RESULTS: All 20 players participated in all practices and games throughout the season. No player suffered a concussion throughout the entire season. There were 817 recorded impacts throughout the season. This was an average of 41 impacts per player over the course of the season and fewer than 4 impacts per player per week. Only one impact registered as “high.”

CONCLUSION: We demonstrate that there are few head impacts over the course of an entire season at the middle school level. Guardian Caps, safe tackling techniques, and the age of participants may have contributed to the very low number of impacts recorded and the complete lack of injuries. This study only provides data demonstrating that youth football, when Guardian Caps and safe tackling techniques are enforced, does not appear to result in significant head impacts causing immediate head injuries. This study cannot comment on the safety of playing football at the collegiate or professional level.

KEY WORDS: Concussion, CTE, Head injury, Youth football

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The safety of youth football has undergone scrutiny. This is particularly true among parents concerned that their children may suffer long-term neurocognitive deficits from repetitive head trauma. Much concern has resulted from research demonstrating that repeated blows to the head can lead to long-term adverse neurocognitive effects secondary to chronic traumatic encephalopathy (CTE).¹⁻³ The issue of whether sports-related head trauma can result in long-term sequelae that may negatively impact the participants in the future has been debated.⁴⁻⁸ The typical levels in which

American football is played include youth, high school, college, and professional.

The exact correlation between concussions and subconcussive blows, and the development of CTE later in life, has not been definitively established.⁷ Numerous sports have been associated with the subsequent development of CTE. These sports include soccer, professional wrestling, and ice hockey.^{7,9}

Football has been the most well-studied in terms of outcomes following head trauma. Youth football has more participants than high school, college, and professional players combined. Numerous studies have listed annual numbers of 3 500 000 youth players compared to 1 300 000 high schoolers, 100 000 collegians, and 2 000 NFL professional players.^{4,6,10-12} Although youth football players make up 70% of all participants, most of the work has been in players at higher levels, mainly at the collegiate and professional levels.⁴

ABBREVIATIONS: **CTE**, chronic traumatic encephalopathy; **NFL**, National Football League; **p-tau**, phosphorylated tau; **SYFL**, Summit Youth Football League

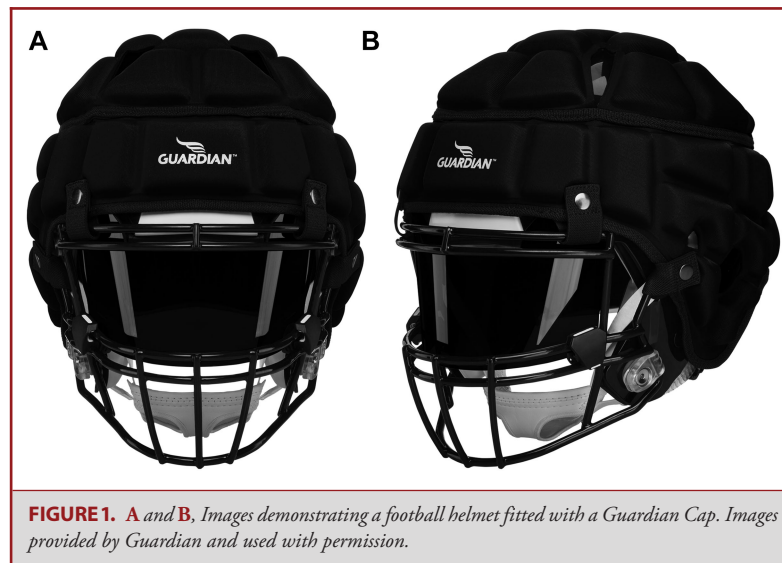


FIGURE 1. A and B, Images demonstrating a football helmet fitted with a Guardian Cap. Images provided by Guardian and used with permission.

An area of concern for parents of youth football players has been whether their child's participation may predispose them to the risks and eventual neuropsychological difficulties that have been reported for older players. Several studies have investigated head impact exposure at the youth level.^{4,6,11,13-15} These studies have led to changes in the way youth football is played. Until recently, football players were expected to participate in frequent full-contact practices. The use of the helmet as a “weapon” by the defensive players involved in the tackling process was likewise commonplace. The game played in the United States, at all levels, is different than the game played today in which using the helmet as a weapon is illegal and teams practice full contact a maximum of once daily. In addition, the duration of full-contact drills in current-day football practices is less than it was in previous decades. These changes have been implemented as evidence linked to repetitive head injury has been published.

We investigated the number of head impacts in the Summit Youth Football League (SYFL) equipped with helmets using the Riddell InSite impact monitoring system (Riddell, Des Plaines, Illinois). The monitoring system allowed for analysis of the number and severity of impacts. In addition, all helmets were fitted with Guardian Caps (Guardian Innovations, Peachtree Corners, Georgia) during practices. These changes, along with safer tackling education and limited-contact practices, were expected to result in decreased numbers of high-energy impacts to the head.

METHODS

The SYFL initiated a monitoring program for the middle school team. In the 2018 season, all members of the team wore helmets equipped with the InSite impact monitoring system (Riddell, Des Plaines, Illinois). In addition, “Guardian Caps” (Guardian Innovations, Peachtree Corners, Georgia) were fitted over the helmets during all practices throughout the

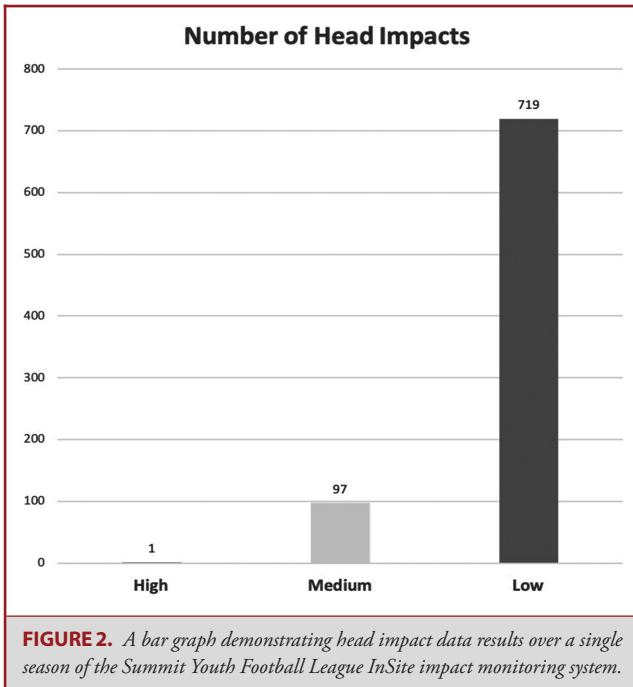
season (Figure 1). The Guardian Cap, which weighs 7 ounces, is padded and covers the outside of the helmet. The Guardian Caps provided an additional layer of padding to lessen impacts during practice sessions.

The monitoring system, an accelerometer with 5 contact points, was fitted into each helmet. It relays impact data, in real-time, to a hand-held device. The time, location, and intensity of each impact were recorded. All games were videotaped throughout the season. No practices were videotaped. Likewise, certified athletic trainers were present at all games during the season, but none were present during practices. During games, 2 player safety representatives were authorized to interrupt play at any time an injured player was identified. Furthermore, there was a low threshold for game officials to request that an injured player be brought off the field for medical attention. Verbal parental assent was provided for participation in this study. This study was approved by the Rutgers New Jersey Medical School Institutional Review Board.

The InSite system immediately signals any “high impacts” to the coaching staff by an alarm. When a “high impact” occurs, the involved player is removed from play and evaluated. The classification of hits (high, medium, and low) is proprietary information from Riddell, who has stratified the intensity by their own historical data. Subsequently, depending on the results of the assessment, the player is either cleared to return to play or further evaluated. The presence of an alarm does not mean that the player has sustained a concussion or that he is in danger. It is an alert to the coaching staff that a blow of a particular magnitude has occurred and that the player needs to be evaluated.

An additional safety measure was a tackling coach. This individual was a former Division-1 college offensive lineman who worked with all levels of the football program to emphasize tackling techniques that allow for maximum safety. The tackling coach spent time each week with the program. The program utilized the “Tip of the Spear” (Scottsdale, Arizona) program, which was developed by the Safe Football program and was taught to all players and coaches. This program is designed to teach safe tackling techniques to lessen harm to the individuals doing the tackling and to the players being tackled.

Data were obtained for the entire season for all 20 team members. Total hits were recorded, and the level and location of impacts were documented. Impacts were recorded by intensity (Figure 2). The advantage of this system is that a third-party assessment records the



environment that the players are working in. In effect, the coaching staff's subjective opinion is removed and is replaced by objective, data-driven determinations.

RESULTS

Twenty players participated in all practices and games throughout the season. Not a single player sustained a concussion. No games were missed because of head injuries. Guardian Caps were worn at every practice. There were 3 d of practice per week with a maximum of 20 min of full contact per practice. The season consisted of 7 games and 20 practice sessions. The total number of "impacts" recorded throughout the season was 817. This was an average of 41 impacts per player and fewer than 6 impacts per player per week.

A single impact registered as "high." This occurred during practice, and the player was immediately removed from play. He was determined to be uninjured and returned to the practice. Of the remaining impacts, 719 (88%) were rated as "low" and 97 (12%) were "medium" severity. Majority of the impacts occurred during practices; not during games. On further assessment, it was discovered that some players were hitting their heads on the ground while doing sit-ups early in the practices.

DISCUSSION

When high impact hits to the head occur, concussions as well as subconcussive blows may occur.¹⁶ This includes sports such as soccer, during which players undergo significant impacts while heading the ball.¹⁷ In recent years, as the data have

demonstrated that football practices have a higher frequency of head impacts than games, the focus in youth football has shifted from games to practices.⁴ In previous decades, far more aggressive blows to the head occurred among football players, at all levels, when compared with present-day experiences. In an attempt to reduce the number of high-impact hits, the SYFL elected to equip their football team with a helmet monitoring system during all games and practices, as well as Guardian Caps during practices. In addition, the players and coaches were taught safe tackling techniques. The importance of player safety coaches, educated in concussion awareness and proper tackling techniques, was published by Kerr et al.¹⁸ These measures were implemented as football coaches attempt to improve the safety of the game to combat the risk of developing CTE.

CTE, a tauopathy associated with repetitive brain trauma, was first described in 1928 by Martland,¹⁹⁻²¹ a medical examiner/pathologist from New Jersey. Martland¹⁹ described 23 boxers who became "punch drunk" at a time remote from the end of their boxing careers. The neurocognitive and neurobehavioral status of the boxers was described; however, the term CTE was never used. During the following decades, CTE was described in reference to individuals who received repeated blows to the head and ultimately developed a dementia-like syndrome wherein their memories and judgments were markedly debilitated.²²⁻²⁵

CTE was first described, in 2005, in the case of National Football League (NFL) Hall of Fame center Mike Webster, who demonstrated memory loss, deficits in judgment, and parkinsonian symptoms in the years preceding his death from a myocardial infarction.²⁶ While having a long career as one of the best offensive linemen, Webster admitted to use of performance-enhancing drugs (anabolic steroids) during his career. This initial presentation of CTE related to a history of professional football play has been questioned, as there is a known association between the use of anabolic steroids and the development of tauopathies.⁷ The current neuropathological criterion for the diagnosis of CTE was developed by a panel of expert neuropathologists during a consensus meeting in 2015. The criterion for CTE, published in 2016, requires at least one perivascular phosphorylated tau (p-tau) lesion consisting of p-tau aggregates in neurons, astrocytes, and cell processes around a small blood vessel in an irregular pattern within the depths of cortical sulci.²⁷

Although the overwhelming majority of cases of CTE have been reported in retired professional football players, CTE is not diagnosed during life and has only been definitively identified in postmortem autopsies.^{7,8} There has not been a definitive clinical study that utilizes blood tests, neuroradiological imaging studies, or clinical examinations to diagnose CTE while the athlete is alive.²⁸ Although the clinical criteria for the Traumatic Encephalopathy Syndrome have been published, this inability to detect CTE in the living has been a confounder.²⁹

A further concern of head impacts rests on the poorly understood differences between a single concussion and multiple subconcussive events. Arbitrary distinctions have been made between 3 or more concussions and fewer than 3 concussions.

The earliest notion of 3 concussions limiting further participation was first proposed by Thorndike in 1952.³⁰ Using the SF-36 mental health component score, Guskiewicz¹⁰ reported that retired football players who suffered 3 or more concussions scored worse than retired players with fewer than 3 concussions. Nonetheless, it is clear that if a participant suffers a concussion while playing, he should be immediately removed from participation. The NFL has added specialists in head injury to the sidelines to monitor for the development of concussions with a formally classified “concussion protocol” that has been standardized throughout the league.³¹

Although concussions causing readily observable signs and symptoms are of great concern to physicians examining football players during and after games, the effects of subconcussive trauma are not as obvious at the time of injury but can result in significant anatomic and physiological damage.³² Baugh³³ defined subconcussion as mild brain trauma that does not result in the readily observable signs/symptoms of a concussion. The number of head impacts experienced by players is important when studying the potential subconcussive injuries. Although the literature provides a spectrum of results in terms of the neurological impact of subconcussive trauma, repetitive subconcussive injury has been shown to result in anatomic and physiological changes.³² In a study of 46 NCAA football players assessed over a single season, Gysland et al³⁴ concluded that repetitive subconcussive head impacts over a single season did not result in short-term neurological impairment. Similar to our study, McAllister et al³⁵ identified 469 mean impacts per athlete per season across 3 Division-1 college football teams. In another similar study, Broglio et al³⁶ identified 774 impacts per player during a single season among high school football players. Our study group did not suffer any obvious head injuries throughout the season and also experienced a substantially lower number of registered head impacts, which could partly be attributed to the equipment and tackling techniques implemented by the SYFL. Given the design of our study, it is not possible to determine whether any subconcussive injuries occurred. Although the published data do not show a definitive correlation between high-impact hits and short-term neurological dysfunction, there has been a formal effort across all levels to reduce the frequency of high impacts because of the potential for long-term dysfunction related to subconcussive injuries.

Interpretation and Generalizability

Campolettano et al⁴ evaluated youth football players who were equipped with helmets utilizing accelerometer arrays. They reported 7590 impacts among 45 players (169 impacts per player over the course of the season). Although this study cannot serve as a measure for direct comparison, this rate is substantially higher than the number of impacts recorded in our study. In addition, this study recorded 8% of the impacts at the high-magnitude level, whereas our study had only a single high impact among 817 total hits. Interestingly, Campolettano et al³² compared

2 groups of youth football players, and they observed the older youth players had more impacts and a higher percentage of high-magnitude impacts, which led them to postulate that larger and faster players can deliver an impact with greater energy than smaller players. This is important to note, as the number of hits increases with the age of the player.

Research efforts have also focused on reducing the incidence of second impact syndrome, which is identified as a devastating brain injury associated with cerebral edema that occurs after an often minor blow to the head is sustained before full recovery from a concussion.³⁷ This typically has referred to an injury that occurs shortly after a concussion when a player has re-entered the game or practice without an adequate period of rest. Although the data we present cannot, it is possible that the monitoring system used in our study might make participation in tackle football, at the middle school level, safer than it has previously been surmised to be.

Stamm et al³⁸ suggested that playing football at an early age could predispose the young football players to later-life impairment, secondary to repeated head impacts. Maroon et al³⁹ commented on the Stamm³⁸ paper and stressed that not all middle schoolers who play football before the age of 12 yr go on to play NFL football. In addition, Solomon et al⁴⁰ found no association between the years of playing football prior to high school and neurological, neuroradiological, and neuropsychological outcome measures. In our study, there is markedly lower number of head impacts than what has been previously reported in the literature, suggesting the safety profile of youth football when additional equipment and safe techniques are implemented.

Limitations

Because of the retrospective nature of this study, we were not able to include pre- and postseason measures of balance, symptoms, or neurocognition. These measures could provide another level of evidence to support that the relatively low number of head impacts incurred in this football season do not appear to add any short-term dangers from head injury.

In addition, the effectiveness of Guardian Caps would be better measured in a direct comparison between 2 groups: one with Guardian Caps and the other without Guardian Caps. Because of the retrospective nature of this study within a suburban community, this was not an option. A larger scale study investigating their use and effectiveness in reducing high impacts is warranted.

Finally, the classification of hits (high, medium, and low) is proprietary information from Riddell. The helmet company stratified the levels of intensity according to their own historical data. This limits our ability to provide numerical data regarding the intensity of hits encountered by each player.

CONCLUSION

The concerns of parents, in 2019, are understandable. They do not want their children to develop learning disabilities or

neurobehavioral or neurocognitive difficulties as a result of participating in football. The prospect of developing CTE and impaired mental health at a later age could be terrifying to a parent. The overwhelming majority of all literature on this topic, and all studies to date, strongly suggest that participation in youth football is not a risk for these devastating later-life occurrences. Our study demonstrates how few impacts occur at the middle school level over the course of a season in which Guardian Caps and safe tackling techniques are employed. Additionally, all participants were middle school football players. Even at the high school level, there are fewer significant impacts than when the players become larger, stronger, and more skilled at the collegiate and professional levels.^{4,11}

Our study has demonstrated that when utilizing the techniques and safety precautions put in place by the SYFL, there are few head impacts over the course of an entire season of practicing and playing games at the middle school level. Utilizing available safety materials, such as the Guardian Caps, may have contributed to the very low number of impacts recorded and the complete lack of head injuries. This study cannot comment on the relative safety of playing football later in life as at the collegiate or professional level or the relationship of early football exposure to later development of CTE. As players age, the number of impacts increases, and likely, the intensity of the impacts increases. Nonetheless, when appropriate safety measures are taken, middle school football did not appear to result in any head injury over a single season.

Because of this anecdotal information, the SYFL tackle football players will again wear the impact monitoring system in 2019. In addition, football players are taught “safe football” through the Tip of the Spear program, which strives to lessen use of the helmet as a weapon. The Guardian Caps may add another layer of protection to lessen the magnitude of hits. The data obtained from this season allow parents, youth football coordinators, and physicians to make informed opinions as well as improve the relative safety of youth football at the middle school level as it is played in 2019.

Disclosures

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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