

A DIGITAL PLATFORM FOR REAL-TIME BRAIN-HEALTH MONITORING IN SPORT

# Pitch-side brain injury monitoring

Most sport-related brain injuries are **non-symptomatic**, so the symptom-based checks used today often miss them, and repeated **undetected injuries** can cause lasting harm.

1.4 M

A&E head-injury attendances a year  
(England & Wales)

< 1 sec

from impact to brain-strain estimate  
vs hours for a full finite-element simulation

## 01 · THE UNMET NEED

### No objective way to know the result of an impact

Instrumented mouthguards can measure the force of every impact, but force alone doesn't tell you what happened to the brain: two identical impacts can injure it very differently. There is no **objective brain-injury risk tool** in use today.

**trace\*** turns mouthguard data into a near real-time estimate of region-level **brain strain** and **injury risk**, with a confidence level, so players, coaches and clinicians know when to act.

One validated core, two forms: a sideline app and a clinician report.

#### Athletes

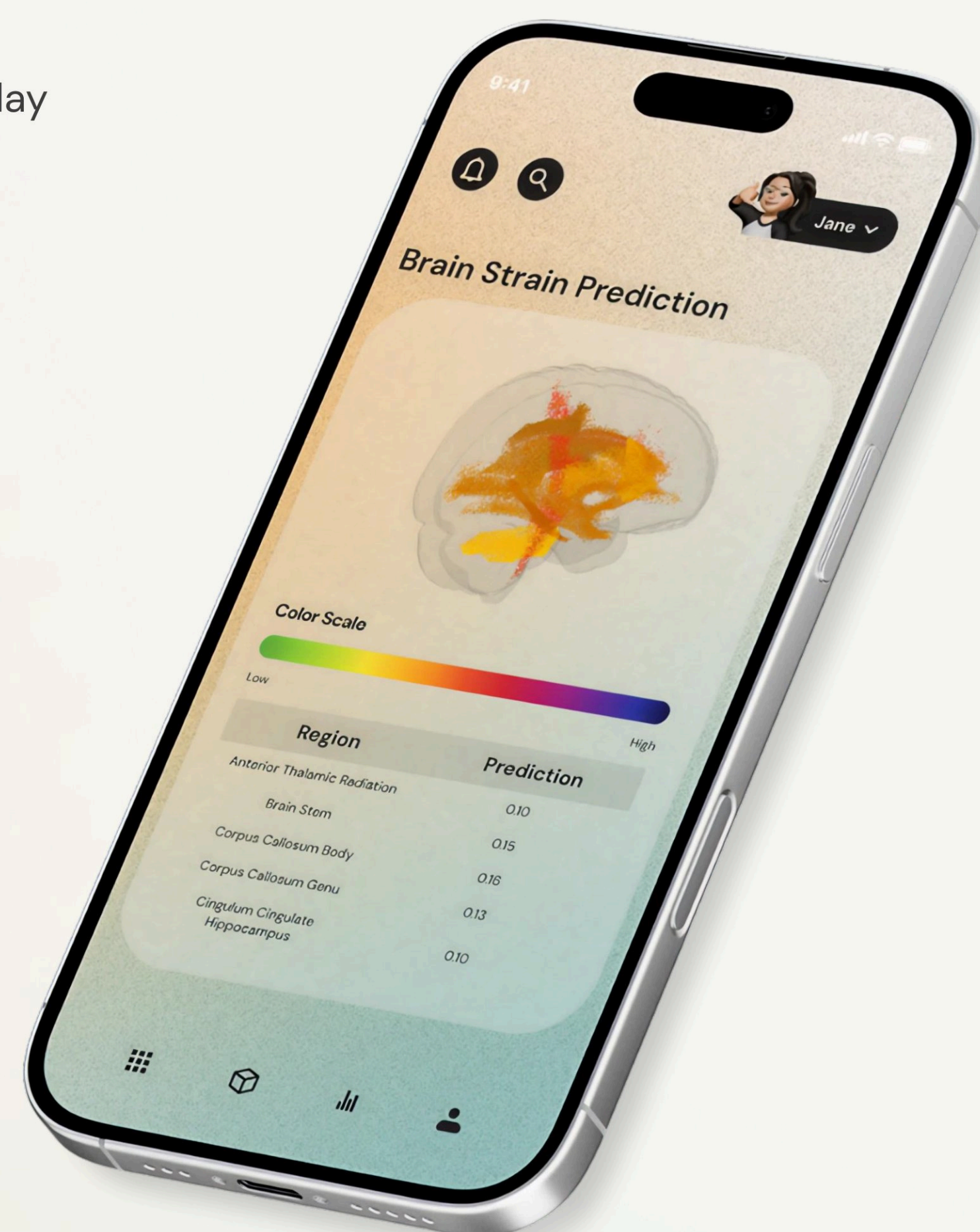
An objective record of their exposure

#### Coaches

A transparent exposure by position & session

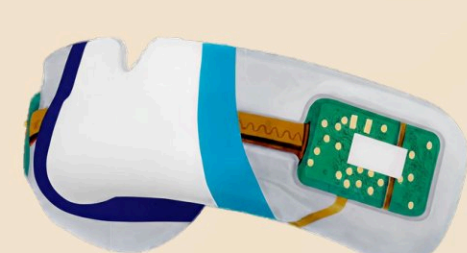
#### Clinicians

Evidence for return-to-play or removal



## 02 · TECHNOLOGY INNOVATION & IMPACT

### From an impact to a per-region strain map, pitch-side

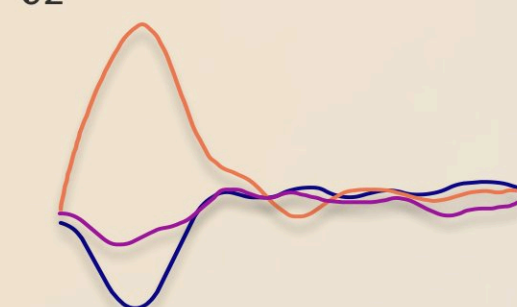


#### Instrumented mouthguard

A worn iMG captures linear & rotational head kinematics for every impact.



02

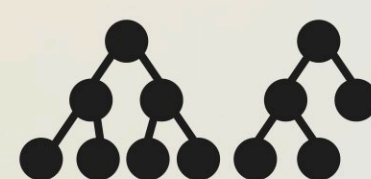


#### Peak kinematics

Four scalar features from resultant rotational velocity & acceleration.



03



#### Surrogate model

Learns the output of a FE brain model, inference in ms.



04



#### Regional MPS90

A calibrated strain value per tract, each with an RMSE band.



05



#### 3D brain readout

Voxel-cloud tracts of regions of interest.

## 03 · TRANSLATIONAL STRATEGY

### A staged path to pitch-side

- **Model validated & published**  
Chan et al. 2025 — surrogate matches FE ground truth. **Done**
- **In-browser + iOS demo**  
ONNX Runtime Web + Swift client. **Live now**
- **Live BLE mouthguard capture**  
Byte iMG streaming, pitch-side. **In progress**
- **Multi-sport & cohort validation**  
Women, youth, grassroots; cross-brand. Next
- **Season-long exposure deployment**  
Clubs, federations, return-to-play evidence. Goal

## 04 · TECHNICAL RIGOR & FEASIBILITY

### Model performance and current scope

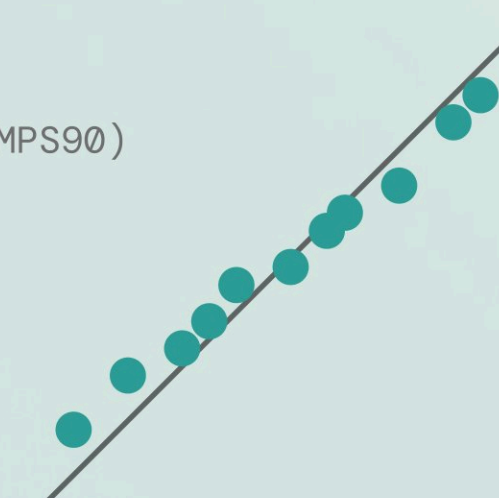
The model is based on the Imperial College FE brain model (Ghajari et al. 2017), trained and tested on **1,701 elite-male rugby impacts** recorded with Protecht mouthguards (Chan et al. 2025).

**R<sup>2</sup> 0.851**

Best region — CST

**±0.02**

Typical RMSE (MPS90)



## REFERENCES

- Ghajari, M., P.J. Hellyer, and D.J. Sharp, Computational modelling of traumatic brain injury predicts the location of chronic traumatic encephalopathy pathology. *Brain*, 2017. 140(2): p. 333–343.
- Chan, E.Y.K., et al., Balancing efficiency and accuracy: Extreme gradient boosting and neural networks for near real-time brain deformation prediction in sports collisions. *Engineering Applications of Artificial Intelligence*, 2025. 162: p. 112489.

TEAM · HEAD LAB, IMPERIAL COLLEGE LONDON

Eleni Koumantou · Emily Yik Kwan Chan · Vahid Darvishi · John Zarogiannis · Assoc. Prof. Mazdak Ghajari

Dyson School of Design Engineering · e.koumantou24@imperial.ac.uk

SUPPORTED BY



See it live  
Interactive 3D  
demo &  
methodology

