

**Written evidence submitted by Professor Andy Harland, Professor Adrian Spencer,
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Written evidence submitted to Parliamentary Enquiry: Concussion in sport

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Summary of Evidence

As researchers in the field of sports engineering with particular interest in the dynamics of collisions and analysis of injurious impacts, we wholeheartedly support an increase in funding and multi-disciplinary research coordination to address the issues identified during this inquiry. We believe that this issue can only be truly addressed by all stakeholders working together to ensure a safe and sustainable future for sport.

Having actively researched the characteristics of football impact and flight over many years, we share our most recent findings that for a given “corner kick” header scenario, the impact speed and ball momentum associated with an older leather ball when wet would have been substantially greater than with a modern football and that this finding is independent of how hard a player may or may not have been able to kick a heavy ball.

We do not make any claim relating to likelihood or severity of injury based on this finding.

Background and Context

As Professor of Sports Technology in the Wolfson School of Mechanical, Electrical and Manufacturing Engineering at Loughborough University, I am pleased to accept the invitation to provide evidence to this inquiry on behalf of myself and colleagues in the Sports Technology Institute.

My colleagues and I have extensive experience in researching collisions between deformable and rigid bodies typically involved in sport. Recently this has focused on collisions between sports balls and human heads and necks, including conceiving and demonstrating a new testing paradigm intended to prevent facial injuries that has been included within British Standard for Head Protection for Cricketers BS7928:2013 and its subsequent amendment covering assessment of neck protection +A1:2019. Since publication, facial injury by players wearing certified helmets has been eliminated from the game internationally.

Addressing the Issue of Brain Injury in Sport

We are pleased that you have heard evidence from a number of eminent scientists and campaigners who have drawn attention to and provided evidence of a statistically significant increase in risk of

brain disease among former footballers. Although we have no medical training that would qualify us to comment on injury or pathology, we believe the FIELD study to have been carried out with excellent rigour and its findings fairly represented. Combined with other evidence that has been presented it is perhaps understandable that many in the media and indeed on the panel have made the assumption that repeated heading of a football must be responsible for the prevalence of brain injury in footballers. More accurately, this represents a hypothesis, which must now be proven, as noted by Dr Loosemore in the second session of evidence.

It is now necessary to urgently seek to identify and explain the mechanism by which specific head impacts either cause damage directly or induce a damaging biological response that would explain the symptoms and pathology. This should extend across the spectrum of collisions seen in sport, from short duration impacts of hard balls used in cricket and hockey through medium duration high frequency events such as headers in football to relatively long duration collisions such as punches and tackles in rugby and martial arts. These are known to induce different dynamic responses from human body parts and constituent tissues. We also know that injury to the head can take many forms including skull fracture, immediate concussion, or the aggregation of numerous sub-concussive impacts. Until it is possible to better relate the specifics of a collision to the damage caused and symptoms exhibited, it will remain challenging to understand how to mitigate injury and safeguard participants.

This is not a trivial undertaking and requires collaboration between researchers from a variety of disciplines over a sustained period of time. As engineers committed to researching physical safety in sport, we are enthusiastic about continuing to contribute to this.

We share the view of many of the witnesses that increased levels of funding should be made available and would emphasise the importance of this to be made available across a wide range of social, physical and medical science disciplines. We also believe it would be worthwhile to establish a multi-disciplinary, multi-sport group to oversee knowledge and evidence sharing to inform research and mitigation strategies, especially related to those sports unable to resource original research activities.

Response to HC1177, Q27, Tuesday 9 March 2021

“Is there any evidence to suggest that the heading of a ball has got less dangerous over the years because of the change in the ball?”

In relation to the specific line of enquiry pursued by the Chair during the oral evidence, we would like to draw your attention to the findings of our research into whether changes in ball materials over the years would affect the speed and ball momentum at impact with the head.

A commonly presented argument follows that whilst it is known that leather football panels were more susceptible to water absorption causing their mass to increase during play, this would result in a reduced kick velocity leading to a reduced impact speed at the head.

Whilst it is true that for a given human capability, a maximal effort kick will result in a reduction in ball velocity with increased ball mass, it should be noted that the vast majority of headers do not result from such kicks. Instead, players are able to adjust their kicking effort to achieve a given ball trajectory or pass length.

Therefore, a more appropriate consideration might be to take a known circumstance, for example a corner kick resulting in a header on goal, which is known to have been a common occurrence throughout half a century or more of football. Such a scenario would require the ball's trajectory to pass through a position where a header might occur, say 2 metres directly above the penalty spot for the sake of argument. The primary determinants of the trajectory of a given kick are launch speed, launch angle and ball spin. Within the range of human kicking capability, only a finite combination of these would result in a ball passing through this point at which it might be headed, a fixed distance from its origin.

Using previously published and fully validated flight models and based on aerodynamic coefficients acquired through wind tunnel testing, this range of finite possible launch conditions was determined across a series of ball types and conditions, allowing direct comparison between modern tournament footballs and older leather balls in both dry and wet conditions.

The findings of the study, due to be submitted for peer review in the coming weeks, were as follows:

- The speed of the ball at impact with the head was found to increase linearly with respect to its mass/area. (The area denominator adjusts for small differences in ball diameters of the sample balls.) In effect, given the launch conditions required for the ball to follow a certain trajectory, the heavier (wet) ball was found to maintain its velocity more so than the lighter (dry or modern) ball which experienced greater deceleration due to drag.
- In all cases, for identical launch conditions, the old wet balls would have had greater speed at impact with the head than dry old balls and new balls, generally in the order of +5%
- When these differences are multiplied by mass (to determine the change in momentum) an increase in the order of 40-60% was observed for old balls in a wet condition when compared to new dry balls. A difference of less than 2.5% was found between new balls in their wet and dry conditions.
- As previously mentioned, we are not qualified to comment on the link between any of these findings and injury, although a number of peer reviewed studies have reported the relationship between ball momentum and resultant head acceleration which is assumed to be a major contributor to brain injury.

For reasons explained above, it is not possible to conclude whether the differences in ball speed or momentum are significant in causing or preventing injury since the mechanisms of the damage caused are not yet known. These findings do suggest, however, that based on an equally weighted average of all possible kicks, the impact speed and momentum of ball-head impacts is no greater in the modern game than it was previously and may indeed be less. This finding would need to be considered alongside analysis of a statistically significant number of headers from different eras of the game before a definitive conclusion can be drawn.

We thank you for your consideration of this evidence and look forward to collaborating with others to ensure a safe future for all involved in sport.