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Concussion in sport - What do we know, and what's next?

Proceedings from a symposium at Nottingham Trent University, UK

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This paper presents shortened versions of talks given at a symposium about concussion in sport. The piece is designed, in similar lines as the event, to help communicate knowledge and ideas between academics in multiple disciplines, communities of practice and to develop public and patient involvement. The seven short essays are presented in the style of a conference proceedings paper. Each author presents their own focus, with one paper drawing on lived experiences and activism, three taking a biomedical approach and the remaining three drawing on social scientific analysis and literature. We have developed this paper to provide readers with a concise, but not complete, understanding of different topics related to concussion and brain injuries in sport. The limitations of space means that the authors have had to reduce the complexity of some ongoing debates on the topic. The final section is based on the comments and discussions that happened during and after the symposium. It offers some important takeaways and encourages scholars working in this area to prioritize multi-disciplinary research, and highlights the importance of centering the experiences and lives of those people affected by concussions and neurological disorders in the development and delivery of future work. It is hoped that communicating ideas in this way will encourage such ways of thinking as a means of tackling the complex set of problems that face those involved in sports where repeated forceful impact is a normalized 'part of the game'.

Introduction

Concussion in sport – And the need to study people 'in the round'

Christopher R. Matthews, Senior Lecturer, Nottingham Trent University

While there's evidence that points to concussion and other traumatic and chronic brain injuries as having a long association with various sports, the last decade has seen a sharp increase in the attention directed at the topic by the media, players, fans, sports officials and governing bodies. This has led to educational programs and awareness campaigns, various changes in practice and policy, and the proliferation of research in a variety of scholarly disciplines. Such work proceeds from a position of seeking to tackle the various personal and social problems that flow from sporting brain injuries. However, these problems, with their complex biological, physiological and sociological origins, often require equally complex 'solutions' and to work in that direction requires academic colleagues, who might often exist in disciplinary 'silos', to value each other's various contributions and engage with the people, communities and policies that are directly affected.

My PhD supervisor referred to such a need to consider the problems associated with sport as studying people 'in the round' (Maguire, 1991). Such a way of working resists the temptation to see research participants as 'atomized' and isolated units of analysis, and instead seeks to situate them within ongoing cultural and historical processes. This means, as Malcolm rightly points out, that alongside biotechnological and game/rule-based solutions, we must also seek to understand the cultural roots of the concussion 'crisis' (Malcolm, 2019). And for such work to have impactful change, academics must seek out, engage and partner with the various public entities who will be central to delivering and benefiting from it. With that in mind, Nottingham, with its two universities, Queens Medical Centre and associated medical school, various professional sporting clubs, numerous sporting venues and central location in the English Midlands provides an opportunity to work in that direction. And specifically at Nottingham Trent University, within our Sport, Health, Activity, Performance and Exercise (SHAPE) research center, we are motivated to deliver community orientated research in partnership with local residents.

So, in late 2022 I organized a one day symposium titled Concussion in sport - What do we know, and what's next? There were two broad aims of the day. Firstly, to help inform people who would like to know more about the risks of concussion and repeated blows to the head, and to detail what is currently being done to support athletes, coaches and medical personnel to reduce the damaging effects of brain injuries. Secondly, to consider what problems still need further understanding and to develop ideas to shape the future directions of work in the area. In this regard, I invited a diverse set of speakers, and we advertised the event widely with a view to attracting attendees with a variety of interests and from various backgrounds in relation to sport and brain health. This included people who play various sports and have suffered concussions themselves, coaches, physiotherapists, trainee sports practitioners in various fields, teachers, representatives from sport's governing bodies, campaigners, and scholars working across all levels of academia. This group enabled the aims of the day to be achieved in that there was a great opportunity for those from sporting communities to enhance their knowledge of concussion - which will hopefully lead to some important social changes at the 'coalface'. And, there was time for free flowing chats between speakers and attendees which would not have been possible if we had followed the structure of a usual academic conference - I return to some takeaways from these discussions in the concluding section.

In what follows, we outline key elements from presentations and discussions from the day. It is important to note that this is neither an exhaustive account or overview of what is known about this topic, nor should it be understood as a definitive statement. Rather, these are the well-considered and empirically informed arguments developed by certain speakers with expertise in the area. One clear gap in this regard is that due to the speakers' expertise the focus is largely on adult populations throughout. All the authors are based in the UK, and largely focus on this context, also, soccer is referred to as football throughout. Each author details their take on 'what we know, and what's next?' and has aimed to write, as they presented, with a wide audience in mind. While we all share connections around wanting to understand brain health in more detail, we also come to this topic via various routes which means there

is a diversity to the writing style and approach. I have edited the work to try and help it flow together while also maintaining the authors' distinctive voices - a challenging task.

I have chosen to start with Penny Watson's powerful piece. This is to show the importance that was placed by attendees in hearing the stories of those who have been personally affected by brain injuries - a topic which has recently received some media attention but is largely absent in academic research connected to sport. Following this I group three discussions that broadly draw on bio-medical approaches and three that proceed from a social scientific position. As these proceedings are necessarily short, I suggest reaching out to the individual scholars if you would like further information about their work and the arguments they present. I conclude by discussing some observations from the day and outlining a broad way of working that colleagues may wish to pursue.

Caring and Campaigning

Living with Neurodegenerative Diseases

Penny Watson, brain health campaigner and activist

My husband Dave was an international footballer, known primarily as a centre half and a great header of the ball. He played professionally for 19 years until he was almost 39, playing over 700 matches including representing England. Dave sustained many head injuries and most likely thousands of sub-concussive injuries especially during training sessions. He was admitted to hospital with one particularly severe concussion. After football he became a successful businessman. His business acumen and ideas were astounding, he even did a talk at the University of Sheffield on sponsorship. He did lots of charity work, raising money for the survivors of Hillsborough and the Boxing Day Tsunami. He was an excellent organizer, with great intellect. However, now he is a different man.

People ask "when did you notice things?" and "is it just his memory?". Well, dementia can be so insidious. About 10/11 years ago, I noticed signs. Yes, short-term memory at first but so much more. This continued for a couple of years or so and eventually the family noticed too. After changes became increasingly obvious we persuaded Dave to go to the doctor. After a scan ruled out a brain tumor he was diagnosed with probable Alzheimer's, we were handed leaflets and left with little else advice wise. It is at this point that many given a dementia diagnosis feel bereft, abandoned.

The Watson family became active, researching big time. We found out more about the connection between football and former players developing neurodegenerative diseases (NDD) – often given the label Alzheimer's. We learnt more about CTE and other forms of dementia. Meanwhile Dave continued attending matches particularly England games at Wembley. It was there in November 2019 when it became apparent that we needed to let the fans know his diagnosis because being asked to sign autographs was presenting issues. We discussed it and agreed that it would not only help Dave still be able to go to games but also hopefully give other former players the courage to "come out" about their diagnoses. 14th February 2020 a statement was released through The Press Association. The reaction from the football community and fans, was so supportive and moving.

By early November 2020 we were ready to do an interview. A full-page article headlined The Forgotten England Captain turned out to be the spark to light the fire to commence the campaigning to help former players. Dave's thousands of fans were outraged that The Professional Footballers Association (PFA) were doing very little to help (after all they are the union for players, current and former). Let's be clear: we never really wanted the publicity but we realized we could use Dave's profile and all this attention to help others. Lots followed, including advising the PFA and Head Injury Policy Oversight group in an independent capacity, which included discussing strategic planning and offering advice on the set up of a new dedicated Department.

The following year Dave won a landmark ruling to have some of the brain injuries he'd sustained during his playing career recognized as 'industrial injuries' paving the way for footballers with dementia to receive industrial injuries disablement benefit. We compiled evidence of 10 serious head injuries. We hope more than anything that this has set a precedent for others to seek help.

Dave's scans show cavuum spetum pellucidum – a potential cavity in a part of the brain which has been associated with dementia in former boxers – which is being recognised in UK now. This is ground-breaking news (we pursued this for almost two years). UK researchers have been woefully behind the USA but the UK scientists have finally taken notice. Concussion Legacy Foundation (CLF) have a UK arm now which assisted greatly in acceptance that UK is behind the USA, specifically Boston University and San Fran. There is much work to be done, but I am quite optimistic about some things: Soon there will be an industry wide fund which the Premier League, English Football League and The FA should contribute to as the success of modern football was built on the legacy of former players. On a more personal note — I set up a self-help group on Zoom for former WAGS (Yes, I was an original WAG I guess). We carry the burden of being the ones who make decisions that before would have been made together with our partners. We are the ones who have lost our husbands, our soul mates and even though physically they resemble our guys they are not the men we have lived with and loved for decades. We have become their mothers. None of us envisaged our lives together ending like this – on a journey we would not have taken by choice. It is truly heart-breaking.

This is where some of you come in. Knowledge is powerful – informed decisions will prevent heartache for others in the future. Educate and spread the word. Sport can do so much good but concussion in sport can ultimately take away so much.

Chronic Traumatic Encephalopathy

Tom Dening, Professor of Dementia Research, School of Medicine, University of Nottingham

Chronic traumatic encephalopathy (CTE) is a term that has been in use since 1949, though the condition was earlier referred to as punch-drunk syndrome or dementia pugilistica, which reflected how it was well-recognized in ex-boxers. CTE has gained recent clinical, research and media interest through high-profile cases involving sportsmen, notably in rugby union, soccer and American football. It is important to note that sports injuries are not the only forms of such of trauma: for example, domestic violence or military injury can also be significant causes.

Recent attention has mainly focused on the long-term cognitive effects of CTE, including dementia, but in fact CTE may have a range of manifestations, including mood changes, depression, irritability, and behavior and personality changes (such as apathy or aggressive behavior). Neurological problems such as parkinsonism and motor neuron disease can also occur. This heterogeneity means that the clinical features of CTE are hard to characterize and to distinguish from other neurodegenerative conditions, such as Alzheimer's disease. As a result, there are not yet any agreed clinical diagnostic criteria for CTE, so at present much of the research is driven by pathological and neuroimaging findings.

There are numerous as-yet unanswered questions about CTE. For example, are multiple concussions required, or could CTE result from a single injury? And is a history of concussion required, or can numerous sub-concussive episodes accumulate to produce CTE eventually? Is there a critical 'dose' of trauma that is required? Do different types of impact make a difference, e.g. front-on versus impact from the side, or is rotational injury particularly harmful? What factors make some individuals at risk from developing CTE compared to their peers? What about CTE risks in non-elite sports people or in contact sports that are less well financed than rugby union and football?

What we do know gives cause for concern though. For example, in one study soccer players with no history of concussion showed evidence of white matter changes, which certainly supports the view that sub-concussive impacts can be harmful (Koerte et al., 2012). Neuroimaging (e.g. computerised tomography (CT) or magnetic resonance imaging (MRI)) does not show any specific pattern for CTE. MRI scans may show cerebral atrophy or reduced cortical thickness. Typically, there is less evidence of hippocampal atrophy than is usually seen in Alzheimer's disease. There is often evidence of cerebral white matter changes due to axonal injury (that is, damage to nerve fibers) and/or vascular changes.

There is more consensus about the pathological criteria required to diagnose CTE, though of course such findings are only available postmortem. Some, but not all experts, regard CTE as a tauopathy, i.e. that it is caused by deposition of an insoluble protein called tau which has originated from damaged nerve fibers in the brain. Imaging studies using markers for tau in positron emission tomography (PET) scans

have shown differences between groups in terms of tau deposition, but the changes are insufficient to be an accurate diagnostic test in individuals.

In summary, CTE is a major issue for clinicians, researchers and those connected with sport. Although there are no agreed clinical diagnostic criteria, there will be some situations where CTE is a very likely diagnosis, notably in a younger person (<50) with a history of concussion or contact sport involving their head, who presents with cognitive decline or behavioral change, and where neuroimaging shows evidence of damage. Where diagnosis of CTE is always likely to be difficult is when it presents later in life and there are also some features of Alzheimer's disease. In these cases, it may be that all that can be said is that concussion may have played a part, but it is harder to say it is the sole cause. Finally, it almost goes without saying that there is much to learn about how to support and provide care for people with CTE. It is timely that sporting authorities have begun to respond to the issues, though there is clearly much to be done.

Concussion in Football

Ian Varley, Associate Professor Physiology, Nottingham Trent University

Various bodies of evidence demonstrate the acceptance of injuries as 'part of the game' by those taking part in team sports. The frequency of injury occurrence differs among sports. In men's and women's international football, injuries were shown to occur at a rate of 28-31 injuries per 1,000 hours of match-play, which equates to approximately one injury per team every two matches (Sprouse et al., 2020). Concussion, or mild traumatic brain injury, is a phenomenon of particular interest due to the associated acute and chronic adverse effects.

In football, the incidence of concussion is suspected to differ depending on the age of the participants, the standard of play (recreational – professional) and the mechanisms in place that facilitate the accurate identification and recording of a concussion. Concussion in football is relatively uncommon, with recent reported incidence in elite Swedish football of 1.18 per 1000 player game hours in men and 1.22 per 1000 player game hours in women (Vedung et al., 2020). However, these data are only from one country and therefore may not be representative of football as a whole. There is greater concussion awareness, due to the publication of documents, such as the English Football Association's concussion guidelines first published in 2019 and high-profile concussion related traumatic events covered by the popular media. At present, there isn't definitive data published on the risk of concussion at all levels of modern football. Therefore, accurate information on the relative risk of concussion from participating in football cannot yet be established with certainty.

Concussion has been become a major area of focus in football due to its association with long-term detrimental effects to brain health. The high-profile FIELD study (Mackay et al., 2019), reported that mortality as a result of neurodegenerative disease together with prescription of medication for dementia related conditions was higher in former football players when compared to a control population. Studies of this nature have led to scrutiny of concussion mitigation in football. Rule changes, such as concussion substitutions, have been introduced by governing bodies to improve the management of concussion and the possible adverse neurological effects.

As well as concussion, sub-concussive impacts, such as heading, have also been implicated with adverse neurological outcomes. As a result, the English Football Association have recommended that heading in training is restricted to a maximum of ten forceful headers per week to reduce the number of repeated sub-concussive impacts that players regularly undertake. In addition, the Scottish Football Association have issued guidance that advises heading practice should only take place once per week and not on the day prior to or after a match.

It is important to note that the long-term effect of repeated sub-concussive impacts on brain health are not well established. However, an array of studies are currently taking place designed to quantify the forces the brain is subjected to, during both concussive and sub-concussive impacts. These studies involve the use of instrumented mouth guards, and other wearable sensors that estimate the amount of 'brain strain' that occurs in actions that are necessitated by the sport. The outcome of research currently taking place in relation to concussive and sub-concussive impacts in football is awaited with intrigue by lawmakers, practitioners, coaches and players. Once the relative risk of concussion/sub-concussive

impacts on acute and chronic brain health have been established, further mitigation strategies can be put in place to optimize player welfare.

Injury is an accepted side-effect of participation for many who choose to play football, however the implications of concussion and the association with long-term neurological issues it may lead to, may be a side-effect that can't be accepted. Further research is required to establish the relative risk of adverse neurogenerative disease as a result of concussion and sub-concussive impacts in football. Player welfare is of paramount importance, however lawmakers are cautious about changing fundamental actions involved in the game, therefore the implementation of heading restrictions to reduce neurogenerative risk remains a contentious matter.

Shifting Sands

Sport Concussion and Dementia Risk

Angus Hunter, Professor of Neuromuscular Physiology and Head of Department of Sport Science, Nottingham Trent University

The field of sport concussion and associated dementia risk has evolved rapidly over the past few years with: i) growing concern about the risk of long term neurological complications secondary to participation in sports; ii) in particular the development of chronic traumatic encephalopathy (CTE); iii) while initially the focus on this condition was within boxing this has now expanded to other contact sports, in particular, American Football, rugby and soccer and; iv) sport concussion is now described as a public health issue. Although concussion guidance describes symptoms to enable recognition, they are still notoriously difficult to diagnose as concussion understanding is still in its early stages. Nevertheless, this guidance provides an important step forward in helping to prevent second impact syndrome in the short term and help reduce dementia risk in the longer term. What is perceived as a related, but in many ways a greater challenge, is management of sub-concussion as there may be no obvious symptoms to act on. To meet this challenge there are studies being performed using sensors for real time monitoring to establish acceptable limits of head impacts that athletes may receive. However, much work is needed to quantify acceptable limits in relation to neurodegenerative risk.

Now sport concussion has been recognised as a public health issue and with impending law suits from former rugby union players the UK Government decided to act in July 2021 by launching an enquiry through its Department for Culture Media and Sport (DCMS). The key findings of the report were concerning as they were unsatisfied that sporting governing bodies were adequately safeguard their players and were "allowed to mark its own homework" when it came to reducing brain injury risk. Following these findings, the DCMS notably recommended that the government needs to establish a UK-wide minimum standard definition for concussion which, while achievable, is a long way off given existing knowledge. Subsequently, and probably consequently, respective sporting governing bodies have recommended that a maximum of ten high force 'headers' are carried out in a training week (Scotland ban heading before and after game), rugby contact in training limited to 15 minutes and children 12 years and younger are not allowed to head footballs in both training and competition.

Any sport modification introduced to protect athlete health and wellbeing are welcome, however, compliance to concussion guidance has been mixed at grass root levels. In particular, this seems to be a problem in the reluctance of some people to adhere to what is perceived to be lengthy post-concussion rest/graded return to play periods in youth sport (McArdle et al., 2021). It may be that traditional attitudes take time to change, but when considering how attitudes towards drink driving shifted, it is reasonable to expect greater social responsibility surrounding concussion to occur too. Whilst improving awareness and understanding of concussion are positive, a potential downside is increased levels of anxiety, in particular with former players and parents of young players, which might be exacerbated by media sensationalism. This anxiety, particularly amongst parents, can reduce sport participation in youth players (Findler, 2015) which may then increase sedentary behavior and increased risk of lifestyle disease later in life. Also, with former players anxiety can cause cognitive deficit, and as cognitive testing is a core component of dementia assessment, this could conceivably contribute to a diagnosis of early onset of dementia (Roberts et al., 2020). To help prevent this issue the Scotland Rugby Union has launched

the Brain Health Clinic targeting, initially, former international players where they are advised on how to reduce their anxiety and dementia risk factors through lifestyle modifications.

Concussion is often classified as mild traumatic brain injury (mTBI), however there is nothing 'mild' about this condition as 15% of individuals with concussion go on to experience persisting neurodegenerative conditions (Smith and Stewart, 2020). Currently, concussion is difficult to truly diagnose as we don't yet understand the underlying pathological processes (Smith & Stewart, 2020). However, our understanding of the causes of CTE is increasing, thanks to (Bieniek et al., 2021) advanced MRI techniques (Shenton et al., 2012). However, as yet, no advance neuroimaging have been included as routine assessment for patients with suspected concussion which is likely due to time needed, cost, accessibility and calibration between MRI scanners (Smith & Stewart, 2020). Additionally, blood biomarkers for detecting concussion are also showing promise although they are yet to be proven to be sufficiently sensitive at an individual level (Johnson et al., 2015; Siman et al., 2013).

In conclusion, concussion is recognized as a public health issue with the UK Government acting to prevent neurodegenerative diseases in contact sport athletes. Sporting governing bodies have responded to this by imposing guidance to limit head impacts but there is still work to be done in terms of tailoring this for different ages and sexes. Concussion research has come a long way in recent years although we are still to understand the pathology behind it to diagnose correctly. However, although the definitive link between head impacts and early onset of dementia is still to be established evidence to date suggests an association does exist. Concussion recognition is likely to come in the form of blood biomarkers although there is still work to be done in establishing acceptable sensitivity. Finally, it is important that the ongoing work on concussion underpins the need to reduce player risk not sport participation.

Concussion and Social Science

Dominic Malcolm, Professor of Sociology of Sport, Loughborough University

While many will think of concussion as a primarily physiological and psychological condition, better social scientific understanding is essential to the resolution of the contemporary issues that sport is currently experiencing. This is because biomedical understanding of concussion's wide-ranging symptoms, and indeed the often quite individualized ways they are experienced, is relatively limited. The underlying causes and mechanisms of concussion are poorly understood, and the few treatment options available (mainly physical and cognitive rest) are as much driven by a precautionary approach as they are by evidence-based medical studies. Conversely, the calls for sport to change to ameliorate public concerns are magnified due to the conflation of concussion with second impact syndrome and CTE. Moreover, public health interventions targeted at sport related concussions are especially complicated, with now decades of research suggesting that while it may be possible to increase people's knowledge and awareness of concussion, it is much more difficult to change behaviors and, in particular, people's intentions to seek medical help for concussion. Given this matrix of scientific uncertainty, medical impotence, and the nature of media representations in the 'post-truth' era of fake news and echo-chambers, concussion in sport is as much a social as a medical issue.

In light of this, the potential contribution of social scientific research is increasingly being recognized. The 2017 Concussion in Sport Group Consensus Statement cited the 'significant role' socio-cultural factors play in the uptake of injury prevention and many have argued that a 'cultural change' is needed to mitigate the harms of concussion in sport. The latest iteration of this consensus statement included a sports ethicist on the scientific committee (Schneider & Patricios, 2023), and was accompanied by a research agenda for concussion 'beyond medicine' (McNamee et al., 2023). It is notable too that social scientists (in the UK) such as Adam White and Joe Piggin have been effective social activists for change. While these are important developments and interventions, the potential of social scientific research is still much greater and also likely to be required before the axiological and potentially existential issues facing sport can be resolved. Here we can identify two illustrative examples of how the 'concussion crisis' might fruitfully be informed by a critical and qualitative sociology of sport, health and illness.

Firstly it should be noted that attempts to tackle the society-wide issues of sport-related concussion require a deep understanding of the complex interplay of the various social processes that have led to sport's 'concussion crisis'. Current concerns about concussion are fundamentally linked to the developing

medicalization of sport – the dual beliefs that sport participation is an essential and necessary component of being 'healthy', and that medical guidance and oversight is required for effective sports participation. Moreover, at the forefront of the wider societal process of medicalization are contemporary fascinations about the potential of neurology to change the human condition. These developments are writ large in the debates about concussion in sport. Additionally, trends in medicine and health are allied to sports-wide changes such as the growing critique of sport's commercialization and the erosion of the historical traditions of self-regulation. The degree to which youth concussion is seen as a concern, stems from the distinct sense of obligation parents feel to undertake the 'concerted cultivation' of their children in order to prepare them for the competitive challenges of life in neoliberal societies. In short, the contemporary interest in concussion in sport can only be understood as a product of the convergence of societal and sport-specific social processes, and both medical and ethical approaches which ignore this fail to address the root causes of the issues.

Secondly, social scientific perspectives provide us with a wider and therefore more adequate conceptualization of cultural change. Specifically, a more socially-oriented conceptualization of cultural change recognizes the structural aspects that shape the more evident psychological manifestations (attitudes, behaviors, social norms). Moreover, these structural aspects are arguably both more important in determining behavior, and more difficult to change. This for instance would explain why public health interventions have consistently, to date, failed to significantly alter participant behaviors. The structural aspects to which we refer might include the importance of belonging and social identity in driving behaviors that represent a health risk, but also the economic conditions of sports participation, and reconsideration of the provision of healthcare both at sporting events and for injured populations that subsequently require state medical support. Indeed, a social scientific approach would lead us to conclude that cultural change cannot be achieved solely within the context of concussion, but must relate more widely to attitudes towards injury and participation in sport more generally. Again, research which attempts to tackle concussion as a discrete physiological condition, or a condition that stems from the psychological orientation of sports participants, fails to grasp the complexity of the socially rooted nature of concussion in sport.

The Perfect Storm?

Women, sport, and some potential problems for brain health

Debi Forbes, PhD researcher, Nottingham Trent University

While conducting the literature review for my PhD research it became apparent that there might be something of a 'perfect storm' brewing in women's sport. This idea provides the empirical, theoretical and political justification for the studies I'm currently in the middle of conducting. Firstly, women have historically been excluded from sport in significant ways, but more recently have increased their participation at various levels. Secondly, athletes regularly damage their bodies in the pursuit of success and the medical support they receive has not only been found to be deficient in numerous ways but can also function to reinforce risk taking, pain and injury. And, thirdly, there is an established history of women being treated poorly by, and excluded from, the medical profession. Of course, there are details and counterpoints within each of these three propositions which can focus attention towards important complications to the broad social processes I'll be researching. However, I think that when taken together, the research which supports these broad claims highlights something of a 'perfect storm' faced by sportswomen.

Research demonstrates that sportswomen often exist in the culture of risk that is prevalent in traditionally dominated male sporting spaces. As such, they frequently prescribe to the same performance oriented and health compromising ideas as their male counterparts (Charlesworth & Young, 2004; Pike, 2005). Despite this, women remain significantly underrepresented in sports and exercise science research (Cowley et al., 2021; Elliott-Sale et al., 2021). The contemporary legacy of their historical and cultural exclusion from sport and medicine is then felt by women in the gendering of their sporting environments which appears to contribute to difference in injury types and rate, the medical care they receive and the ideas for treatment often proposed and taken up by women (Cowley et al., 2021; Parsons et al., 2021; Pike, 2005).

When considered together all these points lead to the continuation of issues faced by women athletes, many of these problems are deep rooted in the historic and symbolic aspects of sport. What is more, there seem to be a range of specific biological problems faced by sportswomen. For example, a systematic review conducted by McGroarty et al. (2020) suggested that "female athletes may be more susceptible to concussion, have prolonged symptoms after a concussion, and are more likely to report a concussion than their male counterparts" suggesting - although, I would argue, certainly not proving in any simplistic sense - that female athletes are at higher risk due to "biomechanical differences and hormonal differences" (McGroarty et al., 2020).

In terms of the biomechanical risk of concussion, neck girth and strength, and head/neck dimensions have been highlighted as possible causes of sex differences, as well as differences in reporting and recovery compared to male athletes. And there is an increasing body of research regarding, concussions in women athletes as related to the phase of the menstrual cycle and the fluctuation of associated hormones. This includes possible differences between hormonal contraceptive users and non-users. When taken together, this means that concussions may present in differing ways, including the severity of symptoms and length of recovery when compared to male athletes.

Chaychi et al. (2022) suggests that employing a lens of sex and gender to understanding "concussion/mild traumatic brain injury is imperative for discovery of its pathophysiology and moving closer to treatments". While important work is focusing on how the biology of sex might be involved in this process, fewer scholars are looking at the topic through the social scientific lens of gender. To that end, in my first study I have shown how amateur sports women appear to rely on medical care though a DIY approach whereby teammates often treat and advise each other. So, while the research described above points towards biological issues which effect women's experiences and recovery from concussion, I would argue these issues may well also revolve around their lack of access to professional medical care. And if it is indeed the case that sportswomen find themselves in a unique position at the center of the perfect storm produced by their traditional exclusion from sport and medicine, their chances for protecting and preserving health will be undermined.

Some Considerations About Fighters' Understanding of Concussion

Reem AlHashmi, PhD researcher, Nottingham Trent University

Recent studies examining combat sport athletes' attitudes towards, and reporting of, concussion have revealed several gaps and misconceptions in their understanding (Bennett et al., 2018; Follmer et al., 2020). This is not surprising, especially given that medical professionals are still striving to achieve 'medical certainty' (Malcolm, 2009) about the diagnosis and management of concussion. Therefore, it is to be expected that combat sports athletes' thoughts on this topic will often be confused, contradictory and incoherent. While Lystad & Strotmeyer (2018) argue that Muay Thai fighters have "reasonably good concussion knowledge", I think that this is an artifact of the methods which have mostly been used to study the issue (surveys and questionnaires) rather than a nuanced representation of athletes' actual (mis)understanding and experiences of concussion.

In AlHashmi & Matthews (2021), I explored combat sport athletes' understanding of concussion by employing immersive research strategies (repeated participant observations and in-depth semi-structured interviews in a social setting I knew well). This method encouraged conversations to develop over time and allowed for different forms of knowledge to come to the fore. This provided 'epistemological space' (room to talk, think and understand) for the potential complexities that lie within athletes' thoughts and behaviors about concussion. The argument here is that inflexible methods (surveys and one-off interviews) would often result in simplistic answers that could conceal, misinterpret and/or misrepresent the realities of athletes' own confusion and self-doubt about the topic.

This work revealed that the fighters' comments about concussion would shift under questioning. In that their initial confidence of what they think a concussion is, or is not, became less certain the more they were encouraged to speak about the specifics of the condition and their experiences in the ring. This, in turn, revealed the uncertainty they experience once they begin to consider their ideas about concussion in more than a passing manner. In this regard, the shift from certainty to uncertainty captured something of their often assumed and loose understandings of concussion and brain injury.

This was most evident in conversations where participants were certain that they never had a concussion even after describing their experiences with symptoms that might have led to a diagnosis of one. This temporary confidence seemed to stem from the cultural codes and practical advice passed onto them by their coaches and other athletes. The fighters often spoke about engaging in practices set up by their coaches that were specifically geared towards helping them avoid potential brain injuries by increasing their skill base and/or physical capacity to absorb blows to the head. They often believed that such practices protected them from future head injuries. This shows one of the ways that the fighters' knowledge about concussion revolved around how they went about managing symptoms in a way that allowed them to stay focused on sporting performance rather than safeguarding their own health.

Indeed, their discussions hardly included any reference to medical conditions, assessments, and any other medical language associated with brain injury. In other words, medical interpretations, definitions and management strategies were not central to the participants' thinking. This is because their immediate focus was not on the medical 'outcomes' of the symptoms they are experiencing, but rather on their ability to continue their engagement in the sport. These performance orientated understandings, which allowed athletes to continue to compete while compromised by symptoms that might be recognized as concussion, failed to provide any sustained means of accounting for health consequences that lay beyond an immediate focus on sporting performance.

Such complexities, contradictions and incoherencies within fighters' understanding of brain injuries might not have been captured using inflexible methods. Other work that explored athletes' knowledge about and attitudes towards concussion (using surveys and questionnaires) seemingly overlooks that athletes, irrespective of whether they are cognizant about the dangers of brain damage, still choose to engage in health compromising practices. This is particularly evident in how these works tend to recommend 'further education' as a working solution within their concluding remarks – regardless of the outcome of their findings. These 'blanket statements' often focus on the importance of educating athletes about signs of brain injury and associated risks, and of the early reporting symptoms. This approach assumes that if athletes have an increased awareness about such topics, their interest in maintaining their health will manifest into protective behaviors. However, as my work shows, these perceived expectations about what knowledge and behaviors the fighters should possess seem to be somewhat disconnected from the reality of their day-to-day lives.

Considering the preceding discussion, I further argue that suggestions for 'passive' education drawn from methodologies that do not capture the complexities that lie within the athletes' thoughts and understandings about concussion are not useful. This not only undermines the validity of the researchers' recommendations but does little to realistically help tackle and reduce the risk of concussion in sport. While it is perhaps tempting to propose possible 'solutions' (something that typically flow from such work), doing so based on an overly reductive analysis is premature and could be counterproductive. As the other discussions in this piece have demonstrated, answering "what's next?" is multifaceted and far more nuanced than the annexation of simplistic answers and solutions to a complex problem. With that said, I strongly encourage scholars to (re)think the methodologies they employ when considering athletes' understanding of concussion and brain injury, especially when the end result of such work is to provide 'workable' solutions and further recommendations for policy and practice.

Concluding Remarks

Some takeaways and ideas for what's next

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There were several take aways from the symposium. Many of these, and the ones discussed here, are connected to comments, questions and discussions that followed on from the talks above. I'll discuss them in turn and then attempt to pull them together. The first of these comes from the realization that none of the expert speakers in attendance were comfortable providing a definitive statement on what a concussion was. Such definition hesitations, and associated debates and wranglings, are commonplace within academia, but it became apparent that some of those in attendance assumed a more solid core sat at the foundation of the science that was being discussed. Of course, something of such a foundation does exist in relation to the disciplinary and methodological standards upon which most good science

proceeds. But clearly there is more work to be done by those of us who seek to communicate our science to a wider audience to capture some of the caveats, doubts and the 'known unknowns' that are central to our work. The associated problem here, is that such intellectual 'honesty', could, in the hands of bad faith actors, undermine some of the important but tentative conclusions we are able to make with our research. In this regard, the epistemological doubt that is central to the scientific method has, in part, enabled sports' governing bodies and those with various vested interests to do exactly that: cast doubt over the concussion debate (for important discussions around this point please see Malcolm, 2021; Piggin et al., 2022).

Secondly, while it is possible to speak about any academic research in rather cold and stilted ways, it was quite clear that the speakers and attendees were all personally and emotionally invested in the topic. Some had seen the neurological consequence that flowed from extended careers in sport, and others had personally felt such outcomes. And while it is important that academic research attempts to present rationalized analysis, we must not fool ourselves into thinking that we are emotionless beings. And, in reality, many of us are drawn to explore such topics exactly because they matter to us in deeply personal ways. It is these emotional connections that provide the (axiological) foundation upon which I believe much of the best science is conducted.

A further dimension of this emotionality is that many people have powerful emotional connections to 'sport', and particularly 'their sport'. Such emotional significance should not be overlooked in how it might present a barrier to more critical and rational thinking about the empirical reality of the damage sport can, and does, do to bodies (see Matthews & Maguire, 2019). Methodological and theoretical approaches that allow the epistemological space for understanding how such emotional connections shape the way people think about and act in relation to brain injuries in sport are important. It is also crucial to consider such ideas when examining the wider cultural response to concussion in sport, which, I argue, would be very different if those who own and govern sport were not so emotionally (and financially) invested in maintaining its status quo.

Such approaches should also be employed to explore the emotional experiences associated with sustaining brain injuries. And, in connection to those experiences, the lives of those who caring for people who suffer the prolonged consequences of brain injuries connected to sport, deserve to be more clearly articulated within academic research. Such a focus would help document important parts of the lives of current and former athletes and help draw much needed attention to the reality of living with neurological disorders. The importance of this was most clear in Penny's talk and when those who lived with neurological damage discussed their experiences.

Thirdly, there was a sense from the day that everyone left having learned something important. This, I think, is a distinctive characteristic of organising an event which seeks to draw people together from across academic disciplines and communities more broadly. And, this is one of the ways that those interested in significantly tackling the problem of brain injuries in sport can follow Maguire's (1991) call to study people 'in the round' and Malcolm's (2019) call for a multidisciplinary approach to the concussion 'crisis'. Of course, there have been calls for this sort of scholarly 'border crossing' for almost as long as academics have separated themselves into different disciplinary groups. But what is a more recent addition to such ideas is the central role funding agencies are now placing on the participation of communities in the development, design and delivery of academic research. Public and patient involvement (PPI) and the co-production of research have reached the level of 'buzz words' within academia, and while some researchers will see this as simply another box to be ticked or a 'trendy' word to be used, others rightly see the positives that come from bringing communities of practice into the core of what we do.

Here, then, we have the communication of scientific ideas, emotion in framing scholarship and as a topic of focus, and the place of multi-disciplinary and community engaged and engaging research. I think there is much to be gained from academics understanding the importance of these ideas especially in relation to increasing the impact of their work on concussion and brain injuries. You see, by working across disciplinary boundaries on an emotive topic such as this, scholars are more likely to overcome the different philosophical start points, methods and academic language, that might usually serve as obstacles to working together. Further to this, the emotional connections that sit at the foundation of such work provide a clear motivation for academics to work closely with communities of practice and center PPI to help develop impactful research with a view to changing the lives of people for the better. And, by bringing communities and various public entities into the core of our attempts to better

understand and change the lives of people, we will also be better placed to communicate some of the parameters and limitations of research, and also the tentative conclusions we make along the way. This would represent a genuine shift to doing research and developing science with people and should be a future direction for scholars working in this field.

An example of such work flowed from this symposium as several of the attendees formed a research steering group to help develop a project on former athletes who live with neurological disorders. The idea here is to tell the stories of these people and their families using a co-produced methodology which centers the needs and voices of patients' carers and communities of practice within the conception, design and delivery of the work. It is also expected that the new forms of knowledge that are developed from this research will help future athletes be far more informed about the reality of living with the neurological consequences of their involvement in sport. While ever such experiences remain largely absent from discussions about the long-term outcomes of involvement in certain sports, it is tempting to argue that almost all athletes involved in regular heavy contact are doing so in an uninformed, if still, consenting manner. This statement and focus builds on recent research on consent in sport Channon & Matthews (2021). One of the goals here is to develop our knowledge of how consent is asked for, given and received in sport, so we can help move past the now repetitive calls for athletes to be educated about the consequences of brain injuries. We argue that focusing on consent has a much more practical intention than is the case with calls for more and more education. This is because working to ensuring someone has an active 'informedness', which means they can easily withdraw their consent to actions that might harm them, has a radically different focus to the passive receiving of knowledge.

And, although this research is in its initial stages, I am confident from the work that has already been undertaken, to make a firm recommendation – within sporting spaces where physical contact is a regular and normalized 'part of the game', coaches, managers, parents, teammates, captains, fans and anyone else with an interest in the future of those playing sport, and therefore, the sport more broadly, should be openly discussing the long-term consequences of sport in terms of brain health, and health more broadly. These conversations should not engage in scaremongering but should approach the very real threats that flow from taking repeated blows to the head. And it is incumbent on those who are in a position of power in such settings to actively create a culture where withdrawing consent to take part in physical contact is normalized. This is especially the case where children and young people are involved – consent in minors is a complicated phenomenon and should certainly not be left to parents to decide in some unitary fashion. In this regard, rather than valorizing those athletes that sacrifice themselves for 'the game', we should be creating sporting cultures where individual sovereignty, and the personal right to say "no" to being involved in injurious and damaging behaviors, is held as a central feature of how athletes are taught to play their sports.

In summary, it is hoped this communication piece based on a cross-disciplinary and cross-community symposium has highlighted the following:

- Some important knowledge about concussion and brain injuries in sport from a diverse field from experts.
- An articulation of areas in need of greater understanding and further research.
- Some direction and perhaps inspiration for scholars who are interested in developing contributions in the field.
- And the value of holding events like this which integrate the underlying ethos of co-production and community involvement into work on concussion in sport moving forward.

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