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Impact of Increased Football Field Width on Player High-Speed Collision Rate

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BACKGROUND: **High-acceleration head impact is a known risk for mild traumatic brain injury (mTBI) based on studies using helmet accelerometry. In football, offensive and defensive players are at higher risk of mTBI due to increased speed of play. Other collision sport studies suggest that increased playing surface size may contribute to reductions in high-speed collisions. We hypothesized that wider football fields lead to a decreased rate of high-speed collisions.**

METHODS: **Computer football game simulation was developed using MATLAB. Four wide receivers were matched against 7 defensive players. Each offensive player was randomized to one of 5 typical routes on each play. The ball was thrown 3 seconds into play; ball flight time was 2 seconds. Defensive players were delayed 0.5 second before reacting to ball release. A high-speed collision was defined as the receiver converging with a defensive player within 0.5 second of catching the ball. The simulation counted high-speed collisions for 1 team/season (65 plays/game for 16 games/season = 1040 plays/season) averaged during 10 seasons, and was validated against existing data using standard field width (53.3 yards). Field width was increased in 1-yard intervals up to 58.3 yards.**

RESULTS: **Using standard field width, 188 $\pm$ 4 high-speed collisions were seen per team per season (18% of plays). When field width increased by 3 yards, high-speed collision rate decreased to 135 $\pm$ 3 per team per season (28% decrease; $P < 0.0001$).**

CONCLUSIONS: **Even small increases in football field width can lead to substantial decline in high-speed collisions, with potential for reducing instances of mTBI in football players.**

INTRODUCTION

Participation in collision sports, such as football, continues to be extremely popular for adolescents and adults. Sports participation results in an estimated 3.8 million mild traumatic brain injuries (mTBIs)/concussions annually.[1] Much research has focused on diagnosis and management of mTBI, with a focus on long-term sequelae. Investigations into the primary preventative strategies for concussion in football have focused on helmet design, rule changes, and changing practice habits.[2] Previous studies using helmet accelerometry suggest that high-acceleration impacts are a risk factor for mTBI.[3,4] In football specifically, offensive and defensive skill players are known to be at higher risk of mTBI, likely due to their increased speed of play.[5] Here, we developed a novel computer simulation to test the hypothesis that increased football field width leads to a decreased rate of player high-speed collisions, potentially identifying a novel strategy to decrease incidence of mTBI in football players.

METHODS

The simulation engine was programmed using MATLAB software (MathWorks, Natick, Massachusetts, USA). The model assumptions are listed in Table 1. An example play generated by the simulation is illustrated in Figure 1.

Each simulated play can be divided into 3 phases. The first phase encompasses the start of play to the time the ball is released. During the first phase, each of 4 wide receivers is randomized to one of 5 possible trajectories: straight line, straight for

Key words
- Computer simulation
- Concussion
- Football field
- Mild traumatic brain injury

Abbreviations and Acronyms
mTBI: Mild traumatic brain injury
NFL: National Football League

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Table 1. Player Collision Simulation Model Assumptions

Parameter	Assumption
Maximum player speed	10 yards per second
Offensive player action before ball release	Randomized to one of 5 possible trajectories
Offensive player starting positions	Spread equally across field width
Offensive player trajectories	i. Straight line
	ii. Straight for 10 yards, then turn 90 degrees to the left
	iii. Straight for 10 yards, then turn 90 degrees to the right
	iv. Straight for 10 yards, then turn 45 degrees to the left
	v. Straight for 10 yards, then turn 45 degrees to the right
Defensive player reaction before ball release	Either follow nearest offensive player or bisect trajectories of 2 nearest offensive players
Play time at which ball is released	3 seconds
Ball flight time	2 seconds
Defensive player reaction time delay after ball release	0.5 second
Receiver selected to catch ball	Most open receiver
Most open receiver	Receiver with fewest surrounding defensive players within a 10-yard radius
Defensive player reaction after ball release	Run toward ball-catch position
Time-window for high-speed collision after ball catch	0.5 second
Receiver-defense distance trigger for high-speed collision	1 yard
Number of plays per game	65
Number of games per season	16

10 yards then turn 90 degrees to the left, straight for 10 yards then turn 90 degrees to the right, straight for 10 yards then turn 45 degrees to the left, or straight for 10 yards then turn 45 degrees to the right. Their starting positions are equidistant from each other, assumed to be spread evenly across the width of the field. Each defensive back or linebacker will either follow the nearest offensive player or bisect the trajectories of the 2 nearest offensive players. The maximum speed of each player is assumed to be 10 yards per second. The second phase begins when the ball is released, assumed to be 3 seconds into play, and ends when the ball is caught, assumed to be 2 seconds after the ball is released. After a defined reaction delay time (assumed to be 0.5 second), the defensive players react to the ball release by changing trajectory to intercept the ball carrier near the anticipated ball-catch position. The third phase begins when the wide receiver catches the ball. The receiver is then vulnerable to high-speed collision for a defined time-window, assumed to be 0.5 second. A collision is detected when a defensive player, other than the defensive player covering the wide receiver, intercepts the ball carrier within a radius of 1 yard during the collision time-window. The third phase ends either when a high-speed collision is detected, or when the time-window for high-speed collision ends without a collision.

One season was defined as 1040 plays (65 plays per game and 16 games per season). For each season, the number of plays with a player high-speed collision was counted. For each change in field width, the number of player high-speed collisions was averaged during 10 seasons, for a total of 10,400 plays simulated per field width. Field width varied between 52.3 and 58.3 yards, in 1-yard intervals. The standard National Football League (NFL) field width of 53.3 yards was included to validate against current data. Hypothesis testing was performed using Student's *t*-test.

RESULTS

The simulated mean number of player high-speed collisions per season per team for the current standard NFL field width of 53.3 yards was 188 $\pm$ 4 collisions out of 1040 plays per season, or a collision rate of 18% of plays, which is in agreement with current data published in the literature.[6] When the field width was increased by 3 yards to 56.3 yards, the player high-speed collision rate decreased to 135 $\pm$ 3 per team per season, a 28% decrease in collisions compared with the standard NFL field width ($P < 0.0001$). The results for the remainder of the simulated field widths are illustrated in **Figure 2**. This decrease in player high-speed collision rate was stable in the range of 56.3—58.3 yards.

Simulation run-time averaged 2.2 milliseconds per play on a 2.6 GHz Intel Core i5 processor with 16 GB 1600 MHz DDR3 memory. **Figure 2** was generated using a total of 72,800 simulated plays.

DISCUSSION

In recent years, a significant research effort has been focused on advancing concussion care. Strategies are primarily focused on diagnosis, including blood biomarker testing and eye tracking.[7-9] Significant research efforts have also investigated strategies for determining time of safe return-to-play. These strategies are principally focused on symptomatic recovery and secondary prevention of mTBI.

Research into primary preventative strategies for concussion in football has focused on helmet design and changing practice habits. Helmet design has been shown to have a potentially demonstrable effect on incidence of mTBI.[10] However, these data are controversial, as some studies[11,12] have shown that helmet type does not affect rate of mTBI. Ill-fitting helmets may also lead to an increased rate of mTBI.[13] Several new helmet designs are entering the commercial market that are intended to reduce risk of concussion. Previous studies have investigated head impact burden throughout the course of the season. Based on helmet accelerometer data, Broglio et al[14] suggested that reducing contact practices to once per week would reduce helmet impacts by 18% per season, whereas completely eliminating contact practices would reduce impacts by 39%. Kerr et al[15] investigated the effect of a coaching intervention, namely Heads Up Football. They found that there was a significant decrease in head