prevent biometrics

DATA GUIDE

Prevent iMG

WHAT DOES THE PREVENT iMG MEASURE?

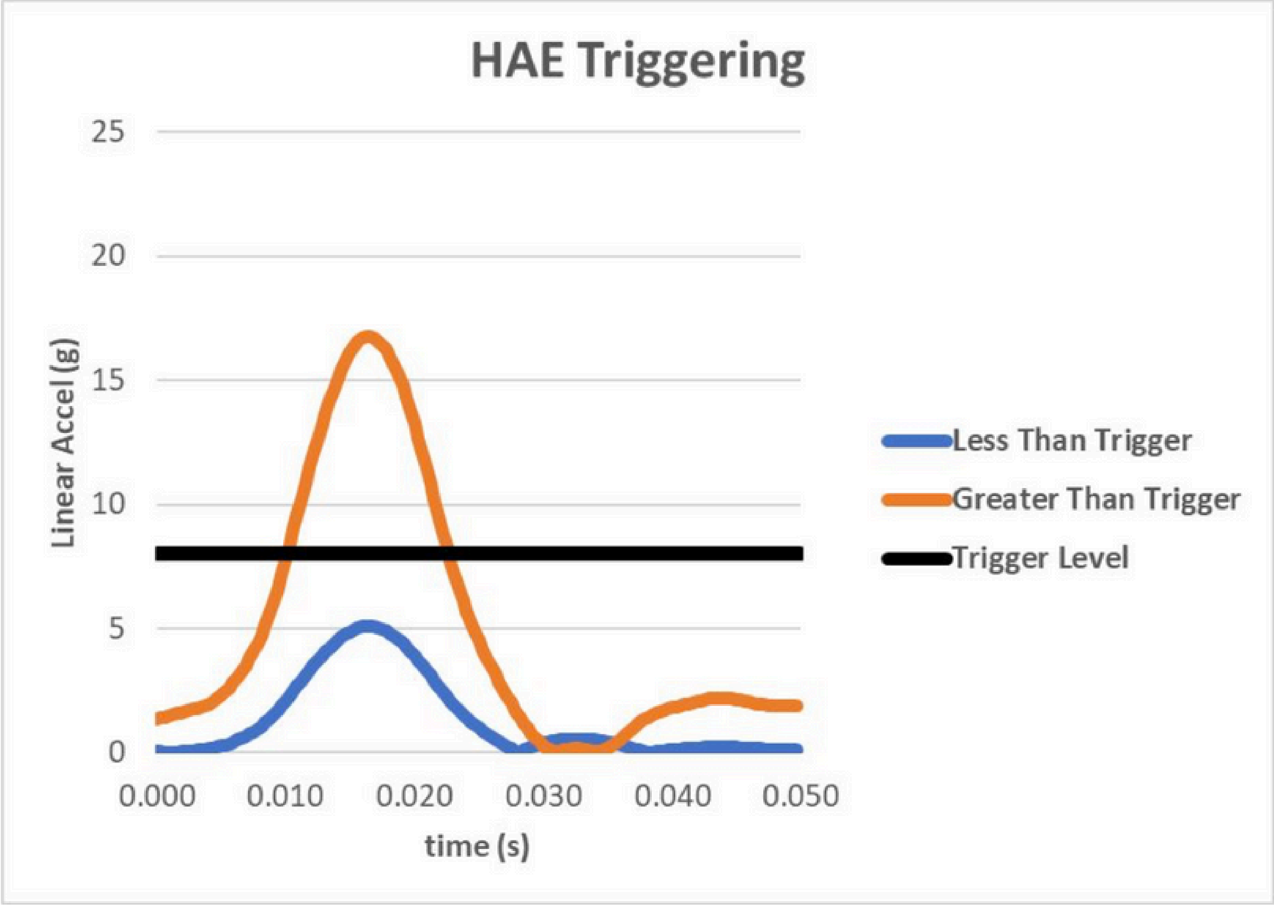
HEAD ACCELERATION EVENT (HAE) = Six degree-of-freedom (6DOF) skull kinematic motion caused by direct head impact or inertial accelerations (running, jumping, shoulder-to-shoulder, etc.)

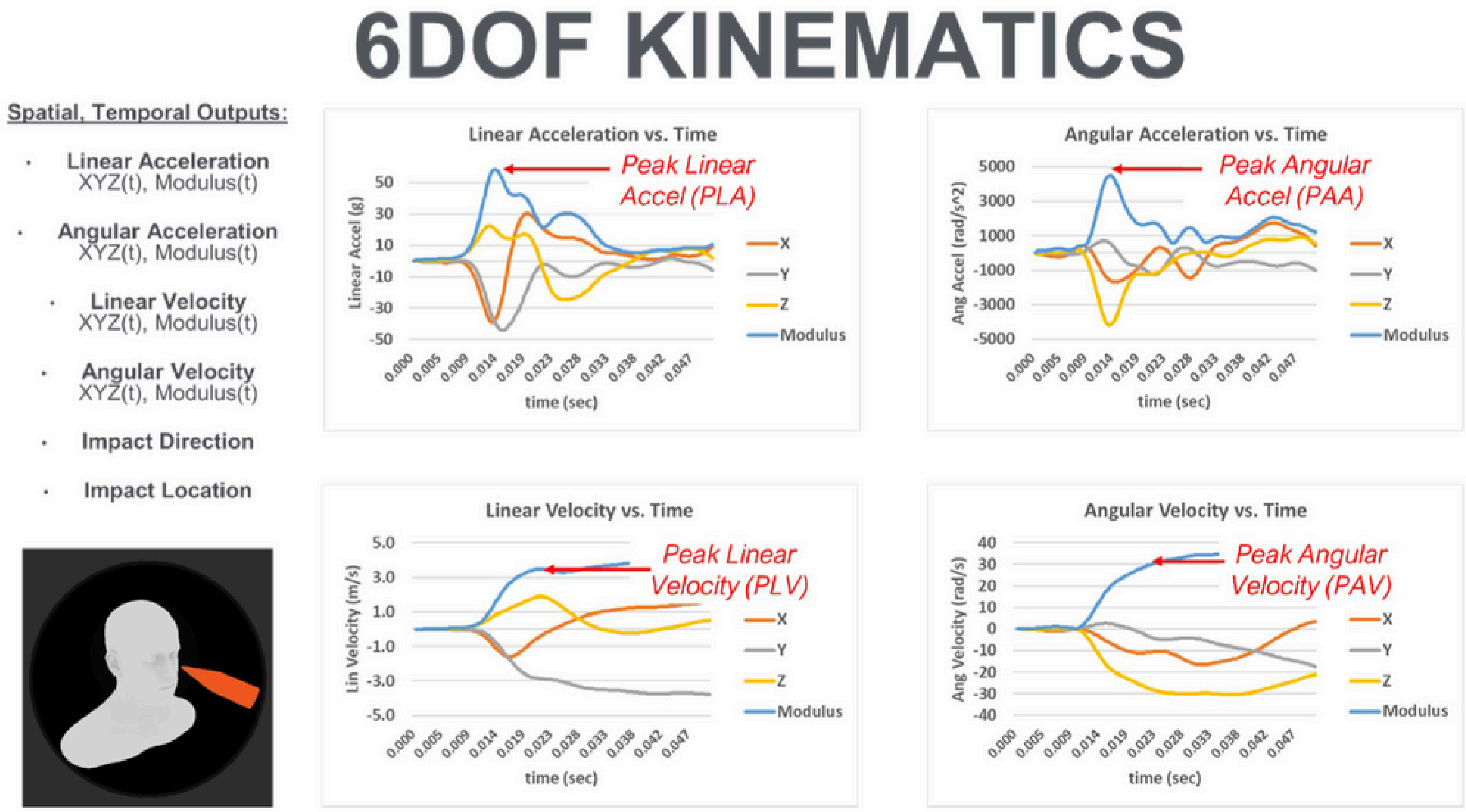
The Prevent iMG measures the head's response to any force applied.

Whenever the iMG is (a) on-teeth and (b) exceeds the acceleration trigger value, HAE data will be recorded (below, left).

The iMG then computes 6DOF kinematics (below, right), whether triggered by inertial motion or direct head contact.

See Bartsch et al. 2014, Bartsch et al. 2019, or Bartsch et al. 2020 for technical details.





PREVENT iMG METRICS

Peak Linear Acceleration (PLA, g): Maximum of the vector resultant of the linear acceleration time trace @ head center of gravity (CG). Computed value.

Peak Angular Acceleration (PAA, rad/s2): Maximum of the vector resultant of the angular acceleration time trace. Computed as derivative of the directly measured angular velocity.

Peak Linear Velocity (PLV, m/s): Maximum of the vector resultant of the linear velocity time trace @ head CG. Computed as the integral of the linear acceleration.

Peak Angular Velocity (PAV, rad/s): Maximum of the vector resultant of the angular velocity time trace. Directly measured.

Direction/Location: Visual representation of the estimated applied force vector and application point on the skull during the instant PLA is computed.

Work (J): Estimated kinetic energy transfer due to HAE. Computed from textbook equation for sum of kinetic energy due to linear and rotational motion.

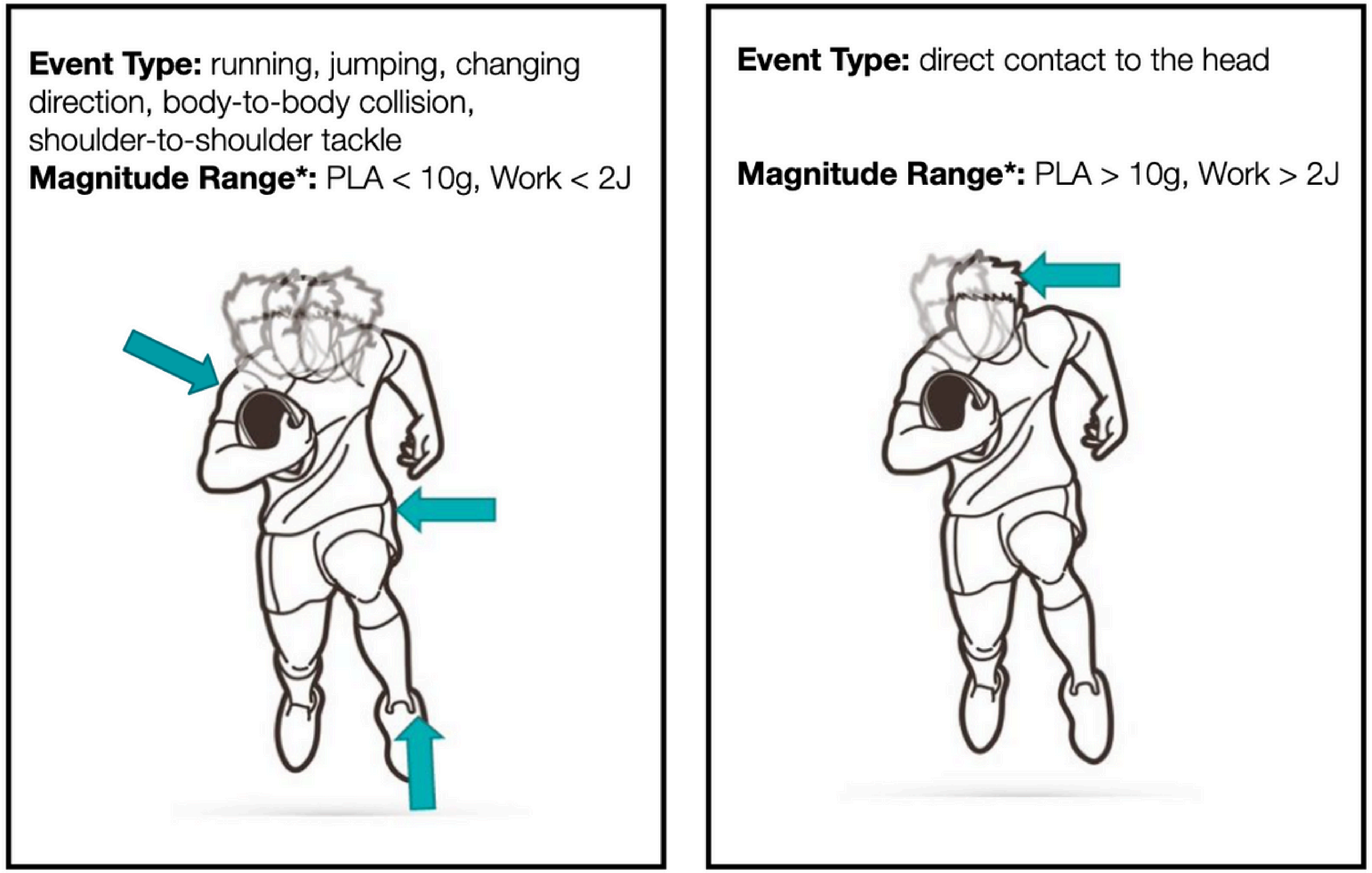
Workload (J): Cumulative Work from a sequence of HAE. Computed as sum of individual Work estimates for each HAE.

Time on Teeth: Monitoring when the athlete puts on/removes iMG.

To learn more about viewing, reporting, and exporting data using the Prevent System, please see here

INERTIAL VS DIRECT CONTACT HAE

When worn on-teeth, and the linear acceleration trigger value is exceeded, the Prevent iMG records Head Acceleration Events (HAEs) generated by inertial movement and/or direct contact to the head.



INERTIAL HAE

Credit: Melanie Bussey, PhD, University Ortego

DIRECT CONTACT HAE

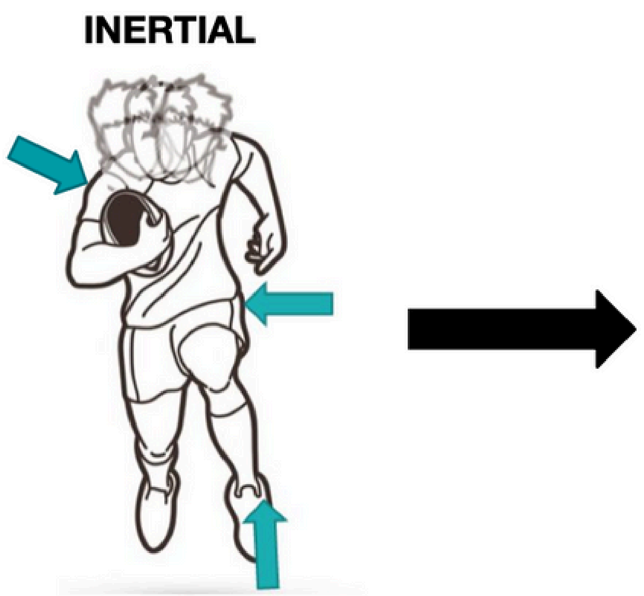
INERTIAL VS DIRECT CONTACT HAE

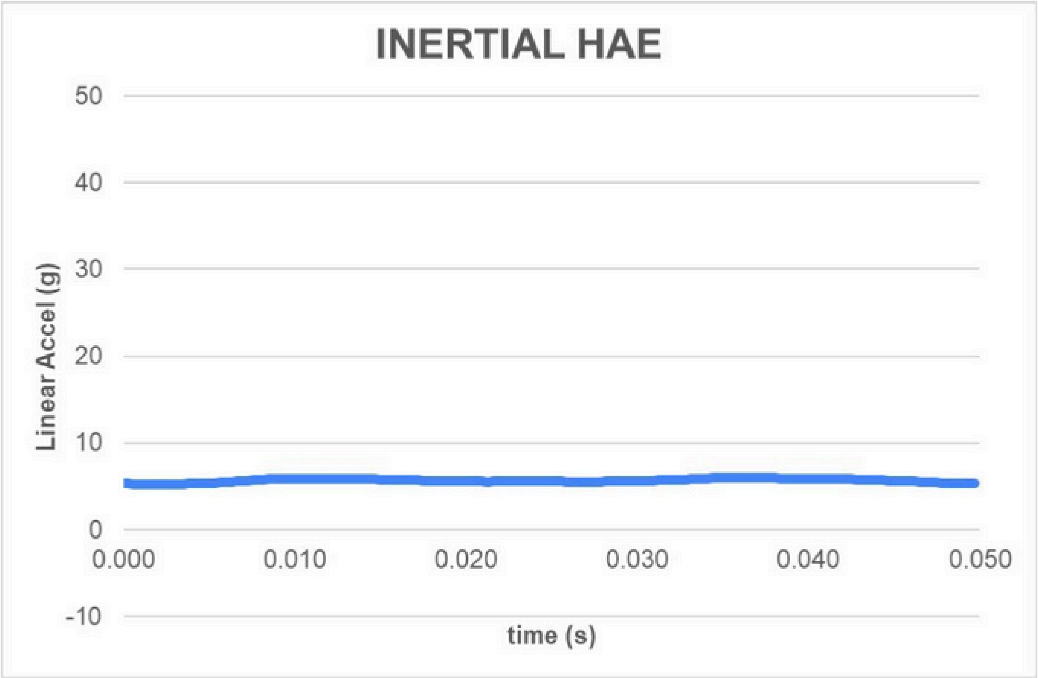
INERTIAL HAE:

Typically, <10g PLA and 2J Work

Time-trace signals with steady-state response and less clearly defined peak value

If inertial HAE accelerates the head less than the on-teeth trigger level, the iMG will not record data





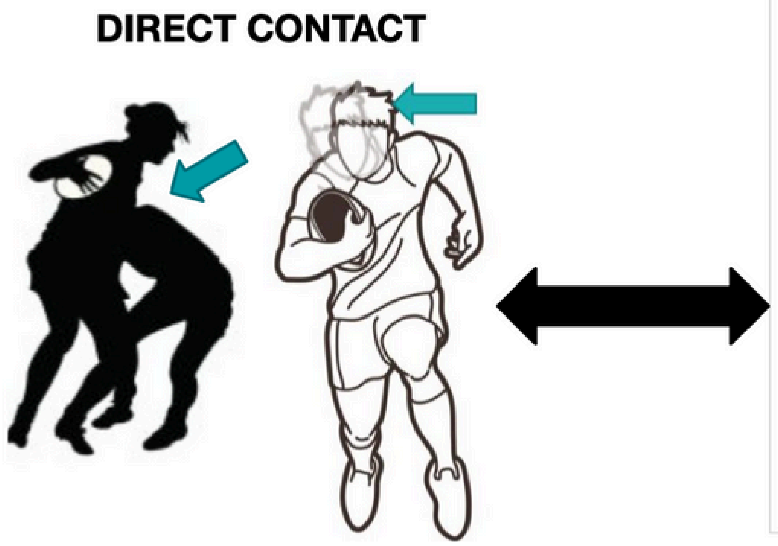
DIRECT CONTACT HAE:

Typically, >10g PLA and 2J Work

Glancing contact can generate HAE <10g PLA

Usually has well defined peak value in the impact time-trace signal, with haversine pulse shape

Direct contact HAE can occur to the ball carrier or tackler



CONTACTS AND COLLISIONS

WHAT IS THE ASSOCIATION BETWEEN HEAD ACCELERATION EVENTS AND CONTACT EVENTS?

The Prevent iMG measures Head Acceleration Events, and does not measure contacts / collisions.

In some situations, the iMG will measure multiple HAEs due to a single contact/collision because the on-teeth trigger level is exceeded more than once.

An example of this could be the initial tackle contact, a second tackler and then hitting the floor, may trigger three HAEs.

Other times, predominantly due to inertial motion alone, there will be no HAE data because the on-teeth trigger level is never exceeded*.

There is a strong association between Contacts and iMG HAE data as referenced in the RFL TaCKLE project (Jones et al. 2022), with 75% of shoulder-to-shoulder tackles resulting in an HAE recorded by the iMG. For the other 25% of tackles, the head acceleration may have never exceeded the iMG on-teeth trigger level.

*[*It is very difficult to video-verify inertial HAE less than 15g. For in-depth investigations into HAE this small, please consider contacting Prevent Biometrics for assistance.]*

HEAD IMPACT WORK

UNDERSTANDING THE WORK METRIC

The Prevent iMG calculates an estimate of kinetic energy transfer to the head due to tackle, ruck, scrum and carry. This energy estimate is called Work.

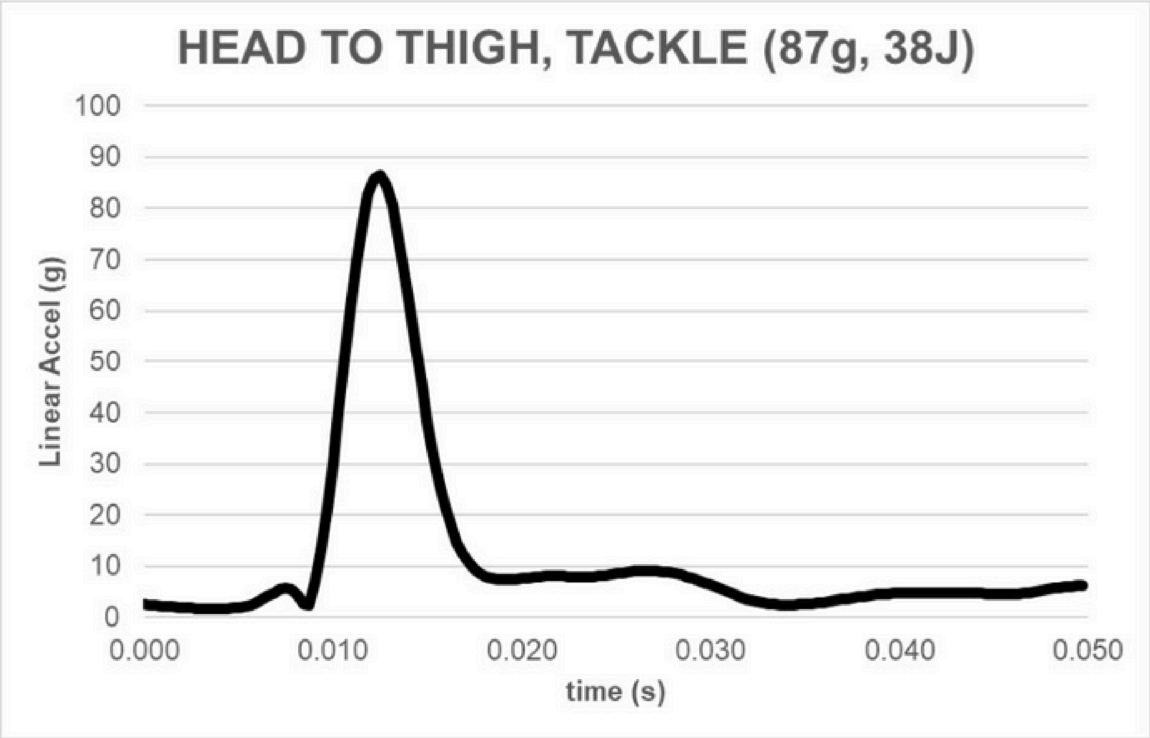
Work is quantified in joules (J) and is the summation of the head's estimated linear and rotational kinetic energy change due to an HAE.

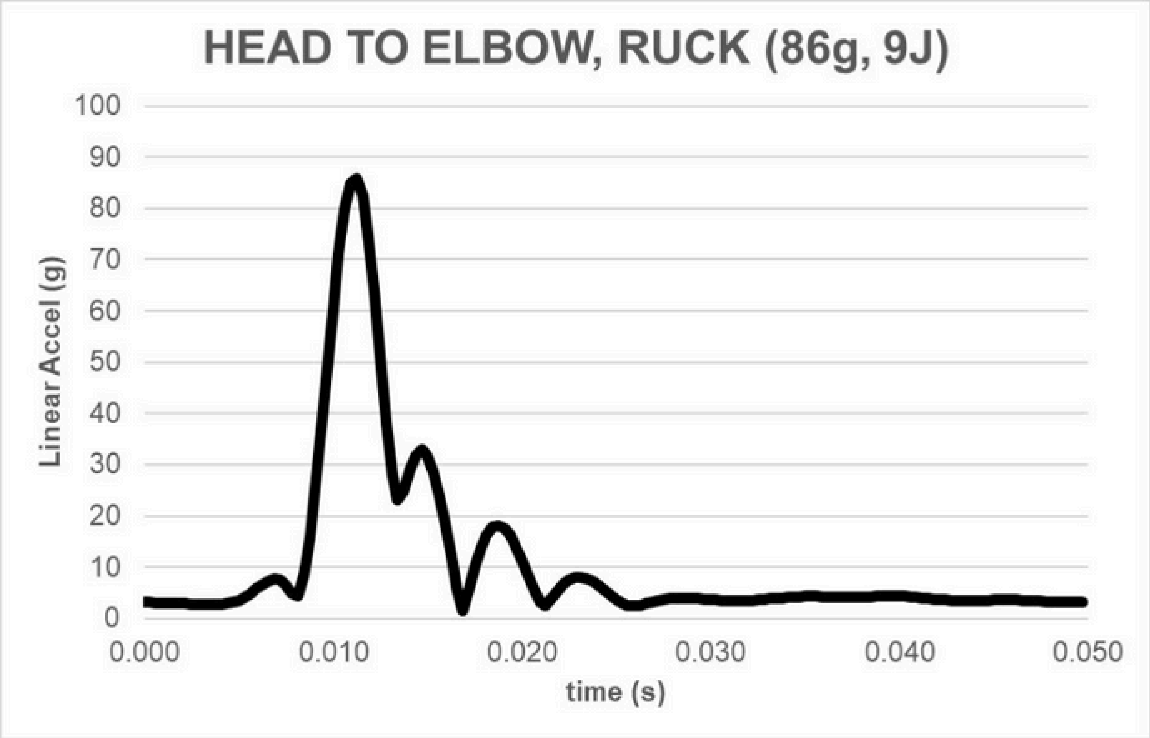
Work can be analysed for a single HAE, an entire day, week, month or season of HAEs. The summation of Work is called Workload.

Work of a single HAE, or Workload of multiple HAE, provide additional insight into the head impact characteristics beyond PLA alone. This is especially true when contrasting situations where the contacting surfaces are rigid versus softer.

HAEs with similar PLA can vary in Work depending on the type of direct contact (see graph). HAEs with higher Work occur when the head impacts objects of sizeable and softer mass (e.g., ground, shoulder, hip, thigh), resulting in a longer impact pulse duration [Head to Thigh, Tackle]. HAEs with lower Work often occur due to glancing or rigid contacts, resulting in a shorter pulse duration [Head to Elbow, Ruck].

While still under investigation by rugby clubs, Work in a single HAE, and Workload for cumulative HAE, are emerging as useful metrics to help performance staff monitor training and match head contact/collision load.





HEAD IMPACT WORK

HOW IS HEAD IMPACT WORK (J) CALCULATED?

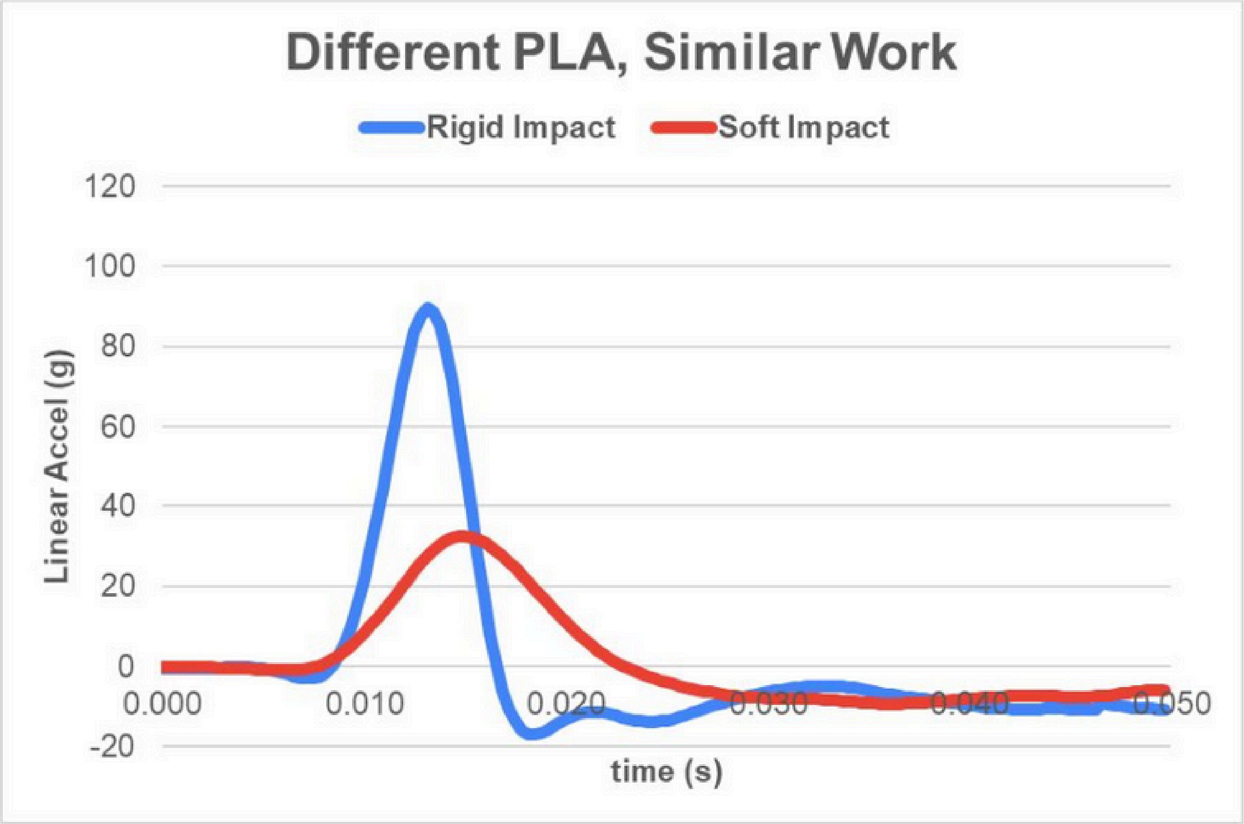
Work is calculated from the estimated* change in translational and rotational kinetic energy due to an HAE. This includes values of PLV, PAV, head mass and head mass moment of inertia. [equation below].

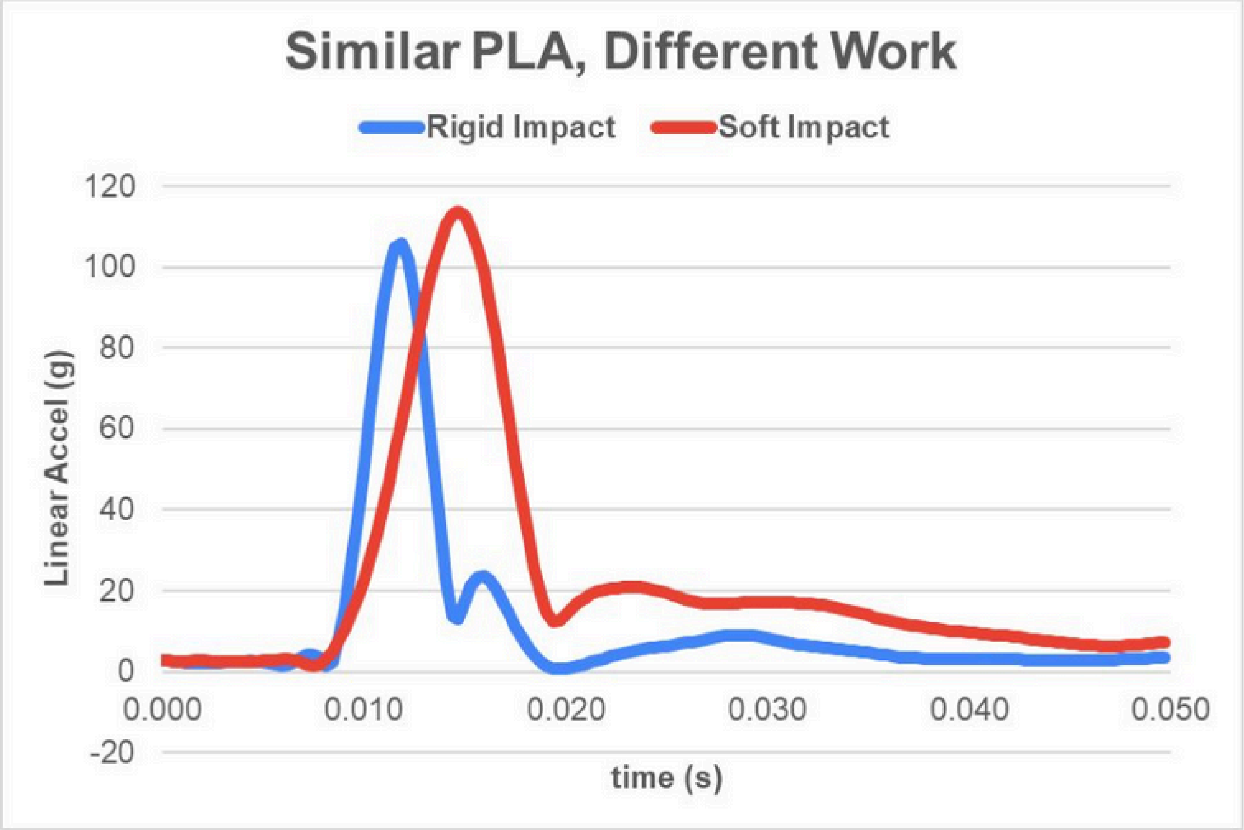
- PLV is computed
- PAV is measured
- Head mass (m) and mass moment of inertia (I) are estimated

The longer the time duration of the HAE, and higher the PLA magnitude, the Work will be larger. [figures, right]

$$Work(J) = \frac{[(m \times PLV^2) + (I \times PAV^2)]}{2}$$

*{*Because initial linear velocity is unknown, the calculation may underestimate true kinetic energy change in cases where the head has non-zero initial linear velocity}*





TYPICAL USE CASES

SAFETY:

01 **HAE Magnitude for Contacts/Collisions** - Use iMG data to establish norms and identify outliers for training and matches. Data can be used to facilitate early interventions and responses to high-magnitude head impacts

02 **HAE Check Engine Threshold -** HAE data can be used to generate a check engine threshold, as an additional data source for the study of head injuries. This can complement existing technologies used in study: saliva swab, medical assessment, video causation analysis. For an example of this use case, please see the next slide.

PERFORMANCE:

03 **Monitoring Head Impact Exposure -** The collection of HAE data longitudinally can assist in the monitoring of head impacts in training an matches. Prevent Biometric's Work and Workload metrics provide value in managing head impact load.

04 **Technique & Strength Improvement -** Analysis of HAE data alongside video review allows club staff to implement changes to tackle technique and neck strength that can reduce the frequency and magnitude of head impacts.

05 **Drill Modification -** Modify training to reduce HAE count and magnitude based on known exposure in specific drills

06 **Return to Play (RTP) -** Manage the prescription of contact loads during RTP and check that sufficient contact loads are met prior to return to training and match play.

EXAMPLE: USE CASE #1 AND #2

COLLECT ALL HAE DATA AND ESTABLISH A CHECK ENGINE THRESHOLD

Collect data for all HAEs for players during training and/or matches. This can be used to visualise the distribution of all HAEs.

Establish a Check Engine Threshold to reflect HAEs with high PLA (g) and Work (J).

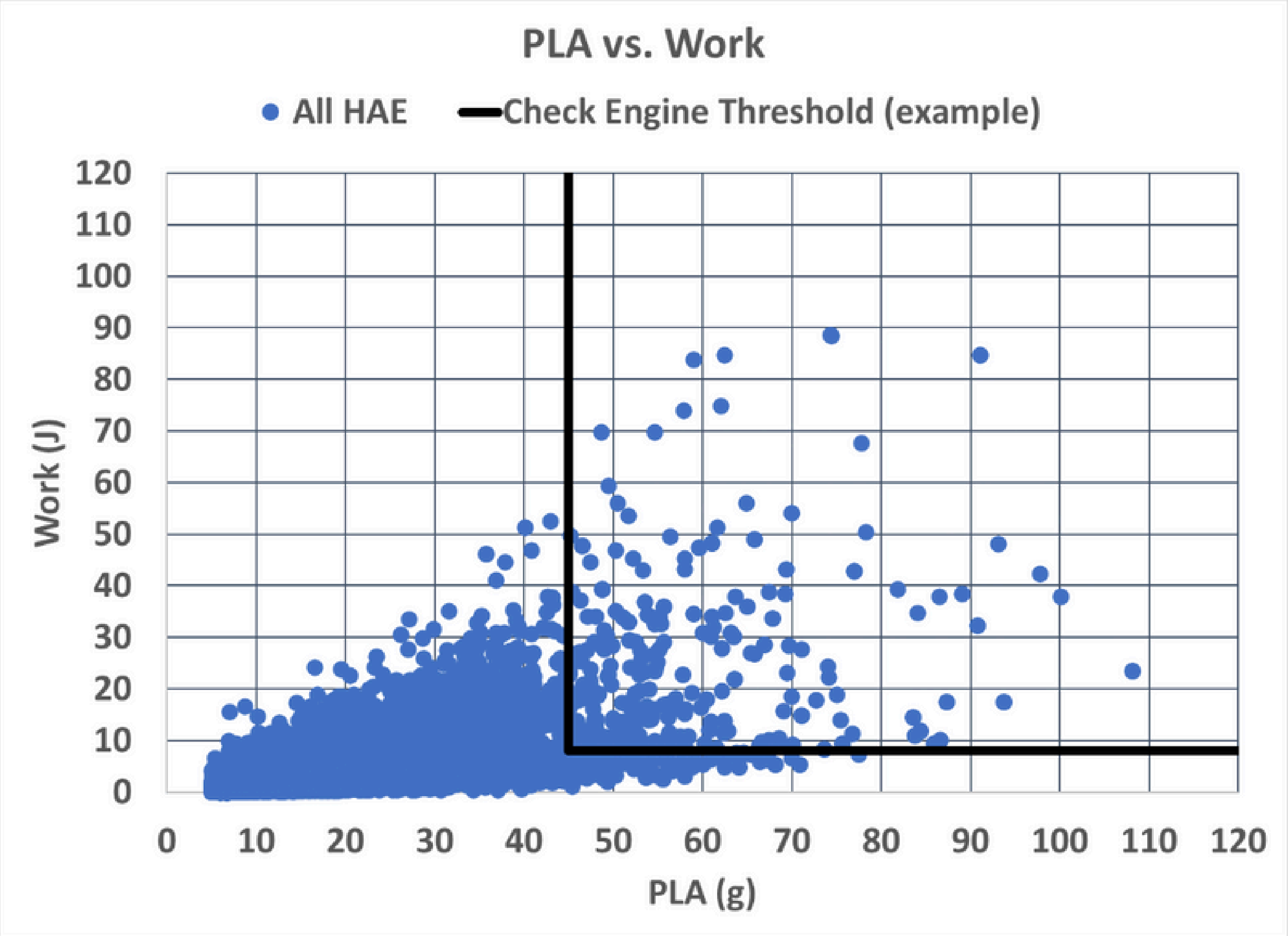
Using the example in the graph (right), to capture roughly the top 1% of HAEs, >45g/8J can be set as the HAE Check Engine Threshold.

This threshold can be used to identify athlete's that require further medical screening, either for research purposes, or as part of a team's practice.

Over time, this HAE Check Engine Threshold can be adjusted based on additional HAE data and studies.

As of today, there is no known link between HAE magnitude and clinical concussion diagnosis.

Note:There is no expectation for medical staff to withdraw player's based on iMG data alone. This is an exploratory use case that can be used to inform current practice.



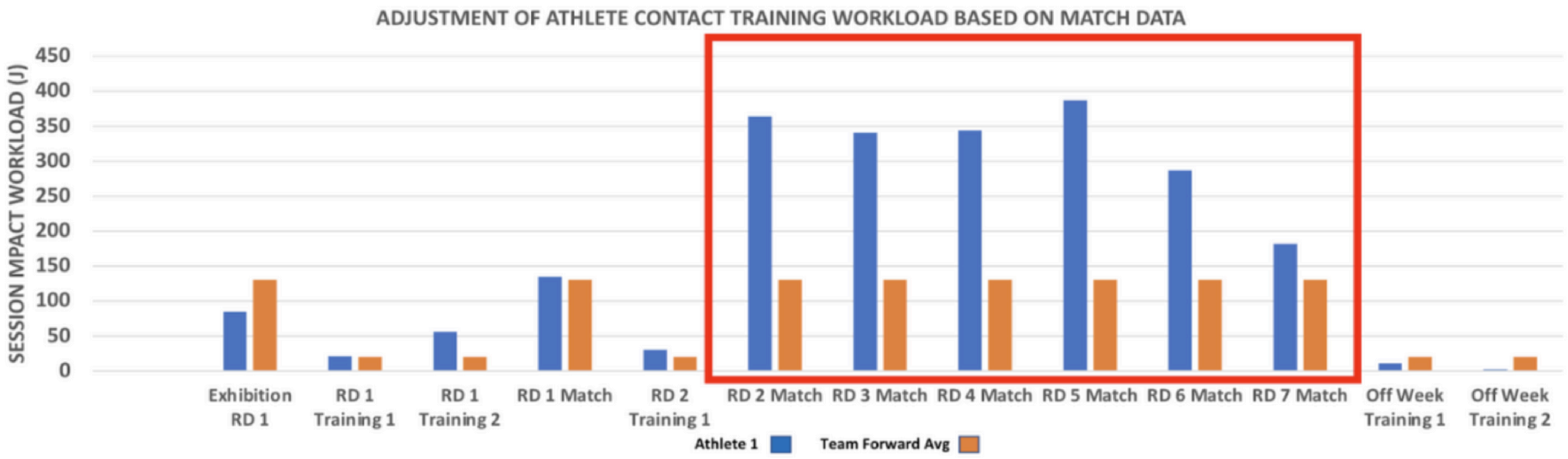
EXAMPLE: USE CASE #3

MONITORING HEAD IMPACT WORKLOAD CAN HELP TO EFFECTIVELY MANAGE TRAINING EXPOSURE TO CONTACTS/COLLISIONS

Through utilising HAE data provided by Prevent's iMG, you can identify athletes that have experienced above average workload in training and matches.

In the example shown, this athlete experienced 2-3x higher workload in matches compared to their team's positional average.

This data can be used to limit subsequent head impact workload in training by modifying the athlete's exposure to contacts and collisions.



EXAMPLE: USE CASE #4

TECHNIQUE AND STRENGTH IMPROVEMENT

The analysis of data collected by Prevent's iMGs can be used to flag individuals experiencing a higher magnitude and total number of head impacts.

The integration of head impact data with video can help determine whether poor tackle technique contributes to an increased likelihood of high magnitude impacts occurring.

In the example shown (right), an athlete with a history of concussions was found to experience high head impact workload during matches in the 21/22 season. Through targeted training interventions to improve tackle technique and neck strength, this athlete's match HAE workload was reduced in the 22/23 season.