A Comparison of Two Data Acquisition Threshold Values on Head Acceleration Event Counts from an Instrumented Mouthguard

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I. INTRODUCTION

Head acceleration events (HAEs) can occur directly from head contact (direct HAE), indirectly from body contact (indirect HAE) or from voluntary movement (voluntary HAE). A 10 g threshold for HAEs is commonly used in contact sports such as rugby with anything below this excluded from datasets as it is deemed possible from voluntary movements such as running and jumping [1]. However, a recent systematic review [2] illustrates that head acceleration magnitudes during these types of events are dependent on the wearable head sensor used to measure it, with poorly coupled sensors (helmet and headband-based) typically showing higher magnitudes.

The data acquisition threshold values chosen have considerable implications on our understanding of head acceleration exposures in contact sports as thresholds that are too high or low may underestimate or over-inflate relevant HAE incidences, respectively. The aim of this study was to assess two data acquisition thresholds on direct and indirect HAE counts in a sample of men's professional rugby league players.

II. METHODS

A total of ten male players were recruited from a professional rugby league team for 1-8 games. The cohort included two backs and eight forwards. Each player was equipped with a custom-fit Prevent Biometrics Instrumented Mouthguard (iMG). The reliability and validity of this iMG has been demonstrated in previous studies [3-4]. Lab-based impact testing on a crash test dummy headform to assess the accuracy of a range of instrumented mouthguards identified that the Prevent Biometrics custom fit iMG was the best performing device with a mean relative error of 4.9%, 4.6% and 2.5% for peak angular acceleration, angular velocity, and linear acceleration [3]. On-field assessment found the Prevent Biometrics custom fit iMG to have a positive predictive value of 96.4% during active minutes of play [4].

The iMG triggered when the accelerometer measures exceeded 5 g on a single axis of the iMG, capturing 10 ms of pre-tigger data and 40 ms of post-trigger data. In-house Prevent Biometric algorithms transformed the kinematics to the head centre of gravity (CG) and then filtered by a 4-pole, zero phase, low-pass Butterworth filter with a corner frequency of 400 Hz. Peak kinematic values were extracted from the resultant waveform of each triggered event (peak linear acceleration, peak angular acceleration and peak change in angular velocity). Peak change in angular velocity was calculated as the peak resultant value from a waveform zeroed to the onset of post-trigger data (i.e. the moment the iMG was triggered). Broadcast quality video footage was available for each match. iMG-triggered events were timestamped and synchronised with video footage to a 40 ms resolution. An initial HAE verification analysis was conducted by the manufacturer using video-verification and infrared proximity and light sensor values in order to develop their HAE impact detection algorithm. A true positive occurred when the iMG HAE impact detection algorithm labelled a triggered event as a HAE and the timestamp corresponded to a contact event (head or body contact) on the video footage for that player. The video of HAEs labelled as true positives by the manufacturer were qualitatively analysed and further labelled as a direct HAE, indirect HAE or voluntary HAE. Voluntary HAEs were removed from the analysis (n=18).

III. INITIAL FINDINGS

A total of 1666 true positive direct and indirect HAEs were recorded using the 5 g single axis iMG trigger. For both direct and indirect HAE, data were positively skewed (Fig.1). Applying a 10 g resultant threshold to this data removed 70.1% of all true positive direct HAEs and 89.3% of all true positive indirect HAEs.

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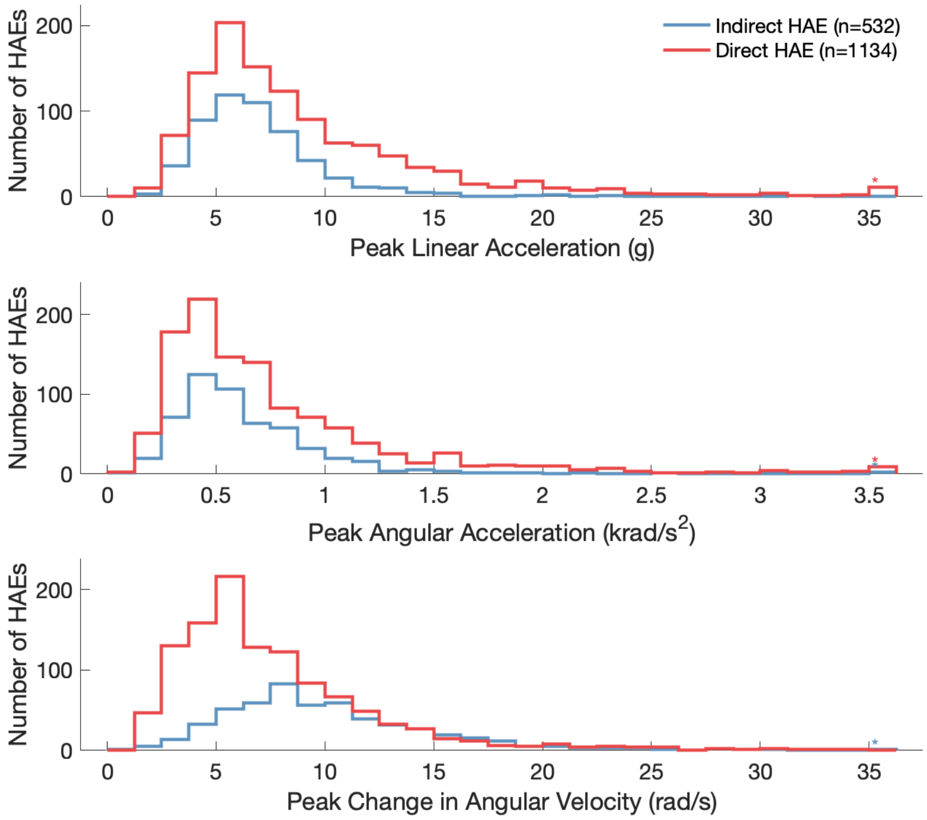

Fig. 1. Histograms of the kinematics of true positive direct and indirect HAEs. HAEs greater than 37.5 g (n=11), 3.75 krad/s^2 (n=11) and 37.5 rad/s (n=3) are not included within the histograms.

IV. DISCUSSION

Clearly, the application of a data acquisition threshold has a large influence on the number of true positive HAEs included in men's professional rugby league datasets. Interestingly, a greater number of indirect HAEs were removed by the 10 g threshold. The omission of lower magnitude HAEs when a data acquisition threshold is applied may withhold vital information on the loads placed on players' brains over their careers. Though, the inclusion of these HAEs can add to the data processing requirements of researchers and iMG technology whilst also likely to positively skew datasets. The clinical relevance of including or omitting these lower end of the spectrum HAEs is still unknown. However, it is needed given the concerns that the number of HAEs a player is involved in over their career can have potential long-term consequences on brain health [5].

An appropriate next step may be to gather a sample of voluntary HAEs from sports currently not associated with long-term brain health issues such as gymnastics and cheerleading where high inertial head loading may occur from voluntary movements. Non-contact versions of sports such as tag rugby and flag football would also be beneficial to include in the dataset. The analysis should be conducted on male and female cohorts as different thresholds could exist. It may be the case that linear acceleration is not the best metric for identifying lower thresholds for HAEs, particularly given the brains susceptibility to rotational motion [6].

V. REFERENCES

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