Combining Qualitative Video Analysis with In-Vivo Head Kinematics in Collegiate-Level American Football

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I. INTRODUCTION

Measuring head kinematics during sports impacts is essential for understanding the severity and mechanism of concussion injuries. A broad range of biomechanical research has linked head kinematics of a single impact event to concussion and other brain injuries [1]. However, it has been contended that the number and magnitude of subconcussive hits and the time between hits should also be considered [2]. In this study, we equipped players from a NCAA Division I American football team with instrumented mouthguards to measure head kinematics during regular season matches and practice. Separately and independently, qualitative video analysis of each match and practice was conducted to identify and categorise the contact events for each player equipped with an instrumented mouthguard. This combined approach enabled a qualitative assessment of video-verified head acceleration events in order to identify a difference in head kinematics between different contact events.

II. METHODS

This study utilised the dataset from Kuo *et al.* [3] by examining video footage of contact events involving players equipped with CamLab instrumented mouthguards during the 2015 autumn season. A total of seven players were recruited, representing mainly offensive playing positions, for a combined total of 11 matches and 22 practices. The mouthguards were instrumented with accelerometers and gyroscopes to record 3D-head kinematics on the field using a typical 10 g head centre of gravity (COG) linear acceleration magnitude threshold. Linear accelerations were transformed from the mouthguard to the head COG using rigid body dynamics assumptions. The mouthguards were previously validated in both cadaveric and anthropomorphic dummy testing in impact conditions typical of American football and with an American football helmet [4]. These mouthguards were shown to measure linear acceleration and angular velocity within 10% of reference measurements at the head center of gravity (COG).

Direct helmet contact and inertial head loading cases were included in the dataset. Impacts collected by the mouthguards were time stamped with 1 s resolution, allowing synchronisation with the video footage. A two-stage two camera-view video analysis method was conducted for all contact events. The cameras followed the passage of play and recorded at 30 fps and a resolution of 1080 p. For the first round of video analysis, trained raters tracked one player in each video and labelled their activity as either Contact, No Contact, Obstructed View, Idle, or Not in Video. For this study, each contact event was subsequently labelled based on the player activity, i.e. Blocking, Blocked, Tackling, Tackled and Ground Contact (see Fig. 1). The timestamp from each video-based contact event was cross-referenced with the instrumented mouthguard timestamped reading. Linear mixed-effects models were calculated to compare peak linear accelerations, peak angular accelerations and peak angular velocities between the contact event categories.

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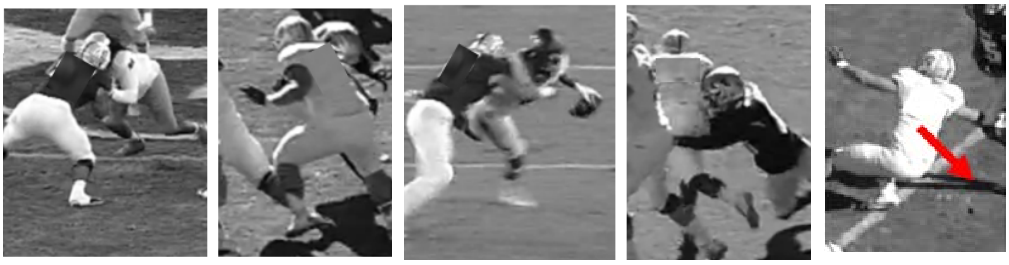

(a) (b) (c) (d) (e)

Fig. 1. (a) Blocking (grey jersey), (b) Blocked (white jersey), (c) Tackling (grey jersey), (d) Tackled (white jersey), (e) ground contact (red arrow indicates falling) event.

III. INITIAL FINDINGS

The method resulted in 528 contact events being labelled, with the majority occurring in the blocking phase of play. Median peak angular velocity for all contact event categories appear similar (Fig. 2). No contact event pairwise comparison for the peak head kinematics resulted in statistical significance (all p>0.05).

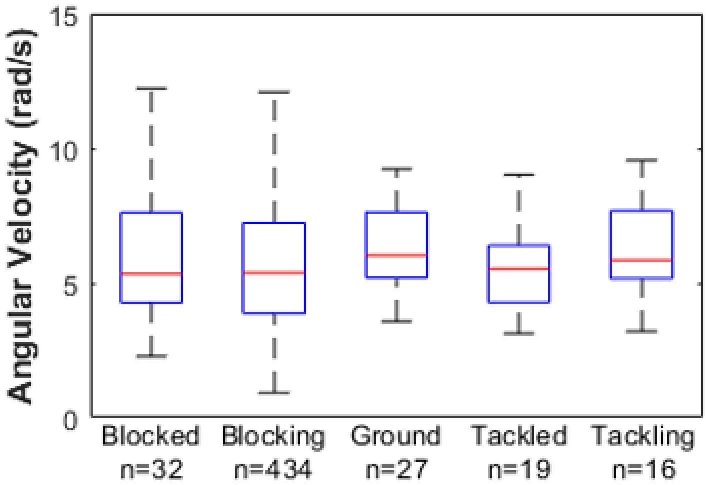

Fig. 2. Median peak angular velocity with quartiles based on contact event type.

IV. DISCUSSION

The results demonstrate that it is important to include all contact events, including direct helmet contact and inertial head loading cases, when assessing head acceleration exposure. The approach demonstrates the importance of a combined biomechanical (instrumented mouthguard) and qualitative (video analysis) approach for further understanding phase of play-specific head kinematics in contact sports. Qualitative video analysis approaches alone tend to focus on direct-head/helmet contact events [5] and thus miss important information from inertial head loading events. Instrumented mouthguard approaches without video verification may be prone to false-positive readings [3]. Additionally, it offers almost no information on the impact event that triggered the mouthguard. This is essential information for guiding head acceleration exposure and concussion prevention strategies.

While it is vital to coach contact technique for player performance, examining and monitoring the degree to which practices can be adapted to reduce head acceleration exposure and severity is an essential future step.

V. REFERENCES

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