

ESTIMATES OF HIGH-RISK SINGLE AND CUMULATIVE HEAD IMPACT DOSES IN AMERICAN FOOTBALL

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ABSTRACT

In this study we conducted laboratory calibrations and retrospectively analyzed 2851 video-verified head impacts in American football players over 445 player-games using an impact monitoring mouthguard (IMM) system to estimate high-risk impact doses.

In 731 laboratory tests versus Reference, the IMM fit a linear model, with results close to the ideal linear model of form IMM=0.97*REF+1g, R^2=0.97.

During gameplay, the median peak scalar linear acceleration (PLA), peak angular acceleration (PAA), peak linear velocity (PLV), peak angular velocity (PAV), kinetic energy transfer (KE) and Risk-Weighted Exposure (RWE) were 21g, 1600rad/s^2, 12rad/s, 1.5m/s, 6J and 0.00002, respectively. Approximately 90% of impacts were to the front and sides of the head.

Notable single play (n=4 players) and cumulative full-game (n=3 players) impact doses were examined for players observed on video meeting the National Football League's "No-go" criteria. High energy doses from single play impacts to the side of the head in the coronal plane, in the range of 40J to 110J, caused players to immediately meet "No-go" criteria. High cumulative energy dosing from a game's-worth of impacts – when players were mostly struck to the front of the head in the sagittal plane, range 100J to 320J - also met the "No-go" criteria.

Future data collection will focus on monitoring head impacts in a broader set of athletes to verify these preliminary findings, and to explore single play sensitivity to sagittal impacts and cumulative dosing in the coronal plane.

Keywords: Head impact monitoring, American football, Concussion, Cumulative, Impact dose

INTRODUCTION

In 2011, after reviewing scalar on-field kinematics data leading concussion clinicians concluded "*Recent studies suggest that a concussive injury threshold is elusive, and may, in fact, be irrelevant when predicting the clinical outcome*".[1] In 2014 the Institute of Medicine concluded that "*Available studies of head injury biomechanics have identified the importance of linear and rotational movements of the head in injury causation...*" and "*there are currently inadequate data to define the direction- and age-related thresholds for linear and rotational acceleration specifically associated with concussions*…".[2] The collection of trustworthy impact monitoring data as a means to address these inadequacies has also been acknowledged by many recently "*accurate measures of individual exposure will yield a direct estimate of the human tolerance*",[3] "*as more accurate sensors are designed*…",[4] "*valid methods of measuring the direction and severity of on-field head impacts are needed*".[5] It is likely that higher fidelity estimates of spatial and temporal impact parameters will clarify the currently unclear impact dose-response relationship.

The aim of this study was to investigate spatial and temporal estimates of head impact doses collected with a laboratory-calibrated impact monitoring mouthguard (IMM) system in American football. We first calibrated the IMM system in n=751 laboratory American football tests against instrumented Reference headforms. Next, we analyzed time-synchronized video and IMM data collected during n=445 player-games of high school and collegiate American football. Summary statistics on all impacts were synthesized. Cases where a player sustained impacts during a single play, or during a