



Overview

About Love of the Game

We, the “Love of the Game” team, are working to protect the sports we love by protecting our players. We are searching for positive solutions to prevent, diagnose and treat head injuries, concussion and related problems through Science, Technology and Innovation.

Our Agenda is to:

- **Diagnose:** To develop faster, cheaper, more accessible diagnostic tools for the identification and treatment of vascular damage.
- **Treat:** To develop technology that treats small but successive amounts of vascular damage, at the point of injury.
- **Broadcast:** To raise public consciousness about post-concussion issues and educate players, families and coaches about new technology.

Sports with concussion issues (not an exhaustive list!)

Rugby (Union & League) | American Football | Football | Cricket | Horse racing | Boxing | Cycling | Snow Sports | Aussie Rules | Ice Hockey | Basketball | Netball | Motorsports (inc. F1) | Wrestling | Judo | Canoeing/ Kayaking

About our Hakathon

Love of the Game (in collaboration with Hacking Health UK) are hosting a Hakathon aimed at bringing the brightest minds across the Design (both User Experience and Product), Developer and Engineering worlds together with amateur and professional Sports People, Academics and Researchers in the Sport Health fields; to create solutions that **Diagnose, Grade, Treat** and **Develop** protocols for return to play, in order to mitigate the effects of head injuries and concussion within sports.

Over the course of this 2.5 day event our Hakathon participants will connect with, and form cross-disciplinary teams, combining their knowledge to create innovations that have real world applications that will improve the lives of those that love and play sports.

This briefing document aims to equip our Hakathon attendees with an overview of the current research and products related to concussive injuries in sports.

Definition of Concussion

The NHS defines concussion as a mild temporary brain injury (mTBI) caused by impact to the head. However, concussion can be more severe which can lead to emergency treatment or long-lasting problems. However, McCrory et al. (2017) reviewed all sports-related concussion (SRC) definitions and found that there were 6 variations identified. They argued there was no gold-standard in assessing the diagnostic properties of SRC. They also stated that new approaches need to be developed to provide an objective definition of SRC.

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NHS Signs and Symptoms of Concussion include:

- A headache that does not go away or is not relieved with painkillers
- Dizziness
- Feeling or being sick
- Memory loss – you may not remember what happened before or after the injury
- Clumsiness or trouble with balance
- Unusual behaviour – you may become irritated easily or have sudden mood swings
- Feeling stunned, dazed or confused
- Changes in your vision – such as blurred vision, double vision or "seeing stars"

Long Term Effects of Concussion

Studies have shown that repeated SRC and head impact have led to cognitive decline, neuropsychiatric disorder (e.g. depression, attention deficit disorders and seizures) or neurodegenerative disease (e.g. Early Onset Dementia, Alzheimer's disease and Parkinson's) (McAllister & McCrea, 2017).

1) Diagnosis

Testing In-Game

OPRO+ Mouthguard

- A mouthguard fitted with PROTECHT's high precision sensor technology which detects, transmits and displays insightful information about every head impact a player receives.
- This means head impact can be monitored in training or in competitive matches and information can be directly related back to their coaches, trainers and medical professionals.
- wired.co.uk/article/rugby-concussion-opro-mouthguard
- Can mouthguards also be developed to monitor biomarkers via saliva?

Earpieces with accelerometers

- Earpieces with accelerometers are used to determine rotations and/or directions of the user's head (Abrahamsson et al., 2016).
- Head impact monitoring through accelerometry has been shown to be useful regarding characterising the kinematic load to the head associated with concussion (Brennan et al., 2017).
- pubmed.ncbi.nlm.nih.gov/27402455/

Tozuda Impact Sensor

- The sensor is attached to a sports helmet and will change to bright red when the users experience impact and collision severe enough to caused SRC.
- The sensor can be used for any activity or level of play.
- tozuda.com

Livall Smart helmet with Gyroscope

- The cycling helmet includes a three-axis gyroscope for crash detection.
- A gyroscope is a device used for measuring or maintaining orientation and angular velocity. If the helmet detects a crash, it will send an SOS alert to an emergency contact if it is not turned off by the user.
- The helmet also includes a built-in light and microphone.

- livall.co.uk

Other Head-impact measurement devices (O'Conner et al., 2017)

- Given that concussion risk is influenced by many factors in addition to impact biomechanics, viewing an athlete's head-impact data may provide context for the clinician working on the side-lines, but impact sensors should not replace clinical judgment.

Testing Post Game

SCAT5 (Davis et al., 2017)

- A standardised tool to assess head trauma developed by the International Concussion and Head Injury Research Foundation.
- The SCAT5 includes 6 steps to follow to diagnose concussion which involves different tests and screens.
- 6 Steps: Immediate or on-field assessment, Symptom Evaluation, Cognitive Screening (Standardized Assessment of Concussion; SAC), Neurological Screen and Balance examination (Modified Balance Error Scoring System; mBESS), Delayed Recall and decision.
- For the full SCAT5 visit: bjsm.bmj.com/content/bjsports/early/2017/04/26/bjsports-2017-097506SCAT5.full.pdf

The Birmingham Concussion Test

- The study involves saliva and urine samples from injury and uninjured Premier league football players. <https://www.uhb.nhs.uk/bbcc-instructions-for-players.htm>
- The samples will be tested using the ground-breaking 'Birmingham Concussion Test' developed by Professor Tony Belli.
- The test is a handheld device that looks for molecules in blood, urine or saliva (microRNAs), which can be used as biomarkers to indicate whether the brain has suffered concussion.
- Also refer to drakefoundation.org/evaluating-concussion/

Diagnostic Imaging tests (Purcell, 2014)

- Concussion is a functional brain injury, not structural. Therefore, structural diagnostic imaging should only be used if structural injury suspected.
- ECT, PET and fMRI scans may uncover functional brain abnormalities caused by concussion.
- SPECT Scans Use in Detecting Traumatic Brain Injuries (stanford.edu)
- Scans are expensive and are not widely available nor always recommended. However, mobile scanners being developed World's First Portable MRI Cleared by FDA | Medgadget - medgadget.com/2020/02/worlds-first-portable-mri-cleared-by-fda.html

Pre-season Biomarker comparisons

- In cricket, SCAT5 results are compared to a baseline score taken in pre-season.
- If concussion is confirmed, players must sit out the rest of the match and they cannot return to full training for 6 days.
- In rugby union, working in conjunction with Prof Tony Belli, pre-season biomarkers present in saliva and urine are tested via a handheld device following head trauma to assess if concussion has occurred. Can be carried out on pitchside - youtu.be/2ue83l-TYTo

WAVi Brain Performance Headset/EGG brain test

- Observes brain state changes. Can it be developed further as cost-effective protective headgear that also performs

a brain monitoring role?

- wavimed.com/medical/

2) Grading

SCAT5: Step 6 “Decision” (Davis et al., 2017)

- The SCAT5 states that the scoring should not be used as a stand-alone method for assessing SRC, recovery or decisions about an athlete's readiness to return to the game.
- This is because an athlete may have a concussion even if their SCAT5 is “normal”.

6

STEP 6: DECISION

	Date & time of assessment:		
Domain			
Symptom number (of 22)			
Symptom severity score (of 132)			
Orientation (of 5)			
Immediate memory	of 15 of 30	of 15 of 30	of 15 of 30
Concentration (of 5)			
Neuro exam	Normal Abnormal	Normal Abnormal	Normal Abnormal
Balance errors (of 30)			
Delayed Recall	of 5 of 10	of 5 of 10	of 5 of 10

Date and time of injury: _____

If the athlete is known to you prior to their injury, are they different from their usual self?
 Yes No Unsure Not Applicable
(If different, describe why in the clinical notes section)

Concussion Diagnosed?
 Yes No Unsure Not Applicable

If re-testing, has the athlete improved?
 Yes No Unsure Not Applicable

I am a physician or licensed healthcare professional and I have personally administered or supervised the administration of this SCAT5.

Signature: _____

Name: _____

Title: _____

Registration number (if applicable): _____

Date: _____

There are three grades:

- Grade 1: Mild, with symptoms that last less than 15 minutes and involve no loss of consciousness.
- Grade 2: Moderate, with symptoms that last longer than 15 minutes and involve no loss of consciousness.
- Grade 3: Severe, in which the person loses consciousness, sometimes for just a few seconds

Identifying release of brain protein, tau

- Elevated levels of the brain protein tau following a sport-related concussion are associated with a longer recovery period and delayed return to play for athletes.
- Research has also linked tau to chronic traumatic encephalopathy (CTE). Researchers found elevated levels of the protein in the cerebrospinal fluid of more than half of the study participants, who were former professional athletes who experienced multiple concussions.
- livescience.com/65434-cte-concussion-biomarker-tau.html
- bu.edu/articles/2020/what-does-football-do-to-the-brain/
- ‘There is some evidence that tau can be detected in the retina so could an easily accessible, rapid scanning device be developed to establish the presence of tau?’
- Tau accumulation in the retina promotes early neuronal dysfunction and precedes brain pathology in a mouse model of Alzheimer’s disease | Molecular Neurodegeneration | Full Text (biomedcentral.com)
- [The role of tau in brain-function and dementia](#)

- Alternatively/additionally, might the optic nerve provide a 'window' into brain trauma? The anatomy of the optic nerve makes it a sensitive marker for problems inside the brain. The optic nerve's whole surface is bathed in cerebral spinal fluid. This fluid protects the nerve from sudden movement. However, even slight increases in the pressure of this fluid, from swelling of the brain, can compress the optic nerve around its whole circumference in a "choking" manner.'

3) Treatment

Rest

- Physical rest: complete one task at a time, limit household chores and abstain from any form of exercise.
- Cognitive rest: avoid exercises that use demanding mental processes e.g. memory, multitasking, making important decisions and reaction time.

Returning to sport - SCAT5 (Davis et al, 2017)

Graduated Return to Sport Strategy

Exercise step	Functional exercise at each step	Goal of each step
1. Symptom-limited activity	Daily activities that do not provoke symptoms.	Gradual reintroduction of work/school activities.
2. Light aerobic exercise	Walking or stationary cycling at slow to medium pace. No resistance training.	Increase heart rate.
3. Sport-specific exercise	Running or skating drills. No head impact activities.	Add movement.
4. Non-contact training drills	Harder training drills, e.g., passing drills. May start progressive resistance training.	Exercise, coordination, and increased thinking.
5. Full contact practice	Following medical clearance, participate in normal training activities.	Restore confidence and assess functional skills by coaching staff.
6. Return to play/sport	Normal game play.	

Hyperbaric Oxygen therapy (HBOT) (James, 2020)

- It is thought that a higher concentration of oxygen may be a way for damaged cells to receive nutrients that can help revitalise them.
- It may also play a part in reducing the inflammation caused by brain damage.
- As the severity of a disease or injury increases, an incremental increase in the dose used for oxygen treatment is mandated. When 100% oxygen at normal atmospheric pressure is not adequate then a pressure chamber is needed.
- Measurements show that a lack of oxygen in damaged tissues (hypoxia) may be present despite normal levels of oxygen in the blood.
- However, currently it is not part of mainstream medical practise in the West.
- pubmed.ncbi.nlm.nih.gov/24260334/
- Administer oxygen immediately after head trauma on the 'field of play'?

Head-neck cooling device (wang et al., 2015)

- Recent data has shown an association between brain temperate elevation and mild traumatic brain injury (mTBI).
- Using head-neck cooling technology before and after mTBI is implied to be a sensible, practical and effective method in contact sports to enhance recovery and minimise subsequent behavioural deficits.

- To lessen the risks for and detrimental outcomes of mTBIs, a multidisciplinary (more than one field of study) scientific approach is required.
- Research efforts are crucial in achieving the much-needed objectivity and certainty in first defining and recognizing an mTBI, and then assessing and stratifying its injury severity.

Wim Hof Method

- The power of the Wim Hof Method is the combination of the three pillars: Cold therapy, Breathing and Commitment.
- A committed, consistent practice, including the breathing technique and cold exposure, can help you unlock a host of benefits, including natural anti-inflammatory, increase sports performance and controlling the autonomic nervous system.
- wimhofmethod.com

4) Prevention

Helmets

- Helmets are used to distribute the energy of impact and protect the head from penetration.
- Used in American football, baseball, cycling, cricket, field hockey, ice hockey, and horse racing.

Mouthguards

- They prevent the jaws from coming together fully which may reduce the risk of jaw joint injuries and concussion.
- Used in rugby, American football, field hockey, ice hockey and martial arts.

Faceguard

- Normally attached to the helmet or hat to cover the exposed area of the face.
- Often used in sports that wear helmets for protection.

Headguard

- A padded headguard that leaves only the face exposed.
- Used in boxing, some martial arts and rugby.

N-Pro Headguard

- "Utilising our cutting edge defentex™ impact management technology, N-Pro is designed to reduce the G-Force energy transferred to a player's head during impact, one of the major factors in sports-induced brain injury."
- Headguard used in rugby
- n-pro.com

Head and Neck Restraint (HANS Device)

- The purpose is to keep the head from whipping in a crash.
- Used in motorsports
- hansdevice.com

2nd Skull Technology

- A product that is scientifically engineered to absorb impact under pressure.
- The material that is flexible at rest but then hardens under pressure or impact.
- The product comes in the form of a headband, cap, softshell helmet which can be worn on its own or under any headgear.
- 2ndskull.com/pages/about

Effectiveness of protective equipment?

- Whilst protective equipment is useful for a range of different reasons, including minimising the risk of concussion, most do not completely prevent SRC.
- Some work better than others.
- ncbi.nlm.nih.gov/books/NBK185338/

Non-equipment related preventive approaches

- Review and development of *return to play protocols*
- In Cricket, *concussion substitutes* introduced in England in 2018.
- *Concussion education*: Research indicates that concussion education programs are effective in improving concussion knowledge, although there is a lack of research concerning the effect of these interventions on behaviour.
- *Enhance Brain Endurance* - "Rewire Fitness": <https://rewirefitness.app/> Can this improve the brain's ability to endure trauma?
- Creation of '*concussion passports*' for sportspeople, particularly the young?
- Are some sportspeople genetically predisposed to concussion? 'Wooden heads' or 'glass jaws'? Women more susceptible than men?

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