THE PODIUM INSTITUTE
2024 INAUGURAL ANNUAL CONFERENCE ON SPORTS MEDICINE AND TECHNOLOGY

26TH & 27TH SEPTEMBER 2024

Richard Doll Lecture Theatre, Old Road Campus,
University of Oxford

UNIVERSITY OF OXFORD

THE PODIUM INSTITUTE
FOR SPORTS MEDICINE & TECHNOLOGY

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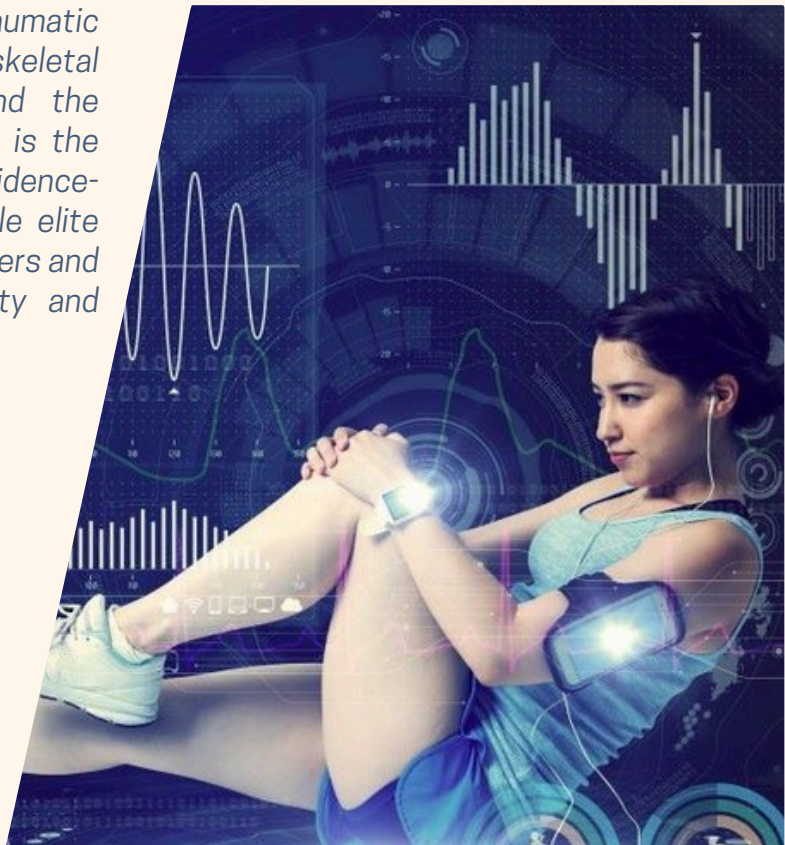
The Podium Institute for Sports Medicine and Technology is the world's first independent academic institute focused on the safety and lifelong health of youth and grassroots as well as professional athletes. Its purpose is to inspire and forge evidence-based changes in sport and physical education, and to develop innovative and scalable technologies to monitor, analyse and ultimately prevent sport injury across the 22 million adults and 3 million children who participate in sport annually across the UK, as well as the hundreds of millions who partake in amateur and professional sport internationally.

The Institute combines Oxford's longstanding tradition in sports and education with the very best of cross-disciplinary scientific, medical, and technological research. It forms part of the Institute of Biomedical Engineering – which has a 15-year track-record of combining medicine and technology to achieve adoption and healthcare impact – and draws on world-leading expertise across the medical and technological sciences, including clinical neurosciences, orthopaedics, experimental psychology, population health, and biomedical, electrical, mechanical and information engineering. The Podium Institute represents an ambitious long-term partnership between the University of Oxford and the NGO and registered charity Podium Analytics, and the coming together of leaders across sport, science, academia, technology, and business to spearhead a new approach to the issue of sports-related injury for athletes of all ages.

The initial work of the Institute is focused on traumatic injuries such as concussion, serious musculoskeletal injuries as well as sudden cardiac death and the psychological factors that lead to injury. Our aim is the practical adoption, within 5 years, of impactful evidence-based changes for sport safety, not just for male elite adult athletes but for sports participants of all genders and ages across professional, grassroots, community and school sports.



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PLENARY KEYNOTE SPEAKER

PROFESSOR ANDREW ZISSERMAN FRS

Andrew Zisserman is the Professor of Computer Vision Engineering at the University of Oxford, where he leads the world-renowned Visual Geometry Group (VGG). He is one of the principal architects of modern computer vision, having established the computational theory of multiple view reconstruction and developed practical algorithms that have enabled widespread application of computer vision across multiple fields of science, technology and medicine. He has been recognized by the Royal Society's Milner Award and Bakerian Medal, and is the only person to have received the International Conference on Computer Vision's best-paper award (the Marr Prize) three times.

KEYNOTE SPEAKERS

- *Prof. Lee Goldstein (Boston University) on Traumatic Brain Injury*
- *Prof. David Sharp (Imperial College London) on Neuroimaging*
- *Dr. Hongwei Zhang (Abbott) on Biomarkers and Point-of-Care Diagnostics*
- *Dr Damian Smith (Podium Analytics) on Big Data in Sport*
- *Dr Mazdak Ghajari (Imperial College London) on Brain Modelling and Helmet Testing*
- *Prof. Keith Stokes (University of Bath) on Instrumented Mouthguards*
- *Dr Greg Tierney (Ulster University) on practical considerations of Instrumented Mouthguards*
- *Prof. Antonio Belli (University of Birmingham) on Neuroimaging*
- *Prof. Lucy Bowes (University of Oxford)*
- *Prof. Ben Seymour (University of Oxford)*
- *Prof. Robin Cleveland (University of Oxford)*
- *Dr Lara Prisco / Prof. Jose Leal (University of Oxford)*
- *Prof. Antoine Jerusalem (University of Oxford)*
- *Prof. Natalie Voets (University of Oxford)*
- *Mr Tim Lawrence (Oxford University Hospitals)*
- *Prof. Mauro Villarroel (The Podium Institute, University of Oxford)*
- *Prof. Liang He (The Podium Institute, University of Oxford)*

CONFERENCE PROGRAMME

THE PODIUM INSTITUTE
FOR SPORTS MEDICINE & TECHNOLOGY

DAY 1

Thursday 26th September, 8:30–17:00

8:30-9:00 **REGISTRATION**

9:00-9:20 **PROFESSOR CONSTANTIN COUSSIOS**
DIRECTOR OF THE PODIUM INSTITUTE
Introduction

TECHNOLOGIES FOR MENTAL HEALTH & WELLBEING, SLEEP & COGNITION

IN MEMORIAM - GREGOR HENDERSON

Thursday 26th September, 09:20-10:50

9:20-9:40 **PROFESSOR LUCY BOWES - UNIVERSITY OF OXFORD**
Keynote

9:40-10:00 **PROFESSOR BEN SEYMOUR - UNIVERSITY OF OXFORD**
Keynote

10:00-10:20 **PROFESSOR ROBIN CLEVELAND - UNIVERSITY OF OXFORD**
Keynote

10:20-10:25 **EAMON DEVLIN - UNIVERSITY OF OXFORD**
Contributed Talk

10:25-10:30 **RUOHAN LIU - UNIVERSITY OF OXFORD**
Contributed Talk

10:30-10:50 **DEBATE**
Do sleep, mental health and wellbeing have a measurable impact on sport injury and, if so, how can we intervene?

PANELLISTS - *Professor Lucy Bowes - Professor Ben Seymour - Professor Robin Cleveland - Dr Carly McKay - Dr Catherine Wheatley*

10:50-11:10 *BREAK*

ABSTRACTS - PAGES 11 TO 14

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WEARABLES

Thursday 26th September, 11:10-13:10

11:10-11:30	**PROFESSOR KEITH STOKES - UNIVERSITY OF BATH** *Keynote*
11:30-11:50	**PROFESSOR MAURO VILLARROEL - THE PODIUM INSTITUTE** *Keynote*
11:50-12:10	**DR GREG TIERNEY - ULSTER UNIVERSITY** *Keynote*
12:10-12:15	**AKSHPREET KAUR - PANJAB UNIVERSITY** *Contributed Talk*
12:15-12:20	**ELYSE LEVENS - THE PODIUM INSTITUTE** *Contributed Talk*
12:20-12:25	**OGUZHAN UZUN - IZMIR INSTITUTE OF TECHNOLOGY** *Contributed Talk*
12:25-12:30	**YIXING LEI - THE PODIUM INSTITUTE** *Contributed Talk*
12:30-12:35	**YASEMIN ÜK - IZMIR INSTITUTE OF TECHNOLOGY / UNIQGENE** *Contributed Talk*
12:35-12:40	**DR JOSEPH RUSSELL - UNIVERSITY OF OXFORD** *Contributed Talk*
12:40-12:45	**MORGAN MITCHELL - UNIVERSITY OF OXFORD** *Contributed Talk*
12:45-12:50	**RICHARD WHEATLEY - HEADX LTD** *Contributed Talk*
12:50-13:10	**DEBATE** *Can wearables alone predict/prevent concussion? Should they be regulated and how?* **PANELLISTS -** *Professor Keith Stokes - Professor Mauro Villarroel - Dr Greg Tierney - Dr Carly McKay*
13:10-14:00	*LUNCH*

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COMPUTER VISION

Thursday 26th September, 14:00–15:20

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14:00-14:45	**PROFESSOR ANDREW ZISSERMAN - UNIVERSITY OF OXFORD** ***Plenary Keynote***
14:45-14:50	**LORENZA PROSPERO - THE PODIUM INSTITUTE** *Contributed Talk*
14:50-14:55	**PRANAV MAHAJAN - UNIVERSITY OF OXFORD** *Contributed Talk*
14:55-15:00	**MARLENE FÖRSTERLING - UNIVERSITY OF OXFORD** *Contributed Talk*
15:00-15:20	**DEBATE** *Can computer vision provide automated sport injury detection and what are the challenges?* **PANELLISTS -** *Professor Andrew Zisserman - Professor Mauro Villarroel - Dr Damian Smith - Professor Nicholas Peirce*
15:20-16:00	*BREAK*

BIG DATA

Thursday 26th September, 16:00–17:00

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16:00-16:20	**DR DAMIAN SMITH - PODIUM ANALYTICS** *Keynote*
16:20-16:40	**DR LARA PRISCO / PROFESSOR JOSE LEAL - UNIVERSITY OF OXFORD** *Keynote*
16:40-17:00	**DEBATE** *What are the acquisition, curation, privacy and processing challenges to using Big Data for sport safety, particularly in community sport? How can we best capture the necessary information to understand its economic and healthcare impact?* **PANELLISTS -** *Dr Damian Smith - Dr Lara Prisco - Professor Jose Leal - Professor Nicholas Peirce*

GALA DINNER AT BALLIOL COLLEGE

Thursday 26th September, 19:15–22:00

19:15-20:00	**DRINKS RECEPTION** *Old Common Room*
20:00-22:00	**DINNER** *Hall*

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DAY 2

Friday 27th September, 9:00–16:40

8:30	**DOORS OPEN**

MODELLING

Friday 27th September, 9:00–10:20

9:00-9:20	**PROFESSOR LEE GOLDSTEIN - BOSTON UNIVERSITY** *Keynote*
9:20-9:40	**PROFESSOR ANTOINE JERUSALEM - UNIVERSITY OF OXFORD** *Keynote*
9:40-9:45	**LUCY BUCHANAN - THE PODIUM INSTITUTE** *Contributed Talk*
9:45-9:50	**ERIK VANEGAS MÜLLER - THE PODIUM INSTITUTE** *Contributed Talk*
9:50-9:55	**ALONSO SOTO-ROSALES - CARDIFF UNIVERSITY** *Contributed Talk*
9:55-10:00	**PHOEBE HASTE - THE PODIUM INSTITUTE** *Contributed Talk*
10:00-10:20	**DEBATE** *What are the most appropriate biomechanical metric(s) to predict head injury and other injuries, and their long term consequences?* **PANELLISTS -** *Professor Lee Goldstein - Professor Antoine Jerusalem - Professor Johannes Weickenmeier - Dr Mazdak Ghajari*
10:20-10:45	*BREAK*

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PPE

Friday 27th September, 10:45-12:00

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10:45-11:05	**DR MAZDAK GHAJARI - IMPERIAL COLLEGE LONDON** *Keynote*
11:05-11:25	**PROFESSOR LIANG HE - THE PODIUM INSTITUTE** *Keynote*
11:25-11:30	**DR CHENYING LIU - THE PODIUM INSTITUTE** *Contributed Talk*
11:30-11:50	**DEBATE** *What does tomorrow's PPE need to do that it doesn't currently?* **PANELLISTS -** *Professor Mazdak Ghajari - Professor Liang He - Dr Gemma Parry- Professor Antoine Jerusalem - Professor Lee Goldstein*
11:50-12:00	**KATHERINE BAYSAN - THE PODIUM INSTITUTE** *Overview and Feedback*
12:00-13:00	*LUNCH*

IMAGING AND NEUROIMAGING

Friday 27th September, 13:00-14:45

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13:00-13:35	**PROFESSOR DAVID SHARP - IMPERIAL COLLEGE LONDON** *Keynote*
13:35-13:55	**PROFESSOR NATALIE VOETS - UNIVERSITY OF OXFORD** *Keynote*
13:55-14:15	**PROFESSOR ANTONIO BELLI - UNIVERSITY OF BIRMINGHAM** *Keynote*
14:15-14:20	**EOIN KELLEHER - THE UNIVERSITY OF OXFORD** *Contributed Talk*
14:20-14:25	**IZABELLE LÖVGREN - THE PODIUM INSTITUTE** *Contributed Talk*
14:25-14:45	**DEBATE** *Can functional imaging enable us to see and characterize injuries that cannot be detected with structural imaging alone?* **PANELLISTS -** *Professor David Sharp - Professor Natalie Voets - Professor Antonio Belli - Professor Heidi Johansen-Berg - Professor Peter Jezzard*
14:45-15:10	*BREAK*

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BIOMARKERS

Friday 27th September, 15:10-16:40

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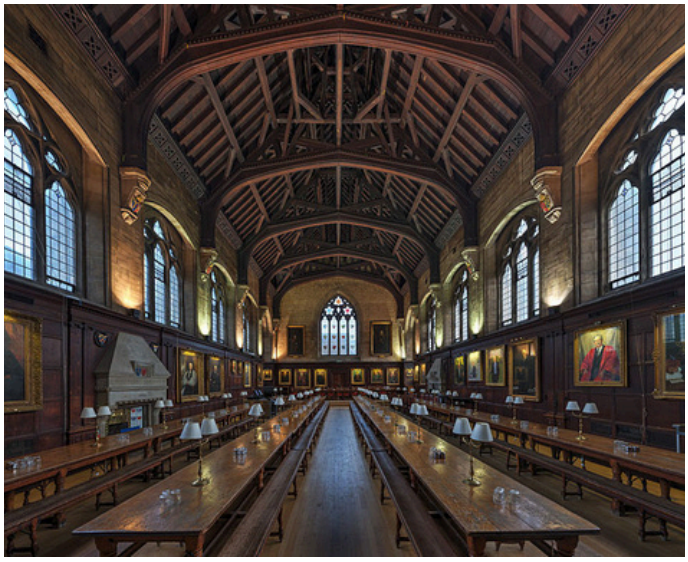
15:10-15:30	**DR HONGWEI ZHANG - ABBOTT** *Keynote*
15:30-15:50	**MR TIM LAWRENCE - OXFORD UNIVERSITY HOSPITALS** *Keynote*
15:50-15:55	**SIERRA SPARKS - UNIVERSITY OF OXFORD** *Contributed Talk*
15:55-16:00	**ARIA APPOO / DR DANIELLE HEWITT - UNIVERSITY OF OXFORD** *Contributed Talk*
16:00-16:05	**MELIS ATBINEK - THE PODIUM INSTITUTE** *Contributed Talk*
16:05-16:25	**DEBATE** *Are point-of-care biomarker diagnostics of mTBI and other significant sports injuries effective and practicable?* **PANELLISTS -** *Dr Hongwei Zhang - Mr Tim Lawrence - Professor Antonio Belli*
16:25-16:40	**PROFESSOR CONSTANTIN COUSSIOS** *Closing Comments*

VENUES

Richard Doll Lecture Theatre
Conference Venue

Richard Doll Building
University of Oxford
Old Road Campus
Oxford
OX3 7LF

Link to Map



Balliol College
Drinks & Gala Dinner
Venue

Broad St, Oxford
OX1 3BJ

Link to Map

ABSTRACTS

TECHNOLOGIES FOR MENTAL HEALTH & WELLBEING, SLEEP & COGNITION

THE PODIUM INSTITUTE
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TALK TITLE *Is There a Bidirectional Relationship Between Mental Health and Sports Injuries?*

AUTHOR *Professor Lucy Bowes - University of Oxford* **KEYNOTE**

ABSTRACT

Millions of adolescents participate in organised sports worldwide. Whilst sports participation has great health benefits, sports injuries in adolescent athletes may lead depression, anxiety, stress, and lower quality of life. Emerging evidence also suggests that poor mental health and wellbeing in adolescent athletes might lead to an increased risk of injury, severity, and time taken to recover. We systematically reviewed 84 studies, including data from 221,095 children and young people aged 10-24 years worldwide and provide significant evidence for a bidirectional relationship between sports injuries and mental health. Our findings have important implications for future research, policy and practice.

TALK TITLE *Understanding Injury: A Glimpse Inside the Brain's Control System*

AUTHOR *Professor Ben Seymour - University of Oxford* **KEYNOTE**

ABSTRACT

Humans and other animals excel at self-protection; usually avoiding catastrophic damage for long lifetimes. There are two parts to this: first is an effective harm avoidance strategy which combines early detection, rapid response, and effective learning. Second is an injury system, in which behaviour is carefully modulated after injury to limit further damage and enhance safety whilst tissue healing occurs. In this talk, we look inside the brain's control systems that mediate this, and especially the role of pain. I will give an overview for how harm avoidance is underpinned by a modular and hierarchical control system in which greater levels of neural sophistication allow higher levels of control and monitoring. And I will propose how injury recovery is mediated by a homeostatic control system, that builds an internal model of damage through relevant sensors, and elicits control that drives self-protection and recovery. This captures how many cognitive and mental health manifestations of injury, often dismissed as reactive responses, actually reflect global systems control modulation as part of a sophisticated injury system.

ABSTRACTS

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TALK TITLE *Transcranial Ultrasound Stimulation of the Visual Pathway in Humans*

AUTHOR *Professor Robin Cleveland - University of Oxford* **KEYNOTE**

ABSTRACT

Transcranial ultrasound stimulation (TUS) is an emerging approach for non-invasive brain stimulation, which offers better spatial localisation and temporal control than competing approaches.

We used TUS to modulate higher order cognitive function in humans by insonifying hMT+ (associated with motion detection) and measuring electrophysiology and behavioural responses. Subjects (healthy volunteers) were more accurately in detecting motion and respond quicker when TUS was delivered to hMT+. EEG data demonstrated a significant difference in the amplitude in the ERP during a time associated with motion. These results confirm that TUS can be used to modulate higher order cognitive function in humans.

ABSTRACTS

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TALK TITLE *"Tired, Thirsty, Traumatised": The Elite Players' Perspective: A Qualitative Study of Half-Time*

AUTHOR *Eamon Devlin - University of Oxford*

ABSTRACT

Half-time (HT) is a critical juncture during matches, often depicted through dramatic coach speeches that aim to inspire athletes. Failure to manage the HT period effectively can lead to adverse effects on athletes, including impacted cognitive and physical performance. Despite this, psychological research on HT talks is scarce, particularly regarding elite players' perceptions. This study explores how elite athletes perceive and experience HT talks.

Following institutional ethics approval, a qualitative design using semi-structured interviews and reflexive thematic analysis was employed to gather information from 14 senior-elite male Gaelic football players aged 23–69 (median 42). The interviews, averaging 71 minutes each, were conducted in 2023 and transcribed verbatim. Subsequently, a thematic analysis following Braun's six-step approach was conducted, revealing four main themes: Emotional wounds: Negative feedback ("You're shite today– you're meant to be leading here.") and instances of humiliation were detrimental to players' self-esteem, potentially leading to PTSD, highlighting the importance of constructive support. Discontentment: Players found most HT talks "mundane and forgettable," with the environment often feeling like a "war zone." However, an impactful talk can "positively affect the final result." Visual stimuli: Using visual aids at HT had a powerful impact on motivation and the ability to recall information. Leadership: Effective HT leadership was characterised by "calmness." Players wanted "Fewer words, fewer voices and more visuals." They appreciated leaders who could balance control with motivational intensity, describing them as "compassionate leaders - in control - tactically aware." Players perceive half-time talks as "forgettable and low-quality." Effective HT talks can make a difference to the result. More knowledge is needed to help sports psychologists develop effective guidelines for HT. Future research should explore protocols to reduce the mental injury of HT talks and enhance second-half performance.

ABSTRACTS

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TALK TITLE *Exploring the Effort-Reward Paradox in Sports using DOMS as an Experimental Paradigm of Pain*

AUTHOR *Ruohan Liu - University of Oxford*

ABSTRACT

The project studies the neuroscience of human nature when obtaining satisfaction and reward by voluntarily engaging in challenging and even painful physical tasks.

People are often misguided by the concept of 'No pain, no gain' and only associate progress when their training has led to subsequent muscle soreness or pain. The concept is a widely recognized mantra that emphasizes the idea that achieving success and improvement in sports and physical fitness requires enduring discomfort, effort, and even pain. Using time frequency analysis of EEG and VR based on a static cycling task we aim to dismantle the unstudied relationship between pain, effort and reward as well as potential neural biomarkers when a person is approaching overexertion. The aim of the study is to discover psychological traits or tractable biomarkers which can potentially aid athletes and sport amateurs to prevent overexertion injuries and overtraining

DEBATE *Do sleep, mental health and wellbeing have a measurable impact on sport injury and, if so, how can we intervene?*

PANELLISTS *Professor Lucy Bowes - Professor Ben Seymour - Professor Robin Cleveland - Dr Carly McKay - Dr Catherine Wheatley*

ABSTRACTS

WEARABLES

THE PODIUM INSTITUTE
FOR SPORTS MEDICINE & TECHNOLOGY

TALK TITLE *Concussions and Head Impacts in Rugby Union*

AUTHOR *Professor Keith Stokes - University of Bath* **KEYNOTE**

ABSTRACT

There has been a focus on concussion recognition, management and prevention in rugby union for many years, but there is increasing recognition that all head impacts should be considered important in the context of brain health. Using instrumented mouthguards, rugby union is building a dataset of head acceleration events that, when linked with other data streams, can inform reduction strategies.

This presentation will provide an overview of the early insights regarding head acceleration exposure in matches and training, the game events that result in head acceleration, and the variation observed in head accelerations across playing positions and between individuals.

TALK TITLE *Health Monitoring in the Age of Fitness: from Wearables to Non-Contact Sensing Technologies*

AUTHOR *Professor Mauro Villarroel - The Podium Institute* **KEYNOTE**

ABSTRACT

Commercially available ambulatory devices are used for managing patients at risk of physiological deterioration, particularly in cardiovascular and sleep medicine. Non-contact sensing modalities such as video cameras, wireless technologies (Wi-Fi or radar) can also be integrated, thereby providing context to the assessment of physiological and cognitive health of individuals. The improvements in mobile and data communication technologies, the increasing availability of consumer wearable sensors, smartphones, and the advent of interconnected medical devices offer new opportunities to monitor the health and fitness of individuals in the general population. Affordable consumer devices now claim to continuously track vital signs, exercise output, and other health metrics. However, their reliability is not known, often using proprietary algorithms. New radical analytical methods are required to process the large volumes of data generated by these devices, identify patterns of health deterioration to characterise human physiology, exertion and injury in athletes.

TALK TITLE *Head Exposure to Acceleration Database in Sport (HEADSport)*

AUTHOR *Professor Greg Tierney - Ulster University* **KEYNOTE**

ABSTRACT

There are mounting concerns surrounding the risk of neurodegenerative diseases and complications associated with concussion incidence and repetitive head acceleration events (HAE) in sport. Biomechanical approaches such as instrumented mouthguards (iMG) provide a unique opportunity to explore HAE exposure and brain injury mechanisms. However, biomechanical considerations are required to maximise the benefit of this technology.

TALK TITLE *Triboelectric Nanogenerators: Empowering Sports Wearables with Sustainable Energy*

AUTHORS *Akshpreet Kaur, Ankur Gupta , Mohsen Rahmani, Cuifeng Ying and Gaurav Sapra - Panjab University*

ABSTRACT

With the tectonic evolution in technology, the paradigm shift in wearable electronic devices has underscored the critical importance of establishing sustainable power sources for their continued advancement. Triboelectric Nanogenerators (TENG) convert mechanical energy to electrical energy offering promising solutions for realising self-powered wearable devices. In this work, TENGs are fabricated by using varying weight concentrations of Multiwalled carbon Nanotubes (MWCNT) – Polydimethylsiloxane (PDMS) as triboelectric layers along with Aluminium and Copper as electrodes. The experimental results reveal 79% increase in the open circuit voltage of TENG with the addition of MWCNT into PDMS. The fabricated TENG is affixed in an athlete's shoe to power a digital wristwatch for 2 minutes with 11 minutes of jogging followed by walking and running. To demonstrate self-powered sensing capabilities, the developed TENG is integrated in a smart glove for grip strength monitoring, aiding in tracking the progress of patients with disabilities. The developed TENG represents a significant advancement in both sustainable energy generation and sports wearable technology. Its ability to power devices with real-time monitoring and tracking of athletes exemplifies its potential to revolutionize the field, paving the way for enhanced performance and well-being in sports and beyond.

TALK TITLE *Quantifying Coordination Between People*

AUTHOR *Elyse Levens - The Podium Institute*

ABSTRACT

In team contact sports, such as rugby or American football, players rely on each other to complete successful plays. This coordination between players is also vital to avoid collisions and unnecessary injuries. Group coordination is not well-defined within the fields of human biomechanics and sports medicine, and so the exploration of simple verifiable metrics is needed. Inertia Measurement Units (IMUs, Xsens DOT Sensors, Movella) were placed on pairs of participants who were tasked to coordinate with each other in order to complete a goal-oriented game task.

Pearson correlation coefficients (r) were utilized to define coordinated and uncoordinated sections of game play based on acceleration data. The average correlation coefficient (± standard deviation) of a coordinated task was found to be normally distributed with a $r = 0.37 \pm 0.12$, and the uncoordinated section 0.16 ± 0.04. A significant difference in the IMU data was found ($p < 0.05$, $n = 57$), showing a first indication that quantitative methods can be developed to measure group coordination.

TALK TITLE *Innovative Protective Wearable Equipment Design to Prevent Knee Injuries in Sailing*

AUTHOR *Oguzhan Uzun - Izmir Institute of Technology*

ABSTRACT

Knee injuries are a common issue in sailing, caused by frequent impacts with hard surfaces on the boat. This project proposes an innovative protective wearable equipment designed to prevent knee injuries in sailors. This project involves researching suitable materials and identifying promising candidates. The materials being considered include D30, EVA foam, Kevlar, and thermoplastic polyurethane (TPU), chosen for their lightweight, flexible, and impact-absorbing properties. Planned laboratory tests will evaluate these materials for impact resistance, durability, and flexibility to ensure they meet the demands of sailing activities.

In addition to material testing, this project aims to gather insights from the target audience regarding their expectations and requirements for such protective equipment. Surveys and interviews will be conducted to collect detailed feedback on existing solutions' shortcomings and the desired features of an ideal product. This user-centered approach ensures the final design addresses the real needs of sailors, providing optimal protection without compromising mobility.

The ultimate goal of this project is to develop a prototype that combines superior protection with comfort and usability. Following successful lab tests, the prototype will undergo field trials with sailors to validate its effectiveness and gather additional user feedback. This project has the potential to enhance safety and performance in sailing, with broader applications in other sports requiring similar protective solutions. By addressing a critical need in sailing, this innovative wearable aims to make the sport safer and more accessible for athletes of all levels.

TALK TITLE *Bimanual Motor Rehabilitation System with Augmented Reality Integration*

AUTHOR *Yixing Lei - The Podium Institute*

ABSTRACT

Background: Rehabilitation gloves are commonly used for patients with stroke, cerebral palsy, and sports injury to (re)learn and enhance hand motor functions. However, existing rehab gloves typically support only unimanual training or simple mirroring bimanual training, lacking overarching training algorithms for complex bimanual rehabilitation in collaborative tasks and quantitative feedback.

Methods: This research designs and evaluates a bimanual rehabilitation system featuring soft robotic gloves controlled by a pose controller and a task-trigger recognition algorithm using web camera hand reconstruction. The system integrates multisensory feedback and an augmented reality (AR) training environment implemented with Microsoft HoloLens 2. Temporospatial asymmetrical hand functions (e.g., screwing a bottle cap, serving a ball in table tennis) are tested to evaluate this system. A visualisation system with quantitative feedback via a performance matrix is developed in Unity to guide user movement with the AR system.

Results: A deep neural network (DNN)-based model has been developed to predict the assistive control input of the soft robotic glove using hand pose data. A motion trigger algorithm is being developed with a supervised classification model. Five healthy participants were invited to join the training sessions to validate the usability of the system.

Conclusion: The rehabilitation system demonstrated potential in enhancing recovery for temporospatial asymmetrical bimanual tasks, addressing gaps in complex bimanual hand rehabilitation. This advancement enables further research in rehabilitation and assistive training, including bimanual coordination, skill transfer, and learning. Future work will optimize it for home-based use and broader applications.

TALK TITLE *Integration of Genetic Testing with Wearable Technology: Advanced Biomarkers for Personalised Sports and Nutrition Management*

AUTHOR *Yasemin Ük - Izmir Institute of Technology / UNIQGENE*

ABSTRACT

The integration of genetic testing with wearable technology represents a burgeoning frontier in personalised sports health. Genetic tests for biomarkers, which do not require blood samples, offer a less stressful and more efficient alternative for athletes. Genetic information enhances data accuracy, providing deeper insights for wearables and continuous data for machine learning. Academia and industry are actively exploring this integration, highlighting the critical role of wearables in modern healthcare. Devices like Garmin, Fitbit, and Apple Watch provide real-time tracking of physiological parameters, enabling continuous health monitoring beyond traditional clinical settings.

Studies such as "Genes For Good" and "MIPACT study" demonstrate the potential of combining genetic data with wearable technology for personalised health interventions.Sport and nutritional genetics offer insights into individual predispositions and responses to health factors, influencing personalised fitness and nutrition plans. Continuous monitoring via wearables ensures consistent measurement of vital signs, reducing variability and enhancing data accuracy for predictive modelling. This field promises precise health interventions and a deeper understanding of individual health needs. Smartwatches integrated with genetic data can provide tailored advice and alert users to overtraining risks based on genetic predispositions.

Our objective is to review existing literature at the intersection of wearable technology and genetic testing and to develop a comprehensive research framework integrating genetic testing results with wearable devices for continuous monitoring. We propose an AI-powered framework designed to facilitate continuous monitoring and provide personalised recommendations, enhancing the sustainability and efficiency of sports activities and nutritional life.

TALK TITLE *BioGuard: Biometric Data Collection Using a Sports Mouthguard-Based Sensor Platform - An Overview*

AUTHOR *Dr Joseph Russell - University of Oxford*

ABSTRACT

The BioGuard is an innovative biometric sensor platform contained within a sports mouthguard. Developed by the Natural Interaction Lab at the University of Oxford, the BioGuard is able to monitor motion, breathing rate, temperature and heart rate from within the user's mouth. This allows coaches and players to monitor their levels of fatigue, high levels of which have been shown to correlate with not only reduced performance, but also increased risk of injury. The device could therefore be used to inform decisions about rest periods during training and substitution during gameplay, improving player safety. The data could also be used to assess head impacts to predict risk of concussion, to quantify user fitness by estimating VO2Max, to make predictions about player intent, and to quantify coordination between players.

To achieve this, several new methodologies were developed. The device itself was designed on a flexible circuit board, with a layout optimised for the available space within the mouth. Protocols for safely encasing the mouthguard within a double-layered EVA sport mouthguard, based on a 3D scan of the user's mouth, were produced. An algorithm was developed to estimate the volume flow of air inhaled and exhaled, using audio recorded by an on-board microphone. Temperature models were produced relating the recorded temperature at the gum to the core body temperature.

Following successful human trials of the individual system components, prototypes of the complete integrated system will shortly undergo usability studies during exercise, with an aim of commercial implementation in the next few years.

TALK TITLE *Validating a Low-density EEG Device for Brain Activity Recordings in Real-World Settings*

AUTHOR *Morgan Mitchell - University of Oxford*

ABSTRACT

We have developed (and are currently validating) a custom-built low-density EEG device to record brain signals in real world settings outside the laboratory. Future use cases could include brain recording during sport training, pitch-side brain assessments post injury, or sleep monitoring at home.

As an initial use case, we are validating use of the device for sleep recordings, by comparing it to current gold-standard approaches. Participants wear our low-cost portable device alongside a polysomnography set up during overnight sleep in a sleep laboratory. Our principal outcome measures are EEG Signal Quality and Sleep Stage Classification Similarity. We assess EEG signal quality between the two sleep recording methods using relative spectral power computed in our frequency bands of interest (1-4Hz, delta waves; 11-16Hz spindle range). To determine how similar the sleep staging is between the sleep recordings we will assess the percentage agreement for each 30 second epoch of staged sleep, calculated using Cohen's kappa (κ) (κ= 1−P(e)/ P(a)−P(e)).

The next step for validation will be testing the device for overnight sleep recordings at-home. This opens possibilities for developing clinical tools for long-term monitoring of the sleeping brain at home, for example monitoring after-effects of sport-related concussion.

Future development of the device will add capability to deliver auditory or other stimulation in response to brain signals. This could be used to enhance particular brain signals that are associated with consolidation of motor memories during sleep, which is highly relevant to motor rehabilitation post-injury and to motor skill training.

ABSTRACTS

TALK TITLE *Head Acceleration Monitoring devices - Future of Wearables and How do we Build a More Complete Picture?*

AUTHOR *Richard Wheatley - HeadX Ltd*

ABSTRACT

The introduction of instrumented mouthguards provides the first insight into brain impact exposure. It offers the potential to inform on a wide range of asymptomatic cases and provides secondary input into the identification of events. However, what about applications that don't require mouthguards? How do we broaden this insight? What information is relevant for users? Will brain health be another "circle" on your smartphone device?

HeadX has developed a fully flexible wearable for accurate head impact and vibration detection using dual high-end accelerometers aligned with the brain's center of mass. The device provides real-time identification of brain trauma exposure and offers longitudinal load analysis via our data analytics platform. This wearable device can be fitted into a headband, helmet, or headguard to monitor risk exposure in sport, military, and industrial environments. Safety, comfort, and data quality are essential. The fully flexible device, including a flexible battery, is encased in a soft silicone body, providing a safe and configurable solution that can be comfortably worn close to the wearer's head in various applications.

The flexible, soft nature of our device offers two further advantages. Firstly, it provides a lower safety risk compared to the hard formats of other head-worn wearables. Secondly, compared to instrumented mouthguards, the headband format can be applied in a vast range of use cases and sectors for more widespread risk monitoring.

DEBATE *Can wearables alone predict/prevent concussion?*

PANELLISTS *Professor Keith Stokes - Professor Mauro Villarroel - Dr Greg Tierney - Dr Carly McKay*

ABSTRACTS

COMPUTER VISION

THE PODIUM INSTITUTE
FOR SPORTS MEDICINE & TECHNOLOGY

TALK TITLE *What Can Computer Vision Do for Sports Video Analysis?*

AUTHOR ***Professor Andrew Zisserman*** **PLENARY KEYNOTE**

ABSTRACT

Computer vision is a field that seeks to understand and measure the visual content of images and video.

The talk will describe how computer vision methods can enable automated video analytics for sports. It will cover four broad areas: (i) 3D human pose prediction in videos; (ii) anonymising videos; (iii) quantifying forces in videos; and finally (iv) a potpourri of useful techniques for analysing and searching videos.

The aim is to introduce what tools are available now, and how they can be used.

ABSTRACTS

THE PODIUM INSTITUTE
FOR SPORTS MEDICINE & TECHNOLOGY

TALK TITLE *Generalizable Human 3D Reconstruction and Pose Estimation from Sports Images*

AUTHOR *Lorenza Prospero - The Podium Institute*

ABSTRACT

Computer vision algorithms are becoming increasingly important in sports, both during training and competition and at all skill levels. One core problem in applying Computer Vision to sports activities is estimating a realistic 3D human model of the athletes, which can then be employed in further analysis. Sports present unique challenges for computer vision: fast, chaotic action, multiple participants to track, and a limited number of views available (especially in lower leagues). With the recent advancements in the fields of human 3D reconstruction and pose estimation, new techniques can be leveraged to understand the dynamic sport context. In particular, 3D Gaussian Splatting (a scene representation composed of a mixture of Gaussians [1]) can be predicted jointly with pose parameters from standard human pose estimation methods. This approach takes advantage of both research areas since the vertices of human model meshes (such as SMPL [2]) provide an adequate density and initial position for the Gaussians, and the differential rendering from Gaussian splatting allows for training the model using only image-based metrics. The final model appears to respect the physical constraints of human pose, while at the same time being flexible enough to accommodate a variety of clothes and poses. With this work, we propose to move one step forward in this research and apply the same techniques to the more challenging sports datasets. We plan to investigate whether we can obtain a reliable pose estimation in the context of highly dynamic motion, as well as verify the temporal consistency of multi-frame estimations.

[1] Bernhard Kerbl, Georgios Kopanas, Thomas Leimkühler, and George Drettakis. 3d gaussian splatting for real-time radiance field rendering. ACM Transactions on Graphics, 42(4), July 2023.
[2] Matthew Loper, Naureen Mahmood, Javier Romero, Gerard Pons-Moll, and Michael J Black. Smpl: A skinned multi-person linear model. ACM Transactions on Graphics (TOG), 34(6):1–16, 2015.

ABSTRACTS

THE PODIUM INSTITUTE
FOR SPORTS MEDICINE & TECHNOLOGY

TALK TITLE *Quantitative Movement Testing (QMT): A Pipeline for Measuring Movements from Handheld Video Inputs*

AUTHOR *Pranav Mahajan - University of Oxford*

ABSTRACT

Quantifying movement is important in tracking recovery from injury and musculoskeletal disease. We present a pipeline that processes video input from a single handheld camera, capturing patients as they perform designated movements (e.g., three repetitions of bending forward), and outputs metrics of interest to the clinical scientist (e.g., distance of the hands from the floor).

The pipeline operates as follows: 3D poses are extracted from input videos using VideoPose3D, a pre-trained temporal dilated convolutional model. From these poses, time series of 3D joint angles and distances are derived and filtered. To extract metrics of interest across repetitions and subjects, it is necessary to identify relevant motifs in the continuous time series (e.g., determining how low participants reach over three repetitions without manually labelling motifs for each repetition in all participant videos). This challenge is addressed by manually labelling only one participant's time series to serve as a template, and then mapping all other participants' time series (queries) to this template using dynamic time warping (DTW). This process extracts the corresponding motifs for all participants.

We validate this pipeline using videos from an ongoing randomised clinical trial involving fibromyalgia patients, recorded before and after cognitive sleep therapy. Patients performed three repetitions of three movements: back bending, mini-squat, and marching on the spot. We demonstrate the quantification of various metrics, including the distance from the floor, the angle of the lower back relative to the transverse plane, the sideways sway angle relative to the sagittal plane, and hip-knee-feet angles.

ABSTRACTS

THE PODIUM INSTITUTE
FOR SPORTS MEDICINE & TECHNOLOGY

TALK TITLE *Exploring the Expression of Emotions in Children's Body Posture Using OpenPose*

AUTHOR *Marlene Försterling - University of Oxford*

ABSTRACT

Emotions regulate social interactions from early in ontogeny, but are difficult to assess in young children. Previous studies have used body posture as a measure of emotion expressions, employing depth-sensor imaging cameras (e.g., Kinect) in laboratory environments. Advances in artificial intelligence now allow researchers to track posture keypoints from existing video recordings. The studies reported here explored the feasibility of OpenPose to capture children's emotional expressions. In Study 1, we analysed posture data from previous studies and found that children's expressed valence was positively related to changes in their upper-body expansion whereas expressed arousal was related to overall levels of movement. In Study 2, we asked children (n = 64, aged 5 to 10 years) to recall emotional episodes of 'happiness', 'sadness', 'pride', and 'shame'. There were no effects of specific emotion categories on changes in children's posture, but exploratory analyses revealed that recalling positive emotions yielded greater changes in upper-body expansion compared to negative emotions. Together, these results suggest that the valence and arousal of expressed emotions can be captured using OpenPose.

DEBATE *Can computer vision provide automated sport injury detection and what are the challenges?*

PANELLISTS *Professor Andrew Zisserman - Professor Mauro Villarroel - Dr Damian Smith - Professor Nicholas Peirce*

ABSTRACTS

BIG DATA

THE PODIUM INSTITUTE
FOR SPORTS MEDICINE & TECHNOLOGY

TALK TITLE *Using Big Data to Transform and Accelerate Research into Sports Injury Prevention, Management, and Recovery*

AUTHOR *Dr Damian Smith - Podium Analytics* **KEYNOTE**

ABSTRACT

Damian will describe how Podium Analytics is changing the way we treat data and undertake research. Podium is applying insights from medical research in public health, cancer, and neurodegenerative diseases to remove the obstacles and barriers that prevent the delivery of high-quality academic research. Through the adoption of Trusted Research Environments and Secure Data Environments, built using the latest cloud-based and big-data technologies, Podium enables high-velocity governance to accelerate research, attract new sources of funding and help create a world with more sport and less injury.

ABSTRACTS

THE PODIUM INSTITUTE
FOR SPORTS MEDICINE & TECHNOLOGY

TALK TITLE *Incidence and Economic Burden of Sport-Related Concussion in the United Kingdom*

AUTHORS *Dr Lara Prisco / Professor Jose Leal - University of Oxford* **KEYNOTE**

ABSTRACT

The growing burden of sport-related concussion (SRC) represents a major public health issue. Using a systematic review and meta-analysis we calculated the cumulative SRC incidence, across the 14 most popular sports in the UK, as 232,413 adult and 178,199 paediatric SRCs annually, almost one fifth of all emergency department visits due to head injury nationally. The direct healthcare costs of SRC simulated using an economic model for head injury could amount to £198m per annum for adults and £178m for children, which compare favourably to the £2.3bn of annual healthcare savings arising from adult sports participation.

DEBATE *What are the acquisition, curation, privacy and processing challenges to using Big Data for sport safety, particularly in community sport? How can we best capture the necessary information to understand its economic and healthcare impact?*

PANELLISTS *Dr Damian Smith - Dr Lara Prisco - Professor Jose Leal - Professor Nicholas Peirce*

ABSTRACTS

MODELLING

THE PODIUM INSTITUTE
FOR SPORTS MEDICINE & TECHNOLOGY

TALK TITLE *Concussion, Traumatic Brain Injury, and Chronic Traumatic Encephalopathy: Lessons from the Battlefield, Ball Field, and Lab Bench*

AUTHOR *Professor Lee Goldstein - Boston University* **KEYNOTE**

ABSTRACT

Traumatic brain injury (TBI) is a leading cause of death and disability and a signature injury of recent military conflicts. Concussive and subconcussive TBI is linked to cognitive deficits and neuropsychiatric sequelae, including chronic traumatic encephalopathy (CTE), a tau protein neurodegenerative disease associated with repetitive head injuries in contact sport athletes and blast exposure in military veterans. This talk will review TBI and CTE neuropathology and experimental results from biofidelic animal models of blast neurotrauma and impact concussion. This work provides new insights into mechanisms leading to acute-chronic effects of neurotrauma and opens new translational pathways for development of new diagnostics, therapeutics, and preventive measures for TBI and its aftermath.

TALK TITLE *Biomechanical Metrics for TBI, from Pa to J to… Whatever*

AUTHOR *Professor Antoine Jerusalem - University of Oxford* **KEYNOTE**

ABSTRACT

In this presentation, we will briefly explain how the identification of injury criteria for TBI remains challenging despite decades of research. In particular, we will show how our group moved away from mechanical and kinematics criteria towards energy-based criteria to avoid some of those pitfalls. We will finally propose a new approach currently being applied in the context of rugby head injuries, but first used in the context of assaults, whereby an AI-mechanistic coupling framework allows to bypass the need for criteria altogether, while allowing for mechanistic identification of cognitive deficits.

TALK TITLE *Evaluation of a Markerless Motion Capture System for Assessing the Kinematics of Gymnasts*

AUTHOR *Lucy Buchanan - The Podium Institute*

ABSTRACT

Background: Monitoring the movements of gymnasts could enhance our understanding of their injuries and facilitate the implementation and evaluation of injury prevention measures. Markerless motion capture (mocap) with video cameras offers a potential way of investigating the biomechanics of gymnasts in the large and appropriately equipped training and competition environment of a gym. This study aims to compare a smartphone-based markerless mocap system (OpenCap) [1] validated for walking, squatting, and jumping to a gold-standard marker-based mocap system in a laboratory to see if it can track basic gymnastics movements to the same level of accuracy.

Methods: One adult female gymnast, with full-body mocap markers attached, performed walking, squatting, sit-to-stand, handstand, cartwheel, handstand walk, and handstand hop while her motion was tracked using a 16-camera Vicon mocap system simultaneously with a two-smartphone OpenCap set-up. Marker trajectories were analysed using both a Vicon model [2] and the OpenSim musculoskeletal model [3] implemented by OpenCap. Output kinematics from both systems were compared.

Results: This pilot study showed that, while OpenCap was able to estimate kinematics for walking, it struggled with continuous tracking of common gymnastics movements, leading to sections of incorrect or less accurate kinematics in some cases.
Discussion: The OpenCap system shows promise for tracking gymnastics movements, but further investigation of the camera arrangement and collection of gymnastics-specific training datasets are necessary.

References: [1] Uhlrich et al. (2023). PLoS Computational Biology, 19(10), e1011462. [2] Vicon Plug-in Gait Reference Guide (2023) [3] Lai et al. (2017) Annals of Biomedical Engineering 45: 2762-74.

TALK TITLE *Explainable Self-Attention Neural Network to Classify Sports-Related Cardiac Arrhythmias in Youth Athletes*

AUTHOR *Erik Vanegas Müller - The Podium Institute*

ABSTRACT

Background: Sudden cardiac death (SCD) is an unexpected death that occurs within one hour of a witnessed or 24 hours of an unwitnessed cardiac arrest, often resulting from arrhythmias. Athletes, particularly during physical activity, face a doubled risk of SCD compared to non-athletes because strenuous physical activity can result in exercise-induced functional, electrical, and structural cardiac changes. This risk is pronounced especially in adolescents and young adults with underlying heart conditions due to the complexities introduced by youth athletes' anatomical and physiological biological development. Consequently, discerning between exercise-induced physiological adaptions and cardiac pathologies with the potential for arrhythmia and sudden cardiac death presents a challenging but fundamental clinical problem. Using a 12-lead electrocardiogram (ECG) database of professional football players, this paper proposes new methods to classify exercise-induced cardiac arrhythmias to differentiate those from pathological adaptations in adolescent and young adult athletes.

Methods: We used a dataset involving 54 male (25.4 ± 3.1 years old) professional Spanish football players from the Pro-Football league recorded between 2018 the post-season and pre-season 2022. For each participant, 10-second 12-lead resting ECG were recorded at 500 Mhz. The database consists of a total of 163 resting ECG recordings, offering a detailed examination of the at-rest heart activity of professional football athletes. Up to six players can be found with the complete screening series between 2018 and 2022. The participants in this dataset presented either a healthy or abnormal ECG during screening. We developed a residual neural network with a multi-head attention mechanism to classify the cardiac arrhythmias. For the neural network's pre-training we used the public PhysioNet Challenge 21 dataset. We implemented a post-hoc explainable artificial intelligence (xAI) algorithm to investigate the indicative features used by the deep learning models developed. We statistically compared the outcomes with the features used by clinicians to classify the presence of sports-related arrhythmias.

Conclusions: The features identified by the xAI methods, highlighted the classification features used by the neural network, making the algorithm more transparent and aiming to provide a novel understanding of the electrophysiology of the athlete's heart. The identification of new classification features for young athletes' electrocardiograms eases distinguishing between pathological and non-pathological exercise-induced cardiac adaptations. The improvement in understanding the athlete's heart contributes to the long-term goal of developing a detection technology that suits day-to-day life and guarantees precise and actionable information to prevent and predict SCD.

TALK TITLE *Investigating the Physiological and Mechanical Brain Response to Football Heading*

AUTHOR *Alonso Soto Rosales - Cardiff University*

ABSTRACT

Exposure to repetitive mild head impacts during football has raised concerns about potential links with neurodegenerative diseases. However, the effects on brain health are not fully understood. To this end, this study uses both Electroencephalography (EEG) and computational Finite Element Analysis (FEA) modelling to investigate the relative electrophysiological and biomechanical effects of heading a FIFA standard ball across a range of football heading related perturbations, including ball inflation pressure, ball velocity and region of head contact.

EEG data were collected to monitor brain neuronal activity, before and after football heading motions, with (experimental) and without (control) head-ball contact. FEA simulations were employed to examine the mechanical response of the impacted and non-impacted brain tissue. Thus, identifying areas of the brain most affected by ball contact.

By correlating EEG findings with FEA simulation results, this study seeks to elucidate the neurological and biomechanical consequences of heading in football. This integrative approach is essential for informing governance, developing preventive measures, enhancing safety protocols and designing protective equipment for athletes.

TALK TITLE *Brain Mechanics and Microbleeds: a Preliminary Investigation*

AUTHOR *Phoebe Haste - The Podium Institute*

ABSTRACT

Traumatic cerebral microbleeds are associated with worse outcomes in traumatic brain injuries (TBIs). However, as they only affect a proportion of patients, across injury severities, their underlying cause is uncertain. One hypothesis is that this variability could be explained by different mechanical characteristics of the injury event itself. This preliminary investigation leverages finite element head model simulations to explore the mechanics of TBIs, and potential factors which could result in the presence of microbleeds. Linear and rotational acceleration values which have been observed in contact sports are imposed, and the resulting brain mechanics discussed. Additionally, potential areas of damage in the brain are identified.

DEBATE *What are the most appropriate biomechanical metric(s) to predict head injury and other injuries?*

PANELLISTS *Professor Lee Goldstein - Professor Antoine Jerusalem - Professor Johannes Weickenmeier - Dr Mazdak Ghajari*

ABSTRACTS

PPE

THE PODIUM INSTITUTE
FOR SPORTS MEDICINE & TECHNOLOGY

TALK TITLE *Hiper – A New Helmet Rating System Based on Real-World Data and Advances in Brain Injury Biomechanics*

AUTHOR *Dr Mazdak Ghajari - Imperial College London* **KEYNOTE**

ABSTRACT

New head protection technologies are entering the market at a rapid pace with a range of claims and prices. There is a lack of objective information to help consumers, including individuals and organisations, to select most appropriate products. In this talk, I will present Hiper, a new helmet rating system that HEAD lab has developed in the last few years, based on advanced knowledge of brain injury biomechanics and real-world data. I will present our findings for 30 most popular cycle helmets and discuss the potential of the rating to guide helmet design for a range of applications.

TALK TITLE *Soft Robotics for "Soft" PPE in Sports*

AUTHOR *Professor Liang He - The Podium Institute* **KEYNOTE**

ABSTRACT

Personal Protective Equipment (PPE) plays an important role in modern sports, ensuring safety and minimising injuries. "Rigid" helmets, for example, have significantly reduced the risk of traumatic brain injuries, while "soft" sleeves, braces, and orthoses provide protection against musculoskeletal injuries and support rehabilitation. Regardless of whether PPE is perceived as "rigid" or "soft" based on its materials, their effectiveness lies in a conceptual "soft": their ability to adapt to human anatomy, absorb impact, and conform to movement. This talk presents recent initiatives at the Podium Institute, exploring the use of soft robotics to redesign PPE in sports. By envisioning next-generation PPE as evolving, adaptive, and intelligent systems, we adopt a robotic approach in our design to enhance injury prevention, aid rehabilitation, and improve performance.

ABSTRACTS

TALK TITLE *Towards Safer Helmets: Design and Numerical Study of Origami-Inspired Energy Absorption Materials under Complex Impacts*

AUTHOR *Dr Chenying Liu - The Podium Institute*

ABSTRACT

Sports like cycling, skiing, and equestrian are highly popular among young people but pose a staggering risk of traumatic brain injuries (TBIs). Helmets are essential in mitigating head impacts and reducing the occurrence of such injuries. However, all current certification standards have oversimplified the helmet tests into linear impacts only, whilst rotational and combined impacts also play a significant role in causing TBIs. As a result, the effectiveness of helmets remains questionable and necessitates improvements. Recent advancements like the multi-directional impact protection system (MIPS) and WaveCel structure have emerged in the market, which claim to address rotational impacts more effectively. Despite their potential, a more comprehensive design guideline is still lacking.

Origami, the art of paper folding, has been successfully employed to design energy-absorption materials for shock absorption in car crashes and earthquakes. In this study, we draw inspiration from origami-inspired computational design to systematically develop cellular structures that can act as a protection layer against both linear and rotational impacts. Those structural materials can be optimised via parametric design to exhibit desirable mechanical properties that are tailored for various sports scenarios. Through finite element modelling and numerical analysis, we have compared the performance of origami-inspired materials under complex impacts with existing helmet materials and structures. Preliminary results indicate a promising future for origami-based design in enhancing helmet safety.

DEBATE *What does tomorrow's PPE need to do that it doesn't currently?*

PANELLISTS *Professor Mazdak Ghajari - Professor Liang He - Dr Gemma Parry-Professor Antoine Jerusalem - Professor Lee Goldstein*

ABSTRACTS

IMAGING AND NEUROIMAGING

THE PODIUM INSTITUTE
FOR SPORTS MEDICINE & TECHNOLOGY

TALK TITLE *Neuroimaging Investigations of Network Dysfunction After Traumatic Brain Injury*

AUTHOR *Professor David Sharp - Imperial College London* **KEYNOTE**

ABSTRACT

Patient outcome after traumatic brain injury (TBI) is highly variable. The underlying pathophysiology of this is poorly understood, but traumatic (diffuse) axonal injury is an important factor. This has been difficult to identify on standard neuroimaging, but can be sensitively measured using diffusion tensor imaging. Axonal damage disconnects the large-scale brain networks that support cognitive function and this can be investigated using MRI. I will discuss our work on structural and functional effects of TBI on brain network function, and highlight the links between network breakdown and cognitive function. I will also discuss the importance of these observations to the view that TBI is a chronic disease rather than a static insult, and how patterns of network dysfunction after TBI can inform understanding of brain function and be used to study treatment response.

TALK TITLE *Clinical Neuroimaging of TBI*

AUTHOR *Professor Natalie Voets - University of Oxford* **KEYNOTE**

ABSTRACT

This talk will describe our experience utilising MRI to explore the hyper-acute, acute and chronic phases of traumatic brain injury in a longitudinal study of adult patients admitted to the Oxford emergency department. We will describe our subsequent implementation of a clinical paediatric MRI service focussing on children experiencing prolonged symptoms following head injury. Finally, we will consider evidence for emerging neuroimaging techniques that hold significant potential to establish the early and later consequences of paediatric TBI.

TALK TITLE *Visualising Concussion: Progress in Diagnostics and Future Directions*

AUTHOR *Professor Antonio Belli - University of Birmingham* **KEYNOTE**

ABSTRACT

Concussion diagnosis remains one of the most complex and urgent challenges in medicine, especially given growing concerns about athlete brain health across all age groups. The lack of validated objective tests hampers efforts to minimise risk and ensure safe return to play. While tools such as neuroimaging, eye-tracking, and biomarkers have yet to see widespread clinical application, advances in technology and AI are driving rapid progress. Given the varied and evolving nature of concussion symptoms, multimodal clinical assessments are essential for the personalised management of acute, post-acute, and long-term effects.

TALK TITLE *Neuroimaging Biomarkers for Pain and Mental Health: Applications in Sports Medicine*

AUTHOR *Eoin Kelleher - University of Oxford*

ABSTRACT

Objective: The descending pain modulatory system (DPMS) is a supraspinal network of brain regions crucial for pain/injury resilience. Dysfunction in this network is a key component of many types of chronic pain, and also linked to mood and mental health. We aimed to investigate whether neuroimaging features of the DPMS are linked to common physical and psychological comorbidities at a population level, and how these findings can inform sports medicine.

Methods: We analyzed 8753 adults (58.7% female; mean age 64.6) with persistent chronic pain from the UK Biobank, who underwent brain MRI and completed an online pain questionnaire. Using canonical correlation analysis (CCA), we explored relationships between 21 resting state functional connectivity (RSFC) pairs in the DPMS and 28 cognitive/behavioral measures, including anxiety, mood, brain fog, fatigue, sleep quality, pain, health satisfaction, and medication use.

Results: Our analysis identified a significant mode with a canonical correlation of 0.111 (P=0.00027). Key DPMS functional pairs included dlPFC-RVM (structural correlation +0.32), amygdala-PAG (-0.46), and sgACC-RVM (0.39). Associated behavioral variables were anxiety (-0.49), low mood (-0.47), brain fog (-0.32), fatigue (-0.29), and sleep disturbance (-0.41). These findings indicate strong associations between DPMS connectivity patterns and psychological and cognitive characteristics.

Conclusion: This study shows that DPMS is linked to behavioral symptoms in adults with pain, including as anxiety, low mood, cognitive disturbance, and sleep disturbance. In sports medicine, these insights could provide quantification of pain and mental health symptoms and injury prevention in athletes, as well as inform mechanistic models and potentially interventional technologies that support coping and recovery.

ABSTRACTS

IMAGING AND NEUROIMAGING

THE PODIUM INSTITUTE
FOR SPORTS MEDICINE & TECHNOLOGY

TALK TITLE *Identifying MRI Biomarkers that Predict Outcomes Following Adolescent Traumatic Brain Injury: A Prospective Study*

AUTHOR *Izabelle Lövgren - The Podium Institute*

ABSTRACT

Despite concussions being common in young people, research into head injuries in adolescents is scarce. One factor limiting our understanding of head injuries is the absence of reliable predictors of outcome. Specifically, conventional clinical assessment tools are not sufficiently sensitive to certain aspects of brain injury that determine long-term outcome and recovery.

Advanced magnetic resonance imaging (MRI) can provide detailed information about neuronal microstructure, levels of brain chemicals, functional connectivity, and the presence of traumatic cerebral microbleeds, among other features. In a limited number of studies, advanced MRI helped better explain why some are affected more severely by their injury than indicated by conventional tools. We present a prospective, longitudinal study of 11-18-year-olds with: a recent sports-related head injury (n=30); a head injury of any kind which warranted clinical MRI (n=30); a head injury >6 months ago (n=30); and children with no history of head injury (n=30). Patients will be scanned within two weeks of injury, with a second scan 6 months later. By combining advanced MRI techniques with parent- and self-reported questionnaires and a cognitive task, we aim to (1) identify clinical and imaging markers that help us predict how well a child will recover after a head injury; (2) investigate how these markers change over time;(3) test if clinical factors (like injury mechanism) predict specific imaging findings; and (4) evaluate the lasting burden of head injuries, particularly in sports.

DEBATE *Can functional imaging enable us to see and characterize injuries that cannot be detected with structural imaging alone?*

PANELLISTS *Professor David Sharp - Professor Natalie Voets - Professor Antonio Belli- Professor Heidi Johansen-Berg - Professor Peter Jezzard*

TALK TITLE *Biomarkers for mTBI: Detection Technologies and Clinical Utilities*

AUTHOR *Dr Hongwei Zhang - Abbott* **KEYNOTE**

ABSTRACT

Traumatic brain injury (TBI) affects millions of people each year. TBI is not only an acute condition but also can be a chronic disease with serious long-term consequences. Imaging based diagnosis may not be able to detect cellular level damages such as in mild TBI, where biomarkers could bridge the gap and hold the potential for diagnosis of injury, monitoring progression or response to treatment, and prognosis. In addition to the clinical use of S100B, blood-based biomarkers glial fibrillary acidic protein (GFAP) and ubiquitin carboxyl terminal hydrolase L1 (UCH-L1) have been approved for clinical use. The clinical utilities, limitation and future directions will be discussed.

TALK TITLE *Clinical Application of Biomarkers in Sports Related Traumatic Brain Injury*

AUTHOR *Mr Tim Lawrence - Oxford University Hospitals* **KEYNOTE**

ABSTRACT

Biomarker use in traumatic brain injury (TBI) of all severities has gained huge interest in recent years. While there are many examples of how biomarkers have dramatically changed management and care of patients with various other medical conditions, the specific role that fluid and imaging biomarkers might play in TBI has not been clearly defined. It is important to understand what we require of the biomarkers, what outcomes we want to predict or modify, and what the specific outcome measures are in sports related injury.

TALK TITLE *Evaluating the Relationship Between a Standard Model of VO2 Max and End Tidal CO2*

AUTHOR *Sierra Sparks - University of Oxford*

ABSTRACT

Introduction: VO2 max, a common measure of aerobic capacity, is a measure of a person's maximum uptake of oxygen. Endurance athletes tend to have higher VO2 max values. Conversely, end tidal carbon dioxide (ETCO2), a surrogate for arterial CO2 pressure, measures CO2 production and clearance, and can change between resting and exercise states. Here, we compare VO2 max estimates, with ETCO2 measurements assessed at rest, to investigate the relationship between VO2 max and resting ETCO2 in healthy subjects.

Methods: 17 healthy subjects (8 females; 31±7 years) were studied. Blood pressure measurements (min=3, max=5) were taken using an automatic blood pressure monitor whilst sitting. The minimum measured heart rate was used as the resting heart rate. VO2 max was estimated using a standard model incorporating age and resting heart rate data. Baseline ETCO2 measurements were sampled using a thin nasal cannula and an infrared gas analyser (ML206, ADInstruments) while subjects breathed medical air for 3 minutes. Measures were compared using linear least-squares regression.

Results: There was a significant linear association between the estimate of VO2 max and ETCO2 (R^2=0.5311, p=0.003). The association between resting heart rate and ETCO2 was also significant but slightly weaker (R^2=0.4257, p=0.005).

Conclusion: We found an association between VO2 max estimates and ETCO2 that was stronger than the relationship between resting heart rate and ETCO2. More research should be conducted using a more reliable measure of VO2 max, including exertion tests, to further explore this relationship.

TALK TITLE *Behavioural Correlates of Peripersonal Space Alterations During Tonic Experimental Pain: A Multisensory Approach Powered by Virtual Reality*

AUTHOR *Aria Apoo / Dr Danielle Hewitt - University of Oxford*

ABSTRACT

Rapid pain responding is essential in preventing injury, with pain-inducing stimuli capturing attention and eliciting anticipatory preparation and avoidance responses. Sustained pain after sports injuries may result in altered spatial perception and distinct responses to looming threats. However, little is known about spatial attention changes after injury, and the potential impact of changes in peripersonal space representations to new threats.

Twenty-four healthy participants will complete two tasks in virtual reality with no pain, and tonic thermal pain on the left or right forearm as an experimental model of injury. First, during a reaching judgment task, participants estimate how far they can reach in virtual space. Subsequently, in a time-to-collision task, a tennis ball approaches the left or right body side before disappearing, and participants approximate when the ball would reach them. Behavioural responses, eye-tracking, and pain ratings are collected throughout.

Data collection for this study is ongoing. Repeated-measures ANOVAs will assess statistical differences in time-to-collision estimates and reaching distances in thermal pain conditions when pain is congruent or incongruent with the looming direction, and in the absence of pain. We predict reduced accuracy of time-to-collision responses and shorter reaching distance estimations for stimuli congruent versus incongruent to pain.

In conclusion, this innovative paradigm explores changes in spatial perception during sustained pain. Altered reaching judgments and collision estimates could point towards changes in peripersonal space representations and threat detection during sustained pain. Findings could contribute to our understanding the risk of new injury in those with previous injuries.

TALK TITLE *Quantification of Training Load Using Wearable Sensors and Variations in Heart Rate and Blood Lactate Concentration*

AUTHOR *Melis Atbinek - The Podium Institute*

ABSTRACT

Background. Regular exercise can help avoid chronic diseases such as cardiovascular disease, diabetes, depression, bone fracture and joint diseases. However, excessive exercise and insufficient recovery can lead to complications and overuse injuries. There is a need to develop metrics to monitor the training load to fatigue to injury process objectively. Different methods are already used such as wearable devices, questionnaires and biological markers. Biomarkers can serve as surrogate endpoints of clinical outcomes such as lactate. However, the blood lactate concentration is not a direct measure of internal load. We propose that training load can be tracked with external and internal load values.

Method. We used a dataset involving 12 male participants (23.3 ± 2.9 years old). Participants performed squats on a flywheel machine. Heart rate (HR), inertial measurement unit (IMU), motion capture (MoCap), lactate values and rate of perceived exertion (RPE) were recorded. We developed a linear regression model using HR, IMU and lactate values to predict RPE. The association of lactate with session RPE was calculated using Pearson's correlation. Additionally, we quantified each athlete's response to different levels of exercise by adding the exercise load.

Conclusion. We suggest that MoCap, IMU and biological markers can predict the rate of perceived exertion. The model predicted RPE values, when trained with HR, IMU and blood lactate concentrations. We improved the model by including external load, parameters from the flywheel data. This shows us, that using parameters which change for each athlete allows us to predict RPE better.

DEBATE *Are point-of-care biomarker diagnostics of mTBI effective and practicable?*

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