Institution: University of Stirling		
Unit of Assessment: 4. Psychology, Psychiatry and Neuroscience		
Title of case study: Reducing the risk to brain health in youth football: the science that generated public debate, policy U-turns, and the banning of heading practice.		
Period when the underpinning research was undertaken: 2015-2019		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Magdalena Ietswaart	Senior Lecturer	07/2013-Present
Lindsay Wilson	Professor	2000-Present
David Donaldson	Professor	2001-01/2020
Period when the claimed impact occurred: 2016-2020		
Is this case study continued from a case study submitted in 2014? No		

1. Summary of the impact

Stirling's research was the original catalyst for changes to youth football heading guidelines and practices in the UK and throughout Europe. Our research was the first to show effects on the brain *immediately* after a standard heading practice drill, highlighting risks to health by providing direct evidence that heading negatively affects the brain, and critically undermining football authorities' stance that heading is perfectly safe. Our findings triggered a sustained high-profile public debate around the risks of football heading, shifting the previous perception of football as a safe sport, necessitating football-authority sponsored investigation of players' brain health outcomes, and ultimately leading to changes in both policy and practice. In 2019 the Scottish Youth Football Association (SYFA) advised its members to cease heading during training. In 2020 the Football Association (FA), Scottish FA and Irish FA banned primary school children from heading the ball and issued guidance restricting heading in all UK youths (under 18s), impacting millions of young people. The Union of European Football Associations (UEFA) followed suit, publishing new youth heading guidelines. Heading is no longer considered safe and has been curtailed in youth football.

2. Underpinning research

Football is the most popular and widely played sport worldwide, with an estimated 3.5 billion fans and 250 million players in over 200 countries. Despite being widely encouraged for health and fitness, football players routinely incur repeated impact to the central nervous system (because the game involves striking the ball with the head). It is recognised that traumatic brain damage, in particular repeated concussion, is associated with an increased risk of developing dementia later in life (as outlined in detail in output **R2**). Football heading does not cause concussion however, historically allowing football authorities to claim that there is no evidence that heading is dangerous. Nonetheless, the impact of heading is significant enough to cause headaches and leaves players 'seeing stars' commonly enough to be colloquially referred to as 'sparkles'. Moreover, football heading drills are routine in professional and grassroots football worldwide, involving significant and sustained exposure to head impact, often from early school age. To contribute to the debate around the safety of football, and to address the absence of research on the direct effects of heading, we combined behavioural, neuropsychological and neuroimaging methods to identify the cognitive and neural changes that occur following a typical routine football heading drill (output **R1**). In a follow up study, we demonstrated equivalent changes in brain health after boxing, reinforcing the message that repeated *sub-concussive* impact is not safe (output **R3**). Put simply, our findings demonstrate that heading can no longer be described as a safe activity.

The absence of research into the direct effects of repeated sub-concussive impacts is perhaps expected, given that the pathology of full-blown concussion is notoriously difficult to detect at a brain level. To investigate the immediate effects of heading, researchers at Stirling developed an innovative and sensitive measure that allows us to detect brain changes as a consequence of *sub-concussive* impact. Our approach utilises the neuroimaging technique of Transcranial Magnetic Stimulation (TMS), supported by a small grant from the National Institute of Health Research's Brain Injury Healthcare Technology initiative. TMS uses a coil held over a person's head to generate a brief electromagnetic pulse, stimulating a small area of the brain (Figure 1). When combined with electrodes placed over the leg muscle, TMS can be used to measure neural signals from the brain to the muscle, and through this, establish changes to brain chemistry (reflecting

changes in GABA, the most powerful inhibitor in the brain's motor system). Identifying such changes is powerful because increases in inhibition impair learning and reduce control over the body. Moreover, disruptions of the brain's normal chemical balance are implicated in the long-term link between brain injury, disability and the risk of developing brain disease.

R1 was the first direct demonstration (confirmed by Pearce's (2016) commentary - DOI:10.1016/j.ebiom.2016.10.043) that football heading disrupts the brain. Critically, this study examined the impact of the *modern* football, because any effects of heading on brain health have often been dismissed as an issue of the past (related to old leather footballs being heavy in wet conditions). In **R1** we asked a group of football players to head a modern football 20 times, as is typical in training sessions. The ball was fired from a ball machine to simulate the pace and power of a corner kick. Before and after the heading sessions we measured brain inhibition using TMS, as well as assessing players' memory function. We found that football heading resulted in immediate and measurable disruption to brain function: increased inhibition in the brain was detected in 74% of participants, and cognitive tests revealed memory performance was also reduced by 41-67%.

Figure 1. TMS in use. R1 and R3 first author (TDV, now Stirling UoA 24 academic) using TMS to examine Alan Shearer's response to heading, providing the scientific basis for the 2017 BBC documentary '*Alan Shearer: Dementia, Football and Me'*.

3. References to the research

R1. Di Virgilio T, Hunter A, Wilson L, Stewart W, Goodall S, Howatson G, Donaldson DI, Ietswaart M (2016) Evidence for acute electrophysiological and cognitive changes following routine soccer heading. *EBioMedicine*, 13, 66-71. DOI: 10.1016/j.ebiom.2016.10.029 [metrics: Q1 Medicine; IF 5.74; cited by 76]

R2. Wilson L, Stewart W, O'Connor K, Horton L, Menon DK, Polinder S (2017) The chronic and evolving neurological consequences of traumatic brain injury. *Lancet Neurology*, 16, 813-825. DOI: 10.1016/s1474-4422(17)30279-x [metrics: Q1 Neurology; IF 30.03; cited by 179]

R3. Di Virgilio T, Ietswaart M, Wilson L, Donaldson DI, Hunter AD (2019) Understanding the consequences of repetitive subconcussive head impacts in sport: Brain changes and dampened motor control are seen after boxing practice. *Frontiers in Human Neuroscience*,13, 294. DOI: 10.3389/fnhum.2019.00294 [metrics: Q1 Behavioural Neuroscience; IF 2.67; cited by 9]

4. Details of the impact

The publication of **R1** triggered a global call for action questioning the safety of football heading, in particular for youths. The resulting sustained public debate was further intensified through the global reach of the BBC documentary "*Alan Shearer: Dementia, Football, and Me"*, in which Stirling's research was central (as director Jo McCusker [see source S1] states: *"After much investigation I decided to make the evidence provided by the Stirling-led research* [R1] *the centre of the research-focussed part of the programme"* ; see BBC News documentary summary footage here). Consequently, football authorities in Europe, which had been reticent on the issue of heading safety, were forced to act by commissioning their own further investigation and then enacting changes in policy and practice, first in Scotland **(Impact 1)**, then UK wide **(Impact 2)**, and in Europe **(Impact 3)**. Put simply, these impacts were a direct result of **R1** and the resulting media coverage and campaigning.

Below we provide details of the impact and the pathways to impact (see timeline) that facilitated the change. First, however, we highlight the extent of the resistance to change within the football industry. In May 2016, a few months prior to **R1**, *The Telegraph* published an article entitled "*Football's Silent Shame: Dementia 'conspiracy' is a stain on the game*" criticising inaction by UK footballing authorities: "*Football today stands accused of behaving like the notorious tobacco industry of the 1960s and has been warned that its 'scandalous' failure to carry out research into the link between dementia and the world's most popular sport*" [S4c]. The tobacco-playbook analogy was also made in an investigation by the leading Dutch broadsheet NRC '*Evidence of brain damage, but sport associations look away'* about how football authorities have obfuscated research that links heading to changes in the brain [S6b].

Timeline of key events on the pathway to impact	
2015	United States Soccer Federation bans heading in U12s as a response to a class-action lawsuit; English FA states no need to change rules in England.
24-10-2016	**R1** published. Sustained media attention begins.
28-10-2016	Scottish Youth Football Association (SYFA) responds to **R1** by announcing review of guidelines; removes heading from logo (Figure 2).
19-11-2017	*Alan Shearer: Dementia, Football and Me* (BBC) is screened. **R1** provides the scientific evidence core to the documentary.
23-11-2017	Stirling research is catalyst (see S1 & S2) for FA and Professional Football Association (PFA) announcement to start investigating brain health in football, which led to the FIELD investigation of dementia diagnosis and death rates in Scottish ex-professional football players led by Stirling's **[R1** & **R2]** co-author Willie Stewart (Queen Elizabeth Hospital Glasgow-based pathologist).
Oct 2019	FIELD findings published.
Oct 2019	SYFA announce youth heading ban.
Feb 2020	FA, Scottish FA & Irish FA issue under-18 heading restriction guidance.
Jun 2020	UEFA issue youth heading guidance.

Impact 1: Stirling's research led to changes in practice: Scottish Youth FA stops members heading in training

Within four days of publication of **R1**, the Scottish Youth Football Association (SYFA) announced that "*in light of Stirling's research*" it would "*urgently review their [SYFA] guidelines on heading the ball*" working with Stirling's researchers on this [S4a]. Unable to deny the importance of our research, the Scottish FA stated it "*will look at the current University of Stirling study in greater detail with our medical advisory team*" [S4b]. In a clear demonstration of their new commitment to change, the SYFA promptly removed heading from its logo (Figure 2), a change confirmed (informal communication) by their Executive Development Officer as being due to Stirling's research. In Oct 2019 the SYFA released updated guidelines, advising coaches to stop the practice of heading the ball in training and games involving children younger than 11. International journalists highlight how Stirling's research was a turning point, changing the perception of the safety of heading, for example [S5a]: "*The decision by Scotland, although hitting the headlines in 2020, dates back to October 2016 when they first issued a response to a study conducted by The University of Stirling.*"

Before *After*

Figure 2. SYFA logo before (left) and after (right) their 2016 statement to review their heading guidelines in light of Stirling's research [S4a]

Impact 2: Stirling's research was the catalyst for UK football restricting youth heading

In Feb 2020, the Football Association (FA), Scottish FA, and Irish FA changed their governance policy by: i) issuing updated heading guidance (full guidance at: stir.ac.uk/4ai) for training; ii) stating that under-11s should no longer practise heading; iii) severely limiting heading practice frequency for 12-16 year olds; iv) reducing practice frequency for 16-18 year olds; along with v) reduced ball pressures; and vi) specific ball sizes for this practice.

The UK football authorities had always maintained there was no evidence to show that heading affects the brain. For example, even when the United States Soccer Federation banned heading in youth football in 2015 as a response to litigation (see timeline), the FA had "*no desire to ban heading in any age group*" (*The Independent*, 2015, stir.ac.uk/4ax). Due to the direct evidence of **R1** this defence collapsed. In an explicit acknowledgement of the public health concerns the football authorities issued guidance to reduce youth heading "*to mitigate against any potential risks*" (FA Press Release, 24 Feb 2020, stir.ac.uk/4al) – a clear UK-wide change to football's governance position and associated football heading practice.

This policy change, for which **R1** was the original catalyst, will benefit many millions of children in the UK**:** 31% of children under 11 and 43% of 11-15 year olds in England play football at least monthly (Department of Culture, Media & Sport, 2018/19 data: stir.ac.uk/4ao), representing around three and a half million children playing football in organised teams or in school physical education. Using Sport Scotland data (52% of children aged 8-15 play football every month,

excluding school PE) and Irish Football Foundation data, an additional half a million children in these two nations will also benefit through a reduced risk to future brain health.

Impact 3: Continued debate about the safety of heading resulted in new UEFA guidelines

In June 2020, UEFA (Europe's governing body of football the Union of European Football Associations) issued guidelines for heading, to protect the health and safety of youth players. The guidelines are to manage heading in training and in matches aimed at "*limiting the header burden in youth football*". For the first time, UEFA accepted the burden of football heading in European youths by issuing guidelines to reduce the risks to brain health. This "*follows considerable discussion in recent years*" (UEFA Medical Committee chairman) and was approved by UEFA's Executive Committee "*after debates continued over whether* heading *a football could lead to altering a player's brain*".

(A) Pathway to Impact: Stirling research started global debate about the safety of heading

On the day the embargo on **R1** lifted, lead author Magdalena Ietswaart fielded 60 media enquiries and gave back-to-back interviews from 7 a.m. till midnight (and again the next morning in other time-zones) for radio and television reaching an audience of millions around the world (including pre-recorded features for BBC News, ITV News, and Sky News, and live appearances on BBC the Today programme, ITV Good Morning Britain, Sky News, Al Jazeera, ABC News Australia). **R1** has stimulated and informed a global conversation questioning the safety of football heading and of participation in grassroots and youth football. **R1** has an Altmetric score of 1452 to date [S6a] which places the global attention score of this publication in the top 99.98th percentile most talked about of all >15 million papers tracked.

Following **R1**, and the resulting intense public and media interest, football authorities in England [S4c], Scotland [S4a & S4b], and Wales [S4d] were forced to quickly respond with statements promising a review of guidelines and calling for changes to practice, citing Stirling's research as evidence. Headlines from 2016 referring to **R1** include: "*Scottish youth football body reviews header guidelines*" [S4a], "*Ban children under 10 heading footballs in Wales*" [S4d], and "*Football chief* [UK] *says headers should be banned for children under 10 after scientists find heading affects memory test performance for up to 24 hours*" [S4c].

The sustained nature of the media impact of **R1** is difficult to exaggerate; it has appeared in hundreds of news-print articles, radio and television programmes. We highlight just two examples involving high-profile flagship TV programmes that called for changes in heading based on Stirling's research: a) in 2019 the Belgium national broadcaster RTBF questioned the safety of football heading, leading to a statement by the Belgium Health Minister calling for a ban on heading in youngsters, and b) in 2020 the Dutch national broadcaster, NOS, extensively featured **R1**, calling on the Dutch FA to follow the UK's guidance **(Impact 2)** in light of Stirling's research, prior to UEFA's Europe-wide announcement **(Impact 3)**.

(B) Pathway to Impact: Stirling's research was the scientific centre of the influential BBC documentary *Alan Shearer: Football, Dementia and Me*

> *"Stirling's research was essential in allowing us to make a case showing the effect of repeatedly heading a ball"*
> - Alan Shearer [S1]

Of the above examples of **R1** instigating a global debate on the safety of football heading, perhaps the most influential (bringing about **Impact 2**) was the 1-hour long BBC documentary *Alan Shearer: Football, Dementia and Me*, which represents a key turning point in the perception of the safety of heading. BBC filmmaker Jo McCusker stated that Stirling's pioneering research on the issue led to the BBC documentary being centred around **R1** and using it as the scientific basis. More than a quarter of the documentary, broadcast around the world, was about Alan Shearer taking part in Stirling's research **R1**. The programme won a Royal Television Society award. In an exposé of football authorities' reluctance to engage with the issue of brain damage in their sport, the Dutch leading broadsheet *NRC* later stated: "*When the BBC aired a documentary a year later* [after **R1**] *in which Alan Shearer, all-time top scorer in England's Premier League, had his brain tested by Ietswaart's research group, the results became a national debate in the UK*" [S6b]. Alan Shearer said taking part in Stirling's research **R1** completely changed his perspective on the safety of the game. Speaking in Nov 2019 Alan Shearer stated: *"I am passionate about this vitally important area of research and delighted to see Stirling leading the way in attempting to address the concerns of the*

football community" [S6c]. He believes the documentary was important in making the FA listen to the evidence, stating in Nov 2017: "*the people who govern the game are beginning to listen*" [S6e].

(C) Pathway to Impact: Stirling's research was the trigger for the medical survey demonstrating a link between playing football and an increased risk of dementia

R1 led to the FA finally agreeing to commission an investigation into the prevalence of dementia in former professional players (also see S1 & S2). Alan Shearer stated: "*The main reason for doing this [BBC documentary] programme was to make sure the authorities could no longer run away from this issue*" [S6d]. Within days following the documentary's airing, the FA and PFA announced they would commission an investigation, which led to the FIELD study (led by **R1** and **R2** co-author Willie Stewart, a clinical pathologist at the Queen Elizabeth Hospital Glasgow). The FIELD study examined medical records and found that Scottish former professional footballers, who had headed the older, heavier footballs in their careers, had an increased risk of developing Alzheimer's. This was further compelling evidence of the need for changes to football practice **(Impact 1, Impact 2,** and **Impact 3)** even though FIELD did not directly investigate heading *per se*. It is therefore the evidence of Stirling's work pinpointing the problem of heading with modern balls, combined with Glasgow's subsequent work highlighting increased prevalence of brain disease amongst footballers in general, that finally convinced the authorities to introduce restrictions on heading. As leading brain injury advocacy *Headway* executive Luke Griggs [S3] states: "*Scientific evidence, such as the FIELD study conducted by the University of Glasgow and the University of Stirling's paper* [**R1**]*, played a key role in driving the change seen to date….* [**R1**] *is significant as it complemented the FIELD study by using modern footballs to demonstrate that heading remains an issue in today's game.*"

The Telegraph's science team [S5b] wrote in 2020 regarding **Impact 1** & **Impact 2**: "*The pressure on authorities to protect players has increased significantly over the past three years thanks to the involvement of former stars and their families. Former England captain Alan Shearer has led much of the advocacy, collaborating with the University of Stirling for a BBC documentary in 2017". The Telegraph's* sportswriter Jeremy Wilson (awarded a prize by the Alzheimer's Society for his work on football and dementia), writes in the *Telegraph* that Stirling's **R1** research has been instrumental in bringing about **Impact 2** [S5c]. In his testimonial Jeremy Wilson [S2] states: "*Stirling's findings* [**R1**]*, showcased in the BBC documentary Alan Shearer Football, Dementia and Me, formed part of a crucial body of scientific work and campaigning that, in my view, led to the FA's FIELD study.*" And that, "*The Stirling study continues to be a hugely influential piece of research now that the football authorities have accepted the link between football and neurodegenerative disease*".

5. Sources to corroborate the impact

S1. Testimonial from Jo McCusker (BBC) & BBC News (2017) Summary: stir.ac.uk/5d9
S2. Testimonial from Jeremy Wilson (Telegraph)
S3. Testimonial from Luke Griggs (Headway brain injury association)
S4. Calls for heading ban based on R1 (Oct 2016 and Feb 2017):

- **S4a.** BBC. 2016. 'Scottish youth football body reviews header guidelines'. stir.ac.uk/4qu
- **S4b.** SFA. 2016. 'Statement in response to University of Stirling study'. stir.ac.uk/4r0
- **S4c.** The Telegraph. 2016. 'PFA urges FA to consider ban on heading'. stir.ac.uk/4r3
- **S4d.** BBC. 2017. 'Ban children under 10 heading footballs in Wales'. stir.ac.uk/4r6

S5. Examples stating R1 as catalyst for rule changes:

- **S5a.** Gibraltar Chronicle. 2020. 'Critics silenced after SFA decision on headers' stir.ac.uk/4r9
- **S5b.** The Telegraph. 2020. 'England and Scotland at odds over whether to ban children from heading footballs following dementia study'. stir.ac.uk/4rc
- **S5c.** The Telegraph. 2020. 'Exclusive: FA moves to end heading by children'. stir.ac.uk/4rf

S6. Widespread public debate stimulated by R1:

- **S6a.** Altmetric details for **R1**. www.altmetric.com/details/12928201/
- **S6b.** NRC. 2020. 'Evidence of brain damage, but sports look away'. stir.ac.uk/4ri
- **S6c.** UoS. 2019. 'Shearer's tribute to experts shining a light on heading'. stir.ac.uk/4rl
- **S6d.** The Sun. 2017. 'SHEAR FURY Alan Shearer raps FA and PFA for failing to tackle football's dementia crisis after heading the ball 150 times a day'. stir.ac.uk/4ro
- **S6e.** Alan Shearer, BBC, 2017 'Alan Shearer: Making my documentary Dementia, Football and Me'. stir.ac.uk/5lx