Quantifying Head Impact Exposure in American Football Using the Frequency Metric 'Head Impacts per Snap' to Account for the Number of Game Opportunities

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I. INTRODUCTION

Sport-related concussion continues to be one of the leading injuries sustained across all levels of sports and throughout the world [1-3]. Contact sports represent a unique environment, wherein participant athletes receive daily head acceleration events (i.e. head impacts) over the course of months during training and game activities. Reduction of injury risk through rule-making or personal protective equipment requires an understanding of biomechanical injury mechanisms. Despite significant research efforts, the correlation between contact sport head impact biomechanics (i.e. Head Impact Exposure (HIE)) and injury risk is yet to be clearly defined. Whereas earlier studies focused on the magnitude of individual 'concussive impacts' [4], more recent research has focused on the role of repetitive HIE over the course of a playing season [5]. However, studies have also begun to identify the frequency of HIE as an important metric [6], with indirect supporting evidence from higher concussion rates identified during the college football preseason, a time of elevated HIE [7]. The objective of this preliminary study was to characterise the rate of HIE sustained during game participation in American football using a metric that normalises the total number of recorded head impacts over the course of a single game by the number of plays, known as 'snaps', in which the athlete participated.

II. METHODS

We analysed data collected in the Concussion Assessment, Research and Education Consortium, Advanced Research Core (CARE-ARC) head impact measurements (HIM) study. The study protocol was approved by the Institutional Review Board (IRB) at the Medical College of Wisconsin, with participating sites utilising an IRB reliance agreement. There were 476 football players who consented and enrolled in the CARE-ARC with the daily head impact data collected over five football seasons using the Head Impact Telemetry (HIT) system (Riddell SRS, Riddell, Rosemont, IL), resulting in a total of 723 player-seasons. The HIT system is a helmet-based acceleration measurement system that records every head acceleration event that exceeds a threshold resultant acceleration of 9.5 g. Game participation was quantified by counting the number of plays (i.e. snaps) per game for each participating athlete. Snap counts per athlete per game were obtained from a subscription-based website (www.pff.com) and validated in a limited cohort using available game videos where athlete participation was logged in every 'snap' and compared to snap counts for each athlete reported on the website.

Enrolment in the CARE-ARC HIM core adopted a design whereby each enrolled athlete participated during the preseason, regular season, and spring training. In our analyses, we used game data for players participating in at least five games per season. Since snap counts are only available for games, all data reported in this manuscript are for games and do not account for preseason and regular season practices. Our final dataset consisted of the number of snaps and the number of head impacts for 484 player-seasons collected from 329 players.

The focus of this analysis was on studying the frequency of head impact accumulation in games, normalised by the number of opportunities. The analysis included only head impacts recorded on game days, filtering out any head impacts that occurred outside of published game times. A regression model was then used to quantify the association of head impacts with the number of snaps (head impacts per snap (HIpS)). To adjust for the correlations among the observations arising from the same players within a season, we utilised the linear mixed

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models with random slopes for each player-season. Resulting associations are summarised in Fig. 2.

III. INITIAL FINDINGS

Athletes participated in a median of 34 snaps per game (10–55 snaps/game; Q1Q–3), which varied by athlete primary position (Fig. 1). Athletes recorded a median of nine impacts per game during game times (2–23 impacts/game), which also varied by athlete primary position. The number of recorded impacts during game time and the number of snaps per game (i.e. snap count) demonstrated a positive linear relationship (Fig. 2), with an increasing number of snaps resulting in an increasing number of recorded head impacts during game time.

Head impact exposure during games significantly varied by player position ($p<0.05$), with positions generally falling into three bins. Running backs (RB; 0.58 head impacts/snap), defensive linemen (DL; 0.57), tight ends (TE; 0.55), and offensive linemen (OL; 0.49) had the highest number of HIpS. Linebackers (LB; 0.42), defensive backs (DB; 0.41) and wide receivers (WR; 0.41) had significantly fewer HIpS than RBs (ps < 0.01). Quarterbacks (QB) had the lowest number of HIpS (0.31), which was significantly lower than the four highest groups (ps < 0.05).

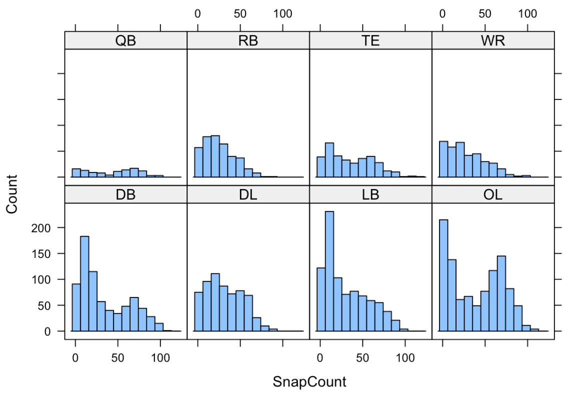

Fig. 1. Distribution of the number of plays (i.e. snaps) per game for participating athletes; separated by position.

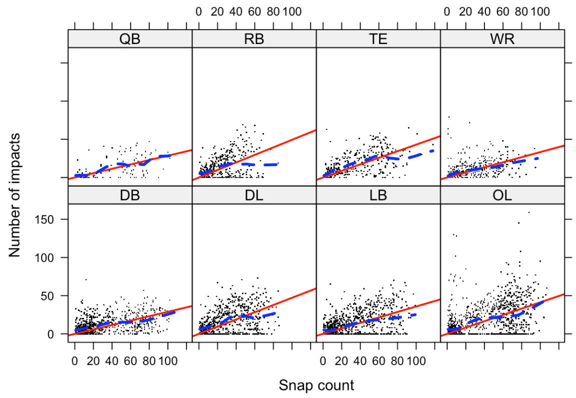

Fig. 2. Number of recorded impacts per game versus number of snaps per game; separated by position.

This analysis also provided marginal evidence of a higher rate of HIE in concussed athletes. Across the entire sample, 33 concussed athletes had higher HIpS across all games in which they participated (avg. 0.51±0.06; mean±std error) compared to athletes who did not sustain concussion (0.47±0.02). When matching based on playing position, four of the six positions that had four or more athletes with concussion demonstrated increased HIpS in concussed compared to non-concussed athletes. The strongest differences were for DBs, who had 56% more HIpS in concussed athletes, and RBs (+22%).

IV. DISCUSSION

This analysis presents novel contact sport head impact exposure data, normalised by playing opportunities. This type of data can be used to understand the frequency of head impact exposure during contact sports while providing certain information about an individual athlete's playing style. The accuracy of concussion tolerance related to head impact exposure will likely be improved by including the magnitude of individual head impacts, the total number of impacts, as well as the frequency of accumulating head impacts. We hypothesise that athletes with a more aggressive playing style, particularly in collision sports such as American football and rugby, will sustain a higher frequency of head impacts (i.e. HIpS) that will lead to an elevated risk of concussion. Preliminary results reported here support this assertion by demonstrating higher rates of head impact exposure (i.e. HIpS) during games for athletes who sustained concussion.

V. REFERENCES

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