Neurophysiological Deficits In Football Assessed Using ImPACT, fMRI, and Head Impact Telemetry
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INTRODUCTION

Current methods for identifying concussions rely heavily on observation of symptoms. Because subconcussive blows do not result in acute clinical symptoms they are difficult to study and are largely absent from the literature. One of the first studies to quantify the effects of subconcussive blows was by Talavage et al. They found that asymptomatic high school football players demonstrated deficits in neurocognitive performance as measured by the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT™) and functional MRI (fMRI). Subsequently, Breedlove et al. observed correlations of measured deficits with number and location of subconcussive blows sustained throughout the season for both symptomatic and asymptomatic subjects. This suggested that neurophysiological deficits are linked to cumulative, subconcussive impairment, even in the case of concussion, which has classically been thought of as an acute injury. Together, these findings lead to speculation that while multiple factors influence occurrence of a concussion, the frequency of subconcussive impacts may be an important component in its etiology. The purpose of this work was to research the relationship between the number of head impacts and asymptomatic neurocognitive impairments.

METHODS

All human subjects protocols were approved by the Purdue IRB prior to beginning the study. Subjects were recruited from a high school football team. A combination of neurocognitive assessment using ImPACT, fMRI, and head impact telemetry was employed to evaluate in-season neurological changes. Each subject received a pre-season baseline. For ImPACT, abnormal in-season changes in neurocognitive performance were flagged automatically by ImPACT. For fMRI, player in-season data were compared to the pre-season group average. Data outside a 95% confidence interval were flagged for abnormal changes in neurophysiology. Note that the N-back task, which was the task used for the fMRI, generally yields reproducible activations and is insensitive to drug use except with overt intoxication; therefore, changes in fMRI were only expected due to some outside influence, such as head impacts. Finally, the number and severity of head impacts throughout the football season were subsequently compared to the probability of a player being flagged by either ImPACT or fMRI.

RESULTS

Examinations of 35 total participants resulted in a total of 66 in-season ImPACT™ tests with 27 having at least one composite score flagged and which were not simultaneously diagnosed with a concussion.

Excluding individuals who were diagnosed with a concussion, subjects who sustained 700 or more cumulative hits at the time of their in-season evaluation were flagged 100% of the time (Figure 1). Below 700 cumulative hits 31/47 (66%) were flagged and 16/47 (34%) were not flagged (Figure 1).

When plotted against the average number of hits per week, 43 examinations fell below an average 65 hits per week. Twenty-eight of the 43 (65%) were flagged by ImPACT™ or fMRI. There were 17 examinations above 65 average hits per week, one of which was a concussion. Of the remaining 16 examinations above 65 hits per week 15 (94%) were flagged, a significantly higher rate than for below 65 hits per week (Figure 2).

Finally, the average number of head impacts sustained during a practice was compared to the average number of head impacts taken during a game (Figure 3). Players who had averaged more than 40 hits per game and 25 hits per practice were found to have a higher likelihood of being flagged. Specifically, a total of ten subjects (one concussion and 9 flagged examinations) were flagged by either the ImPACT™ or fMRI. There were 49 examinations for which the subjects were below 40 hits per game and 25 hits per practice. Of those, 6 examinations were associated with a concussion with the remaining 43 of 49 (88%) were flagged by ImPACT™ or fMRI (Figure 3).

An additional analysis evaluated the effect of player position on the rate at which players were flagged. No difference was found between linemen and skill positions in the rate at which players were flagged. Therefore, player position was not a risk factor, in and of itself, for being flagged. However, it was found that players who sustained greater than 700 cumulative hits were more likely to be linemen. Likewise, players who sustained greater than 65 average hits per week were also more likely to be linemen.

CONCLUSIONS

• Both ImPACT and fMRI are valuable tools for quantifying neurological deficits.
• Impairment on both ImPACT and fMRI could be predicted from the number of head impacts. Predictions did not appear to depend on player position.
• Deficits identified using ImPACT are believed to indicate widespread impairment of working memory while fMRI has the ability to focus on regions of the brain working on specific tasks and provides an assessment of fundamental changes in neurophysiology.
• These data demonstrate that a substantial number of asymptomatic athletes exhibit profound neurophysiological changes in-season, and that, in some cases, they persist in the post-season. This finding highlights the need to develop additional sideline or point-of-care assessment tools.

REFERENCES


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