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RESEARCH ARTICLE

Dementia in Sport: Causation, Management and Prevention

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ABSTRACT

Dementia in sport emerged as a problem at the beginning of the 20th century, when "punch drunk syndrome" was diagnosed in boxers. This diagnosis was soon refined to *dementia pugilistica* and later to chronic traumatic encephalopathy. Since then dementia has appeared in other sports, particularly those involving violent collisions and/or head injuries. The problem continues in boxing, but during the 21st century dementia has become a significant problem in American Football, football in the United Kingdom (soccer) and rugby. For example, a recent study from Boston found evidence of chronic traumatic encephalopathy in >90% of former American Football players, and a controlled study of >7,000 soccer players found that the former footballers were 3.5 times more likely to die from dementia or other neuro-degenerative diseases than the controls, the increased risk being related to playing position and length of playing career, thus establishing a dose-response relationship. The emerging consensus is that dementia in sport is caused by repetitive subconcussive head injuries occurring over a long-playing career.

The author asserts that the brain's vulnerability to repeated minor blows to the head is due to its inherent fragility and evidence is provided to support this view. For effective prevention and management three steps are outlined. The first is recognition and acceptance of the brain's vulnerability and fragility and mounting a public health initiative to educate the public and the sporting world. Second, all players at risk should have baseline cognitive tests which must be repeated regularly; if this show deterioration early retirement from the sport must be considered. The third recommendation is that all the sports regulatory bodies must explore with urgency how brain injuries in their specific field can be reduced and eliminated.

Introduction and Background

Dementia and sport are clashing opposites. Sport is a health-enhancing physical activity while dementia is a devastating condition, a neurodegenerative disorder, probably the most tragic of all illnesses as it slowly destroys the integrity of the individual as a person. Although the title appears to be a contradiction, there is now growing evidence of a link between the two, particularly in sport involving bodily collisions and/or head injuries. The objective of this paper is to review selected aspects of this evidence, and to discuss causation, management and prevention. Although this is a big international issue the main focus of this paper is about the problem in the UK.

For over a century dementia had been recognised in boxers, becoming known as punch drunk syndrome or *dementia pugilistica*¹ and later as chronic traumatic encephalopathy (CTE).² During the second half of the 20th century anecdotal reports occurred occasionally of dementia in other sports, but no significant developments occurred until the 21st century.

In 2002, Jeff Astle, an English football (soccer) international centre forward, a powerful header of the ball, died with dementia. His wife asked me to brief the coroner in advance of the inquest, and at the hearing the coroner ruled, that on the balance of probability, Astle died from an industrial disease caused by heading the ball over many years.³ A further neuropathological examination revealed evidence of CTE, the brain disease of boxers.⁴

During the last 20 years the media in the UK has revealed a litany of high-profile soccer players suffering from or dying from dementia, usually Alzheimer's disease. These include John Charles,⁵ Danny Blanchflower,⁶ Ferenc Puskas,⁷ John Ritchie,⁸ Gerd Müller⁹ and many more. In 1966 England won the Football World Cup; four of the team have since died with dementia - Jack Charlton,¹⁰ Martin Peters,¹⁰ Nobby Stiles,¹⁰ and Ray Wilson,¹¹ while a fifth, Sir Bobby Charlton, is suffering from the condition.¹⁰ In 2018 Sue Lopez, one of the most important figures in women's football in England, became the first female player to publicly attribute her diagnosis of dementia to a long (20 years) playing career.¹²

In the same year as Jeff Astle's dementia was attributed to soccer (2002), Mike Webster, a famous former American footballer, died suddenly; an autopsy found evidence of CTE. This created massive media interest, flagging up the long-term

consequences of repeated head trauma in American football players.¹³ Soon after, Anne McKee, Director of the Boston University Chronic Traumatic Encephalopathy Center, embarked on a systematic study of CTE in American footballers and in due course revealed the extensive nature of the problem.¹⁴

Together with colleagues in 2017 I reported an observational study of 14 retired footballers who had died from dementia.¹⁵ The brains of six were examined; four had CTE and two had Alzheimer's disease. This was the first clinical series in the world showing a link between soccer and the development of dementia. This prompted the UK Football Association (FA) and the Professional Footballers Association (PFA) to fund an epidemiological study which reported in 2019. This retrospective study of 7676 former Scottish footballers and matched controls showed that former footballers were 3.5 times more likely to die from dementia or other neuro-degenerative diseases than the controls.¹⁶ A further analysis of these data found that the footballers' overall risk of developing brain disease was related to playing position (defenders were most vulnerable) and to length of their playing career, thus establishing a dose-response relationship.¹⁷ These three important studies had extensive media coverage in the UK, which raised public awareness of the link between neurodegenerative disease and sport. The Scottish findings have been supported by the results of a recent Swedish study which showed that elite footballers were 1.5 times more likely to develop neurodegenerative disease than population controls.¹⁸

The Current Scene

The landscape of sport continues to evolve and change but in boxing the culture is unchanged; it continues to be a sport predicated on violence and inflicting maximum damage to your opponent. It is now generally accepted that CTE is the result of repetitive sub-concussive blows to the head in sparring and evidence of reduced neuropsychometric performance is associated with the boxer's sparring history and not with their fight record.¹⁹ The regular pummeling of the head in sparring is similar to heading practice sessions in soccer.

American Football (NFL rules) continues to be the most watched and most popular professional sport in North America. Its annual highlight is the final of the Super Bowl Competition, held this year on 12th

February 2023. As Ann McKee, the pioneer researcher and Director of the Boston University CTE Center, was so concerned about the real risks of playing this game she published her latest report to coincide with this major sporting event.²⁰ The study revealed that the Boston CTE Center has diagnosed 345 out of a total of 376 former NFL players as suffering from CTE, i.e. a rate of 92%. The report makes it abundantly clear that the biggest risk factor is not the massive violence but the smaller repeated blows. These sub-concussive blows over time causes the build up of mis-folded tau protein in the brain which is unlike the changes seen from ageing, Alzheimer's disease or any other brain disorder.

Since 1995 major changes have occurred in Rugby Union as played in the UK. The amateur game, when all players had other jobs, has been replaced by full time professionals. This has had a massive effect on the game. Intensive training now occurs regularly during the week, and it soon became obvious that the players were much bigger and heavier. The traditional contact sport, based on skill and guile, gave way to a more brutal approach with fierce collisions - "big hits". Modern rugby is a very different game with similarities to American Football (NFL). Gradually the media, particularly the press, were reporting escalating injuries, concussion being the most common.²¹ In due course early onset dementia was reported in several high profile rugby players including Steve Thompson,²² Ryan Jones,²³ Carl Hayman²⁴ and Alix Popham.²⁵

Currently, in Rugby Union in the UK the most significant development is the unfolding of two large class actions against World Rugby, the Rugby Football Union and the Welsh Rugby Union. The first lawsuit covers 225 professional players while the second covers 55 players who played rugby before it became a professional game, and also includes women who played before their version of the game became professional.²⁶ In these actions the regulatory authorities are accused of negligence in their failure to protect players from brain injuries during their playing careers. These players have a range of neurological impairments: early-onset dementia, probable CTE, epilepsy, Parkinson's disease and motor neuron disease which they attribute to the effects of the concussive and sub-concussive blows they suffered while playing the sport.

Days before this paper was submitted a third class action on behalf of 100 former Rugby League players was launched (Rugby League is a variant of rugby but the preponderance of players have

always been professionals). These players allege that the sport was negligent in failing to take reasonable action to protect them from brain injuries, including early-onset dementia and CTE, caused by concussive and repetitive subconcussive blows.

The overall picture is a cause for grave concern. Several of the major sports are popular and flourishing and at the same time brain injuries and dementia are serious negative consequences. The regulatory authorities for these sports have been slow to acknowledge the existence and the extent of these problems but these issues are beginning to be addressed. In 2015 the US Soccer Federation banned heading for children under 11 and restricted players in the 11-13 age group doing headers during football training. By now in England, Scotland and Northern Ireland children aged 11 and under are no longer taught to head footballs during training while in the UK the Football Association guidelines have asked for coaches to put limits on how much heading older children should do.²⁸ In addition in the UK some attention is being given to how heading can be reduced in the adult professional game. In rugby tackling techniques are being explored to see if changes could result in a reduction of head injuries.

Brain Fragility

The emerging consensus particularly from boxing and American football is that repeated small blows to the head is the biggest risk factor for causing dementia in sport. Curiously there are few suggestions as to why the brain is vulnerable to this form of long term trauma. To me the brain's extreme fragility is the explanation for its vulnerability to repetitive sub concussive head injuries over a long period of time. I'll outline how I came to this view.

My research into dementia in sport began in 1981, soon after I had started a dementia service in Swansea, Wales, UK. As I was reviewing a man aged 71 with advanced dementia, his son asked if his father's serious condition could have been caused by heading a soccer ball regularly for 30 years, as he had been an avid player and well known header of the ball. No references existed in standard texts or learned journals however I considered it an intelligent perceptive suggestion.

The extreme fragility of brain tissue became evident to me in two ways. As a teenager brought up on a farm I had handled fresh mammalian brain during breaking down pig carcasses and I still

vividly remember its watery semi-solid consistency. And as a young doctor working in neurosurgery I saw, at first hand, the soft delicate consistency of the human brain, similar to soft butter, blancmange or jelly. Although the human brain is heavily protected by three membranes and is situated inside a strong bony structure, it is not anchored within the skull and as a consequence is able to move and oscillate within a hard enclosed bony space. With this information I could understand how the human brain would be damaged by regular pummeling of the head by heading.

In my clinical work I looked out for men with dementia who had been footballers. These were followed up and efforts were made to obtain autopsy consent so that neuropathological studies could be undertaken in due course. Recruiting subjects was a slow process; given the overwhelming dominance of rugby in South Wales, soccer is a minority sport. Even so, I collected 14 cases, and neuropathological studies were undertaken in six of these.¹⁵

Heading a football is not a pleasant experience. The well-known travel writer and science communicator Bill Bryson described it thus: "I thought it would be like heading a beachball...but of course it was like heading a bowling ball. I have never felt anything so startlingly unlike I expected to feel. I walked around for four hours on wobbly legs with a big red circle and the word MITRE imprinted on my forehead, and vowed never again to do anything so foolish and painful".²⁹ Similarly, a senior professional football player told me his experience was of frequently "seeing stars" or feeling slightly stunned and it would take a few seconds before he had recovered completely. These accounts clearly convey the idea that heading a football is a minor traumatic head injury.

Neuropathologists see at first hand the brain's lack of resilience to mitigate against the effect of minor trauma. Great care must be exercised when removing the brain intact from the skull as the cerebral cortex is easily damaged. Tearing of the main white matter tract, the corpus callosum and/or separation of the brain stem from the cerebellar hemispheres can easily occur. These postmortem observations emphasise the fragility of the brain to isolated trauma.³⁰

The intrinsic vulnerability of the brain to apparently minor but repetitive trauma is confirmed after transient electrophysiological and cognitive anomalies were found in young amateur footballers after only one session of heading a football 20

times.³¹ Similarly, neuroradiological examination of footballers exposed to different frequencies of heading found a threshold effect above which micro structural white matter changes and cognitive impairment occur.³² It is reasonable to assume that repeated exposure, over a long duration, will amplify these functional and structural changes. In any consideration of the brain's fragility and vulnerability it's important to bear in mind that the human brain takes a long time to develop and this process is only completed during early adult life. Up to this point the developing brain is more vulnerable to trauma.

In the early 1980s when I embarked on the work the human brain had already been compared to a computer, but this comparison was not easy to embrace as the early computers were huge and cumbersome. With massive developments in information technology and miniaturization, as exemplified by a modern smart phone, the comparison is easier to understand and accept. The human brain with its colossal memory, creativity and prodigious information processing ability can be considered an advanced and sophisticated supercomputer. In conversation with Dawn Astle (the daughter of the soccer player whose dementia was deemed an industrial disease in 2002^{3,4}), Professor William Stewart (lead investigator in the study of 7676 former Scottish footballers^{16,17}) captured succinctly the nature and structure of the human brain: "the most fragile, the most complex, the most unique organ in the body". Furthermore, he likened heading a football to using a laptop computer as a bat.³³

The brain's fragility coupled by its complex and powerful computing power makes it particularly vulnerable to physical trauma, particularly repetitive trauma, over a long timescale. It's not difficult to understand how the relentless subconcussive trauma which occurs in boxing and heading the ball in soccer leads to neurodegenerative disease and dementia. In rugby a different mechanism comes into play. Direct trauma to the head occurs but is much less frequent than furious collisions between players involving the torso and lower limbs. These 'big hits' are so powerful that the force and the energy creates reverberations throughout the body and in turn damages the brain as it vibrates within the skull.

Preventing and managing the problem

The first step to be taken must be to recognize and accept the brain's fragility. The concept of "Brain

Health” needs to be established and promoted. A public health/illness prevention strategy should be created to educate the general public and athletes particularly those in sport which carries a significant risk of head and brain injuries. Cardiac disease prevention has already established a sound template. The slogan “*look after your heart*” has long been promoted and a large section of the population is reasonably well informed about the guidelines to prevent coronary artery disease. In the same way the slogan “*Look after your brain*” needs to have a high profile with the subtext of dodging avoidable brain injuries.

Sports psychology is an established discipline with skills to address motivation, improved performance and the well being of athletes. There is now an urgent need for cognitive psychologists to be an integral part of the backup team in any sport where there is a real risk of head injury and brain damage. Baseline cognitive testing should be established particularly for players embarking on a professional career. These tests should be repeated regularly and at least every two to three years. At the first hint of cognitive impairment the tests should be repeated quickly. If the deficit is confirmed the individual should seek advice about early retirement from the sport.

The psychological impact of having to consider early retirement from one’s chosen profession is profound particularly if it’s on account of early cognitive impairment. Giving feedback in these circumstances must be undertaken with great sensitivity and packaged with high quality advice from a multi-disciplinary team and plenty of time allowed to explore alternatives so that the transition occurs as smoothly as possible.

In parallel with a public health campaign and regular cognitive testing the regulatory body for each sport, where there is a significant risk of brain injuries, must give priority to consider carefully how brain injuries can be reduced and eliminated.

Conclusions

During the last decade a consensus emerged that dementia in sport is caused by repetitive subconcussive brain injuries over a long timescale, but there is no suggestion why the human brain is vulnerable to repeated micro-trauma. This paper breaks new ground by putting forward a coherent explanation based on the human brain’s structure and capabilities. The brain is a very fragile organ having the consistency of soft butter or blancmange while at the same time it is a powerful supercomputer. Its memory is prodigious, its information processing ability colossal and its creative ability is immense. Accepting this construct of the brain leads to an understanding of its vulnerability to trauma and in turn to leads to a logical prevention strategy and management plan. For prevention two imperatives stand out. A public health initiative to educate the public about the brain’s fragility and to promote the slogan “*look after your brain*”. In tandem regulatory authorities must take urgent action to reduce and modify aspects of the sport that leads directly to brain injury. Finally, for effective management of the problem any player at risk should be monitored by regular cognitive testing to detect the earliest signs of impaired brain function.

Conflicts of Interest Statement

The author has no conflicts of interest to declare.

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